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Leading Interdisciplinary Research: Transforming the Academic Landscape

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Contents

Abstract

This paper considers the complex challenges entailed in leading and developing interdisciplinary research (IDR) and suggests that, while structural support is vital, cultural change may be equally critical. It argues that, while IDR is commonly encouraged in rather utilitarian terms, as helpful in addressing complex societal and environmental issues, there are deeper intellectual reasons for fostering collaborative research across disciplinary boundaries. The comparison, exchange and synthesis of specialised systems of knowledge can be transformational, enabling new ways of thinking about and conducting research. Emphasising the overarching unity of the academy, the paper argues that successful IDR has the potential to reunite areas of knowledge that have fragmented over time. It examines some interdisciplinary experiments in the UK, and considers how the participants have navigated the obstacles that attend each stage of collaboration to produce exciting and coherent outcomes. Articulating the practices and principles that underlie successful IDR, it discusses how universities can assist such research developments, both in practical ways and through cultural and ideological change.

Introduction: background, perspectives, definitions

Interdisciplinary research (abbreviated in this paper to IDR) is lauded globally among universities and research funders. It has become one of the necessary emblems of quality, relevance and leadership. But it is also easier to claim than to deliver, and problematic to implement and assess. The complex skill-sets it requires are underdeveloped within higher education; and when its underlying motivations are articulated (which is rare), they are often contested. For example, it may be true that IDR addresses current societal challenges more effectively than research within single disciplines, but such an instrumental motivation alone does not capture the radical effect it can have on academic disciplines themselves, and its capacity to transform the way we think.

This paper complements an earlier contribution to this series,[1] which drew on examples of interdisciplinary structures in three American universities. Both papers agree that in achieving successful IDR, cultural change is as important – and possibly more so – than simply creating the right structures. Here we explore some of the underlying reasons for this, and describe some experiments with interdisciplinarity in the UK, offering examples that illuminate good practice in motivation, leadership and implementation.

We are convinced that a fuller discussion of IDR is urgent and important. For although poorly framed IDR can lead to fragmented thinking, it is, at its best, truly transformational of our academic disciplines, and useful in enabling coherent engagement with the wider public.

Towards a unity of knowledge

The notion of interdisciplinarity is fundamentally an aim to reunite areas of knowledge that have, over time, divided into (putatively) distinct and mutually incomprehensible areas. This paper questions these assumptions, proposing, in accord with theologian Nicholas Lash, that from the perspective of underlying purpose, such distinctions are illusory. Lash urged the academy to grasp the ultimately connected structure that underlies all disciplines: 'Not-withstanding the accelerated fragments of specialised academic activities, we trample in

[1] Taylor (2013)

each other's territory, sing each other's songs, whether we want to or not'.[2] His intriguing essay, *Contemplation, Metaphor and Real Knowledge*, challenges established assumptions about the way disciplines construct the world of thinking, ideas and research. His implicit claim is that interdisciplinary thinking returns us to our contemplative core (rather than pushing us to peripheries) and, by regenerating intellectual flows between disciplines, creates new, rather than merely parallel, conversations and outcomes. Such new dialogues are the essence of *interdisciplinarity*. We use this term in our paper, rather than the alternative *multidisciplinarity*, as the latter is now more usually employed for teams in which research efforts act as parallel inputs to a task, but are not integrated.[3]

So familiar are we with the current canonical list of academic subjects, that 'interdisciplinarity' is commonly seen as a super-addition, a structure built over the foundations of the fragmented disciplines themselves. This may be true in practical and organisational terms (and accurately describes 'multidisciplinary' activity as we have defined it), but we would suggest that interdisciplinarity takes us to a place *deeper* than its disciplinary constituents, and that Lash's view provides a more satisfactory account of its transformational potential.

A recent report commissioned by American institutions provided a definition of interdisciplinary research:

> *Interdisciplinary research (IDR) is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or field of research practice.*[4]

This definition usefully stresses the advantages of integration and synthesis, especially in research areas stimulated by what is seen as practical 'problem-solving'. More could be said about the inherently interdisciplinary challenges posed by cross-cutting social, technological, medical, political and environmental issues. But even such utilitarian definitions – and we are dubious about the value of dividing research into 'applied' and otherwise – imply that working collaboratively does more than combine strengths and triangulate perspectives. The 'bodies of specialized knowledge' brought to bear in interdisciplinary projects have, by implication, undergone 'speciation' (the evolutionary metaphor slips in almost without noticing the interconnectedness of the past evolution of academia). With it arises the powerful idea that, when divergent streams of thought, study and methodology are recombined, they are simultaneously at their most effective and most fundamental. There is little doubt, however, that a willingness to work collaboratively rather than competitively, and to pool ideas, requires not only confidence but also sufficient time, resources and an abiding desire to learn.

Successful IDR highlights the virtue of academic humility. As observed by Repko,[5] engaging with other disciplines dislodges all practitioners from an exclusive grip to their realms of

[2] Lash (1996)
[3] Crease, R. in Frodeman et al (2012)
[4] Anderson and Brown (2005)
[5] Repko (2012)

expertise, and from the comfort of enjoying a superior knowledge-base to that of their collaborators. The relationship of expertise is actually inverted with respect to the single-disciplinary case: IDR participants' manifest ignorance invariably outweighs their expertise. Such inversion makes students of us all, healthily disrupting academic hierarchies: professors in the sciences sit at the feet of doctoral students in the humanities, and vice versa. Humility is an essential facilitator but also an obstacle, insofar as it is a personal discipline in itself, not universally acquired.[6]

An anthropological perspective on IDR

Articulating a vision of IDR is one thing; realising it is another. Another route in to good interdisciplinary practice is the (paradoxical) guidance that some individual disciplines themselves can provide. We need to address the obstacles to interdisciplinary research, but although some of these are obvious, other, more subtle issues that impede collaboration are less visible to the untrained eye. As human communities tensioned between individual and corporate goals, we may find it helpful to consider these fundamentally social issues from an anthropological perspective.[7]

Anthropology and other social sciences understand academic disciplines as social networks. This understanding has been influenced by Actor Network Theory (ANT),[8] which usefully highlights the reality that agency is located not in individual actors but in the exchanges between them. Such theories have emphasised the flow and emergence of ideas, encapsulated by Deleuze and Guattari's work on notions of 'becoming'.[9] These are usefully fluid models through which to consider transformative flows of knowledge, as well as the emergent nature of identity and community.

Ideas – and concerns – about disciplinary identities recur in discussions about interdisciplinarity. Like other human communities, academic 'sub-cultures' try to distinguish themselves from each other by constructing, performing and representing specific identities.[10] In focusing upon particular domains they have developed and reified their own worldviews and practices. These 'epistemes' are composed of theoretical models, methods of investigation and analysis, ideas about what constitute data, material culture, and of course disciplinary languages which, like local dialects, provide exclusive forms of communication.

The creation of disciplinary identity can therefore be seen as an attempt to constructwhat Bourdieu termed 'distinction',[11] an active process that enables people to achieve a sense of belonging and to acquire social capital in the form of academic status, resources, and intellectual and/or political influence and security. Such striving for competitive advantage is particularly valued in an academic and wider social environment dominated by neo-liberal ideologies. This implies that the notion of interdisciplinarity may be ideologically subversive. By calling for collaboration and cooperation, and for the open exchange of ideas, it challenges the real and perceptual boundaries that function to

[6] See boxed summary headed 'The ordered universe'.
[7] Barry and Born (2013)
[8] Latour (2005)
[9] Deleuze and Guattari (2004)
[10] Strathern (2008)
[11] Bourdieu (1994)

maintain ownership and authority over 'territories' of knowledge. It is no wonder, then, that an interdisciplinary agenda can generate both passionate enthusiasm and defensive opposition.

Identities and boundaries tend to solidify over time, and there has been much criticism of the reification of 'disciplinary silos' that preclude the exchange of ideas and knowledge. Bender has even offered a categorisation of disciplines from 'strong' to 'weak' that reflects their plasticity or resistance to changes in their intellectual context.[12] In his (admittedly confusing) nomenclature, it is the 'weak' disciplines that are more resilient to contextual changes because they adapt, flow and reform. There is also, as we have already observed, a growing sense that complex cross-cutting social and environmental issues will be better understood collectively, from a range of perspectives, than through the lens of any single discipline. Thus collaborative endeavours to produce 'joined-up' thinking are now being encouraged by policymakers and funding agencies worldwide. When such motivation clashes with the territoriality of (Bender's) 'strong' disciplines, we can expect resistance.

For example, in planning for the effects of climate change, prominence has been given to the disciplines of physical geography and to the highly mathematical and computational tasks of calculating possible global scenarios for temperature, precipitation and storms. But these areas of expertise constitute only a small part of the research programme that is needed to inform political decisions. There are multiple environmental effects – for instance the interdependent responses of crops and vegetation and of wildlife and migration, which call on the life sciences. Anthropogenic contributions to climate change, and thus its solutions – as well as its impacts – lie in the social realm. The social and medical sciences are needed to anticipate challenges in healthcare, nutrition and wellbeing. The more radical solutions offered by geoengineering have generated an urgent need for ethical debates that draw, for example, on philosophy, law and theology. To address complex problems, it would seem, there is a need not only for interdisciplinary collaboration, but also for this to encompass a diverse range of disciplinary perspectives. However, as Lash, Bender and others indicate, dealing more effectively with complex problems is not the only rationale for interdisciplinarity.

The value of cultural comparison

Despite the handwringing over 'disciplinary silos', the differences between disciplines can be turned to advantage when they are compared and contrasted. The development of specialised knowledge and understanding allows different areas not only to challenge, but also to offer each other fresh perspectives on research questions, creating novel insights and solutions. Such creative comparison takes place naturally in IDR. To continue the anthropological 'disciplines as sub-cultures' analogy: the comparison of diverse worldviews can be extremely productive, enabling both criticism of accepted norms and the collaborative construction of more robust analyses. As an example of the effect of such cultural exchange, it has been argued that the theoretical developments in anthropology that distinguish it from other social sciences (for example its holistic, localised and highly integrated approaches) are the direct product of exchanges of knowledge with radically different cultural contexts, in particular those of indigenous peoples.[13] This also underlines an important political point: that scholarship can gain enlightening perspectives from groups

[12] Bender (2005)
[13] Strang (2006)

(for example host communities and research users) generally seen as being situated outside – and therefore without authority in – dominant academic networks and institutions. As IDR gains more traction internationally, it can be anticipated that it will gain not only from the diversity of its disciplinary 'sub-cultures', but also from the more diverse cultural perspectives now flowing into the academy.

Discovering differences

The exchange of diverse cultural or sub-cultural ideas is not necessarily a comfortable process: it has the potential to confront participants with what anthropologists used to call 'culture shock'. In considering the traversal of disciplinary boundaries, Meyer and Land adhere to the notion of territoriality, and describe this as 'troublesome knowledge'. [14] Land maintains that:

> *Like Adam and Eve disciplinary specialists tend to find it difficult to leave the comforting Eden of their discipline, to cross the boundary into interdisciplinarity… an encounter with the wise and provocative serpent of troublesome knowledge might be required to occasion the ontological shift required, though the recipe of transformation may well be a degree of 'ontological insecurity'.*[15]

Responses to such insecurity depend on the predisposition of each researcher. Encountering the 'wise serpent' can be alarming and destabilising, resulting in defensive retrenchment to maintain boundaries. Alternatively, it can be illuminating and exciting, seen not as a loss of identity and coherence, but as a cosmopolitan acquisition of wholly new ways of thinking (an example is given in Box 1).

Creating commonalities

As well as recognising the strengths of diverse disciplinary identities, commitments to interdisciplinarity are underpinned by a recognition that common streams of knowledge flow through all of them. In discussing the capacity for groups to define themselves more specifically and 'multiply their positions' even within disciplines, Strathern notes that they do this 'precisely because they have common origins. The same could be said of the whole company of disciplines that make up academia'.[16] Though knowledge practices may take a particular form within disciplinary contexts (just as pan-human behaviours take particular forms in specific cultural contexts), they retain sufficient elements of commonality to make cross-disciplinary communication possible.

Anthropological experience with diversity is helpful here too, drawing attention to the potential for localised cultural knowledge to be translated into internationally shared theoretical concepts. Writing, for example, about the cross-cultural utility of concepts such as aesthetics, Morphy observes:

[14] Meyer and Land (2003)
[15] Land (2011) p7, citing Giddens (1991)
[16] Strathern (2008) p18.

> *Archaeologists and anthropologists are inevitably involved in the process of developing an analytic meta-language that is used in the analysis of data and the interpretation of culture.*[17]

As this suggests, the analytic commonality that enables IDR lies at a theoretical level, composed of the ideas that flow through and connect the actors within disciplinary areas. This may be why interdisciplinary ideas often emerge not in specific disciplinary 'territories', but in the exchanges between them.[18] (Box 2 gives an example of a science–humanities project in which the team developed a shared language in which to discuss medieval texts.)

An anthropological lens helps us to see IDR realistically. By recognising the social complexities of collaborative processes, it discourages any assumption that IDR necessarily guarantees a higher level of quality or academic desirability; and, by unpacking its particular challenges (which we consider in the next section), it shows how these can impede the attainment of quality if not successfully overcome. Research teams that fail to integrate their activities, or that even work to exploit each other, will not generate high-quality research. But if they make a genuine effort to learn from and assist each other, then the outcome can be extraordinary.

Navigating obstacles to interdisciplinarity

While commonality at a shared or 'meta-discursive' level can support interdisciplinary research conversations, as well as providing a basis for external engagement, encouraging researchers to take exploratory conversations forward into real collaborations requires the careful navigation of significant challenges.[19] It is not enough merely to glean some understanding of the other: interdisciplinarity requires an effort to translate and exchange theoretical concepts to the point where it is possible to engage in a shared approach to research questions.

The two cultures

The epistemological differences developed within disciplines are exacerbated by a particularly Western – essentially Cartesian – notion of 'culture' and 'nature'. Such dualism has tended to support what C.P. Snow famously called 'Two Cultures' in the academy,[20] defining 'science' as relating to the physical environment, and the arts and social sciences as addressing purely socio-cultural worlds. Such dualism has been much critiqued, for example by Strathern,[21] and by Descola and Palsson,[22] who have observed that not only is it conceptually flawed in presenting an artificial separation between social and material events, but also that alternative, more integrated theoretical approaches are available. The last decade has witnessed a fuller recognition that these worlds flow into each other and are mutually constitutive. Thinking more deeply about humanities, and social and physical sciences without dualistic nature–culture assumptions has opened up questions that are

[17] Morphy (2005) p51
[18] Latour (2005)
[19] Strang and Bell (2013)
[20] Snow (1959)
[21] Strathern (1980)
[22] Descola and Palsson (1998)

particularly useful for interdisciplinary discussions, for example about the social dimensions of research assumed to be focused on 'things', and the value of understanding the materiality of social events.

In reality, very few approaches to research are as mutually exclusive as some efforts to maintain 'distinction' try to suggest. Another classic 'incompatibility' is the assumed divide between reductive (science) and context-dependent (arts and social science) approaches. Quite often, interdisciplinary projects stall because they attempt to shoehorn disciplinary approaches requiring location in a comprehensive social and material context into the more focused models favoured in some of the physical sciences.[23] A more radical approach would be to make fuller use of the broader theoretical frames of the arts and social sciences to begin with. Being reliant upon locating events within an explanatory context (which encompasses a whole range of social and material dimensions), these have ample room for more specialised approaches within them, as well as potential to intersect with the cross-cutting ideas that are sometimes generated from the natural sciences. Such holistic approaches, in which new technologies are discussed in the context of social narratives, are proving essential, for example in new work on 'responsible innovation'.[24] However, this – perhaps the real obstacle – may require a more egalitarian approach than often pertains in an academy in which efforts are often directed towards creating or maintaining hierarchical 'distinctions'. Adoption by a UK research council (EPSRC) of the recommendations emerging from the responsible innovation programme (a requirement to undergo societal consultation before embarking on potentially ethically controversial research) is partly due to the successful removal of such disciplinary priority. This usefully demonstrates how more equal collaboration has enabled IDR to be influenced by a longstanding commitment to such consultation in the social sciences. This is exemplified, for example, by the ethical code of practice promoted by the Association of Social Anthropologists of the UK and the Commonwealth, which requires not only societal consultation but a reciprocal relationship in which the research also benefits the participating community. A more historically oriented reflection of an equal IDR exchange between humanities and sciences, can be found in the Box 2.

Laying equal foundations

The preceding examples raise a key issue about the kinds of underlying principles that enable successful interdisciplinary collaboration. One observation, noted consistently by scholars experienced in IDR, is that successful collaborations require equality between participants and a determined effort to maintain openness and inclusivity throughout the research process, most particularly at the design stage when projects are all too easily pulled into dominant disciplinary spheres. There is a need to recognise that relationships between disciplines contain relative power. Such power draws on a number of sources: for example, prevailing ideas about the relative value of 'experimental' versus 'interpretative' research; the presumed utility and reliability of quantitative versus qualitative outputs; and the ways that different disciplines are represented in various media. We should not assume that the academy is immune to such stereotypical thinking. An example would be the use of the terms 'hard' and 'soft' science. While at a superficial level, this might be said to denote the material nature of the physical sciences and the non-material interests of the socially

[23] Community reactions to the introduction of GMOs provides many examples: see Goyal and Gurtoo (2011).
[24] Owen, MacNachten and Stilgoe (2012)

oriented disciplines (which as noted above is questionable in any case), these terms inevitably carry other connotations: of the 'real' versus the 'intangible'; of the 'seriously difficult' versus the 'anyone can do it'; of the 'reliable' versus the 'untrustworthy'. And there is also a hint of hard, 'macho leadership' versus soft, 'pliant femininity', which serves to gender disciplines in terms that parallel the historically gendered dualism of culture and nature. Ortner has noted that rational/scientific (male) 'culture' is seen as having dominion over (female) nature.[25]

A nascent exploration of theories needs to be accompanied by a discussion about what the problem *is*, given that what seems to be a key research question to one discipline may be quite different from that considered by another to be central. Research questions – in particular those generated by funding councils – often come fully formed. Given the realities of 'impact-oriented' funding, a group might take a prescribed question and consider the range of disciplinary skills that could be brought to bear upon it. But it may be more useful – and more innovative – to approach the question critically, and consider how it might be expanded or adapted to gain the most benefit from an interdisciplinary approach.

Disciplinary breadth

A successful approach to an interdisciplinary project needs to recognise the 'disciplinary distances' within the research team. A project requiring, for example, a number of different physical sciences to collaborate intensively (Box 1 gives an example), will usually require less cross-disciplinary translation than a project spanning physical sciences and humanities (examples are given in Box 2 and Box 3) or natural and social sciences. The greater the epistemological distance, the more work the team needs to do in learning each other's models, languages, practices etc before launching into the research. Seminars under explicit 'no question is stupid' rules; guided introductory readings; facilitated conversations exploring what each discipline brings to the project – all constitute time well spent. The foundational phase of an IDR project is an opportunity to exercise academic humility; to venture, as a mature student, into other disciplinary territories, and simply to get to know other team members. This last point is far from trivial: while utilitarian discourses tend to elide the human aspects of the research process, professional relationships are simultaneously social relationships, and it is plain that in meeting the challenges of IDR, giving team members time and space in which to get to know and like each other is a key factor in ensuring successful collaboration.

Even in projects spanning departments within a single faculty, however, one should not underestimate the degree to which research cultures may have diverged. Closely related subject areas can, at times, exhibit the classic symptoms of sibling rivalry. For example, a two-year study of projects bringing physicists and biologists together[26] identified quite different priorities. In general, biologists tended to value detail and specificity more than physicists, while the latter favoured more coarse-grained and generally applicable understandings. Research in biology, especially molecular biology, is more frequently driven by a methodology of hypothesis-testing. The physicists tended to prefer more exploratory programmes of experimental work in which research teams 'go fishing' for hypotheses rather than posit a particular one. The nature of explanation – or what constitutes a solved

[25] Ortner (1976)
[26] McLeish (2011)

problem – also differed to a degree. Research in physics is much more comfortable with mathematical modelling as an inherent and necessary methodology. Taken together, such differences between contiguous natural sciences are enough to create serious misunderstandings if they are not negotiated. One instructive way of enabling people to work together is for the members of a team to tell each other stories about their past research projects, for although science is not often described in narrative terms, there is no better way of exposing the working methods, goals and values that will drive the individual researchers when the project starts.

Interdisciplinary leadership

The extent to which inequalities permeate the academy is readily discernible in the demographics of disciplinary areas, in their relative influence and status, in their access to resources, and – most pertinently here – in their expectations about research leadership. Interdisciplinary research, with its requirement for collaborative equality, necessitates forms of leadership that are often at odds with those that enable individual progression and encourage disciplinary hierarchies in contemporary higher education institutions. A competitive environment has promoted combative images of leadership utilising military or sporting metaphors (for example 'champions' leading their 'troops' to 'capture' grants and intellectual 'territory'). But the open exchange of ideas essential to successful interdisciplinary collaboration is supported neither by the competitive defence of territory nor by aggressive attempts to claim it. Interdisciplinarity is enabled, rather, by a willingness to subsume individual egos (or as one informant put it, to 'check them at the door'), and to risk generous participation in a more collective endeavour.

Such generosity needs to extend to time commitment, as building a collective research enterprise requires open and patient communication at each stage. As well as taking the time to articulate their work in ways that researchers from disparate areas can comprehend, participants must also be willing to learn as much as they can about the ideas and practices of their collaborators. At an early stage, contributors to the innovative interdisciplinary pool need 'permission' to make observations, suggestions and recommendations that transgress disciplinary boundaries, potentially in all directions.

Delineating data and organising outputs

Another key topic – and potential stumbling block – is what constitutes 'data' to the disciplines involved. Many arts and social science researchers are unfamiliar with the datasets that are meaningful to physical scientists, while the latter may see social data (for example quotes from interviews) as purely 'anecdotal', without recognising that what people say and do can be analysed as systematically as, for example, the behaviour of cells or photons, using both qualitative and quantitative methods. For example, discourse analysis may employ computational methods to measure term and phrase recurrences, but it takes a human eye and mind to scan text systematically for nuances, subtexts and complex relationships between concepts and images. IDR collaborators therefore need to exchange methodological information about how data is collected and analysed, and what kinds of outputs can best express the results of that analysis.

As well as overcoming tensions between disciplines, effective IDR needs to uphold their particular strengths. Throughout the process, each participant needs to retain a

sufficiently firm sense of disciplinary identity to feel that they are contributing from a secure position, as well as retaining an ability to publish in disciplinary journals and maintain a 'distinctive' disciplinary reputation. At the same time, all have to be able to pool ideas and gain the rewards of being part of an innovative collective research endeavour.

Publishing interdisciplinary (or for that matter collective) outputs is still not wholly accepted in most disciplinary areas, and may in consequence disadvantage junior researchers' efforts to establish individual reputations. Defining project outputs – their form, their authorship, their direction – therefore requires candid discussion at the outset, and the thoughtful accommodation of diverse needs. In many projects the frequently cited tension between IDR and the requirements of a single-discipline publication culture can be shown to be false. Ideally, the rich context of a deeply interdisciplinary project will stimulate not only innovative joint outputs but also single-discipline work of the highest quality that gains from the interactive energy and contrasting methodologies of IDR.

[INSERT BOXED SUMMARIES 1. AND 2. *MICROSCALE POLYMER PROCESSING* AND *ORDERED UNIVERSE*]

Box 1: Microscale polymer processing[27]

A rich example of a large and long-lasting programme of IDR, driven initially by 'user need' is the microscale polymer processing project. Six UK science and engineering groups worked for over 10 years in an international collaboration with industry and other universities. The driving, 'societal question', conceived jointly at a meeting of a network of industrial and academic scientists, was: 'How could advanced polymeric (plastic) materials be designed at the molecular level to achieve specific properties in their processing and final products?' To build such a linked understanding required collaboration between chemists, physicists, chemical engineers, mathematicians and computer scientists across the participating universities. The central question is an example of *intrinsic interdisciplinarity*: the project could only thrive if all contributory disciplines were in communication with each other and with the industry-based members of the consortium. For example, some essential 'model materials' and characterisation techniques could only be accessed through specialised industrial expertise and equipment, while models from theoretical physicists were needed to shape the synthetic targets of the polymer chemists. The methodology therefore illustrates the advantages of two-way information and conceptual flow between academic and 'user' members of an IDR consortium. Of the 100 or more published outputs from the project over 10 years, the majority were single-discipline papers. But the project also produced several multi-author publications that addressed the central questions holistically. Two of these were published in the high-profile general interest journal *Science*. In this case, IDR did not require compromise on the publication profile of participants. A third category of output emerged as a cluster of software tools capturing the developing multi-scale modelling within the project. Designed to be compatible with the in-house systems of industrial partners and made freely available from the project website, they have been adopted into the development methodologies of several partners.

[27] http://www1.irc.leeds.ac.uk/mupp2/

Box 2: The ordered universe[28]

This international project is examining the nature of scientific development in 13th-century England. Its radically interdisciplinary methodology brings Latin scholars and historians together with natural scientists (physicists, psychologists and cosmologists) whose expertise lies in the subject of the early texts. Close textual readings and translations are made in extended symposia in which all participate, with humanities scholars becoming accustomed to entering the technical discussions, and scientists contributing to the detailed debate on translation.

An unanticipated consequence of the project is that each treatise examined has produced not only a new edition of the texts and commentary from the humanities scholars, but also a companion paper in contemporary scientific literature. For example, Robert Grosseteste's 1225 treatise on colour, *De Colore*, has revealed an intricate mathematical structure (a fully three-dimensional colour space) to the analysis.[29] The perspectives from mathematics and physics have yielded new tools for textual analysis (for example, detecting transcription errors that eluded other methods) and improved translations. In turn, the physical scientists in the project have learned a great deal about the sophistication of thought in the era of pre-experimental natural philosophy. The project has now extended to encompass student involvement, and researchers have worked with educationalists and teachers to develop material suitable for schools.

[28] http://durhamgrossetesteproject.wordpress.com/category/fidem-congress-porto/
[29] Dinkova-Brun et al (2013); Smithson et al (2013)

Creating interdisciplinary environments

The necessity of effective communication at every stage of an interdisciplinary research endeavour can be extremely rewarding, but it takes both time and resources. Institutional structures, for many decades formed by ideas about distinct disciplinary areas, do not readily lend themselves to supporting research that crosses both intellectual and administrative boundaries and, in the current higher education environment, seems to represent a degree of risk.

There are particular challenges raised by the increasing centrality of 'problem-driven' research. Since the 1980s, the environment of national and international research funding has become increasingly utilitarian and inclined to demand research demonstrating direct social and economic 'impacts'. Resources have been largely diverted towards work that can claim direct forms of instrumentalism which, social critics argue, promotes particular political ideologies. The logical extension of this ideological pressure is to integrate it with assessments of performance: thus 'impact' has become increasingly influential in governments' evaluations of universities (eg, in the UK within the Research Excellence Framework or REF). Disciplinary areas that are more focused on complex or intermediate outcomes (or – worse still – committed to providing reflexive critiques of social and political processes) have tended to be marginalised.[30]

In an interdisciplinary conversation, therefore, one of the larger 'elephants in the room' is the extent to which participants are comfortable with an instrumentalist political agenda or critical of it. Collaboration depends upon social bonds that are sufficiently robust to encompass not only diversity in ideas, but also potentially incompatible political standpoints. An illustration is provided, for example, by the differing priorities that emerge in interdisciplinary approaches to freshwater management. While hydrological engineers may be focused on expanding water supply infrastructure in dry climates for irrigation, ecologists may not consider the minimal 'environmental flows' allocated to rivers sufficient to meet the needs of non-human species, while social scientists, bound by an ethical commitment to ensuring that their research benefits its participants, may be far more concerned about the social and cultural impacts of development on less powerful human communities.[31]

Nevertheless, it is precisely this kind of complex issue that most needs IDR, and the pressing need for social or ecological impacts can provide an impetus in this direction for both funders and researchers. Providing that it is recognised that pure instrumentalism leads to poor outcomes for everyone, there are opportunities for universities to re-open channels for the humanities and social sciences into programmes previously seen as the province of technology or management science. The issue of future energy supply constitutes another important example: transitions to sustainable supply, the emerging high-growth economies and the need for low-carbon futures require the integrated expertise of social scientists, engineers, industries and regulators, rather than pivoting on any single 'technological fix'.

[30] Halevi and Bar-Ilan (2013)
[31] Strang (2009)

[INSERT BOXED SUMMARY 3. *HEARING THE VOICE* PROJECT]

Box 3: Hearing the Voice project[32]

What is it like to hear voices and what does it mean? And how does an interdisciplinary approach transform these questions? The Hearing the Voice project, supported by a Wellcome Trust Strategic Award in the Medical Humanities, began with an interdisciplinary collaboration between psychologists and neuroscientists investigating the experience of hearing voices in the absence of any external stimuli (termed 'auditory verbal hallucinations' in a medical context). The research initially focused on the phenomenology of voice-hearing, with a view to advancing cognitive neuroscience understandings of such experiences and informing their therapeutic management in a clinical context. However, the researchers recognised that, although usually associated with severe mental disorders such as schizophrenia, voice-hearing is also an important aspect of many ordinary people's lives. Moving beyond conventional medical views, the project considers voice-hearing as part of social being. In turn, this raised more profound questions about the neural foundations of language, the nature of thought and the unity of the self. As the project broadened its interdisciplinary scope to encompass inputs from history, theology and anthropology, it also began to consider how the experience of voice-hearing might be considered in different historical, religious and cultural contexts: for example as a blessing from God, as direct contact with ancestral beings, or as the basis for shamanistic power and status. This raised further questions about how the framing and the (positive or negative) meanings associated with voice-hearing might have a recursive effect on the experience itself, and how an understanding of more diverse perspectives might change social and therapeutic responses to such events.

It is clear, then, that a move towards interdisciplinary collaboration requires a sea-change both in how researchers think about the relationships between individual disciplines, and in how these relationships are supported. It requires active participation, by those with experience and commitment to IDR, in public debates about research assessment and about the public funding of research. For example, in research quality assessment exercises such as the REF, there is a need for more robust methodologies. Merely cross-referencing an interdisciplinary output (book or article) to a number of different single-discipline panels will not do justice to its holistic contribution, as such panels tend to act as 'filters' rather than integrators. Better practice would embed into the work of all assessment panels the value of IDR, and ensure the presence of panel members with first-hand experience of the highest quality research of this kind. There is a similar need for peer reviewers experienced in IDR in the assessment of proposals submitted to funding bodies.

Quite apart from the utilitarian pressures on research funding and assessment that may disadvantage IDR, there are structural obstacles within academic institutions. Classic studies of the development of 'disciplines'[33] point to their multiple constituents: subjects,

[32] https://www.dur.ac.uk/hearingthevoice/
[33] Bender (*op cit*)

university departments, methodologies, communities, graduate formation, journals, conferences, learned societies, annual awards – all of which serve to maintain notional disciplinary boundaries. Scholars working within interdisciplinary programmes will transgress some or all of these disciplinary dimensions. IDR, by definition, works with these structures, which are foundational to academic activity. But without new and creative supporting structures to enable IDR, the external pressures to focus on imagined 'core business' will deter all but the most determined from deep engagement with other disciplines.

Structural solutions

An examination of the attributes and structures that compose a discipline soon leads the eye to the central structure of the academic department. These local communities of practice emerge organically through the flows of staff and students, hierarchies, annual cycles, budgets and representation within governing structures. They work very well, creating internal networks and presenting them to the external academic world. It is therefore natural to look for structures and processes that deliver the same advantages to interdisciplinary communities. Under the banners of 'institutes' or 'centres' devoted to interdisciplinary themes, they often succeed. But the way they are set up and their relation to traditional disciplines require careful thought and implementation if they are to work well.

Coherent or competitive?

There are many different models for interdisciplinary institutes, but most lie between two poles defined in terms of their relationships with traditional disciplines. At one end there is competition, at the other coherence. Alan Wilson was explicit in forecasting that new, vibrant 'interdisciplines' would displace the older, worn-out disciplines in a Darwinian view of an academic landscape in which they would simply be 'fitter'.[34] Such an underlying philosophy drives a directly competitive model for interdisciplinary institutes which, like academic departments, manage their own budgets, staff and salaries, hold research grants, and run graduate (and some undergraduate) programmes. Such a model has been widely adopted in universities in the USA, for example, by the University of Chicago, and in the Materials Research Laboratory at University of California, Santa Barbara (UCSB). These endeavours possess all the advantages of the traditional academic department, including the physical space and infrastructure, and a community undivided in their commitment to the interdisciplinary venture. There is a ready home to welcome visiting practitioners or scholars, and a tangible environment for a graduate community.

Where funding resources are ample, this model can work well, but where there is competition for scarce resources, setting up institutes on this basis can be problematic. Departments see their more energetic staff reassigned to a new institute; the teaching allocation for those who remain increases; departmental grant income goes down, and fruitful external collaborations move away with the transferred staff. These moves may set up major internal stresses and resentments, and have frequently proved fatal to the flourishing of the new venture. Disciplines and their communities are strong, and there are many ways of waging successful campaigns against such perceived campus pathogens.

[34] Wilson (1999)

The polar opposite is a model of interdisciplinary institutes that builds on a coherent and supportive view of their relationship to traditional disciplines and their departmental structures. In this case resources are much lighter: an institute's budget will typically not contain the salaries of its academic staff, and in terms of infrastructure may be entirely virtual. Researchers remain members of their home departments, where they are managed and where they perform most of their teaching. The institute's resources are focused on activities that assist collaboration between disciplines and their departments. Far from claiming a competitive position, such institutes support associated departments in the interdisciplinary activities that form part of their remit. For example, research grant income won by interdisciplinary teams may be attributed *pro rata* to their home departments. Where staff members dedicate large proportions of their time to the work of the institute (as directors, for example), their home departments may be allocated, from a central university budget, a compensatory amount to provide teaching relief. As long as arrangements for joint PhD supervision are already in place, this lighter structure can still furnish a strong graduate community whose natural home is the institute. In terms of physical presence, such institutes may require no more than an administrative office, relying on a web presence and using existing facilities for meetings, workshops and research work.

Alternatively, coherent institutes may present themselves spatially in much the same form as competitive ones. It is advantageous to dedicate some space to interdisciplinary institutes, not only – as noted above – in providing a symbolically alternative intellectual space, but also providing the institute with a tangible 'front door' to external engagement. The use of this space will typically be more flexible. Directors and their administrative staff can work in proximity, and 'hot-desking' facilities allow participating academic staff to spend time working within range of their colleagues, thus supporting the extended time required to build coherent interdisciplinary collaborations.

Perhaps the most notable advantage of allocated institute space is in support of research teams. Research grants for IDR are typically large, as they need to fund research fellows and/or students in several core disciplines at once. Early-career researchers will work much more productively if they can be housed together, rather than creating 'diaspora' in home departments and only occasionally meeting as a team. Flexible project space, including laboratory-standard space where appropriate, is therefore a highly desirable addition to the facilities of even an otherwise virtual institute.

Scale and starting up

We have referred to both institutes and centres as structures that can support IDR. Individual institutions will naturally differ in the terminology they apply, but our motivation for using two terms is that there are different scales at which it is appropriate to establish such initiatives. Some institutions adopt the terms so that centres tend to represent smaller, more focused research networks, often connected primarily in virtual form, while institutes are more likely to have more extended internal and external networks, and to be assigned physical spaces and administrative support. Institutes and centres have been successfully established in a number of focused areas. Examples include sustainability, hazards and risk, cancer and physics, integrative social sciences and humanities, and energy science and society. But how do interdisciplinary activities begin in the first place?

There is a need within the university structure for spaces and structures that support initial forays, tentative discussions, and the visits of scholars or practitioners from outside who can catalyse such discussions. There are alternatives to choose from here, as there are in the case of the more highly developed centres and institutes. 'Research hotels' or 'hubs' provide spaces that can be used by groups hoping to experiment with co-location outside their home departments. Their administration deals purely with finance and infrastructure. A separate committee is charged with allocating resources in response to applications.

A more managed approach to the initiation of IDR, but one that allows for free self-determination of new research directions as well, is found in the idea of a university-based 'institute of advanced study' (UB-IAS)

Institutes of advanced study

A UB-IAS typically runs a mixed portfolio of activities. Most have administrative support and some percentage of the time of a (varied) number of senior academic staff with experience of IDR, who facilitate its programmes. It will typically have dedicated space, or even a building of its own, even when it runs a 'coherent' relational model to university departments.

A UB-IAS typically combines the 'research hotel' model – funding visiting fellows to stimulate thinking around themes and sub-themes – with research programmes that resonate with expertise within the university, and can attract external funding. The mix of providing resources and services to academics within departments, and at the same time presenting them with 'disruptive' challenges to engage in unfamiliar research contexts and deploy their theories and methodologies in new ways, are essential to the healthy life of a university-based institute of advanced study. Similarly, the host university and its IAS must be clear about what constitutes success, especially as the activities supported may be rich and varied. Success in IDR may appear at any stage, demonstrated in innovative approaches to research questions; the development of new methods and forms of analysis; the production of findings that could not have been achieved within single disciplines. These might be communicated through public lectures, policy forums, media events, and the production of collaborative volumes – all these and more are important aspects of what an IAS can provide. However, these activities should support, but not obscure, the primary aim of planting and nurturing within the university long-term and radical programmes of IDR that draw on its intellectual strengths, and connect with wider academic networks, research users and public audiences in creative and sustainable ways.

In the UK, institutes of advanced study providing the space and resource that healthy IDR requires can be found in an increasing number of universities, including Durham, Oxford and Cambridge, the University of London, Bristol and more recently Birmingham. In the USA, one of the most longstanding international examples is the Institute of Advanced Study in Princeton, and other IASs in the US have been discussed in a previous article in this series.[35] The number of universities with an IAS has also increased internationally, with examples including the University of Freiburg, University of British Colombia; Universidade De São Paolo; Fudan University, Shanghai, and Nanyang University in Singapore. While these institutions differ in the details of their programmes and funding models, they share the

[35] Taylor (2013)

conviction that fruitful IDR requires significant time, an element of separation from 'normal' academic processes and space for open-ended research conversations.

A North-European example

Durham University established an Institute of Advanced Study in 2006 with a remit, above all, to foster interdisciplinary research 'transforming the way we think'. The IAS is positioned both intellectually and administratively outside the university's three faculties and their departments. It therefore has a strong measure of independence, and this is emphasised in material terms, as the institute is located in its own building, Cosin's Hall, which provides a physical as well as symbolic space beyond everyday norms. Its academic staff retain posts within their home departments, but Cosin's Hall provides a place where they, as well as the interdisciplinary research teams and visiting fellows involved in the institute's activities, can congregate and work together. Thus its interdisciplinary activities literally require people to step out of their everyday departmental contexts and into a space where the normal rules of disengagement do not apply, while ensuring a continual flow of ideas between the temporary institute communities and the university departments. This represents by no means the only way of driving IDR within a university, but some details of its operation will exemplify the points we have covered.

The Durham IAS also constitutes an effort by the university to engage with wider international research networks. Each year, it focuses on a broad research theme, with recent examples including *Water, Time, Light* and *Emergence*. An international fellowship scheme brings scholars from around the world to work together and with Durham researchers on this theme. The IAS supports and facilitates this process in a variety of ways, with research workshops, seminars, public lectures and informal discussions. IAS fellows all become part of a long-term network – an international College of Fellows – and many continue to collaborate with Durham scholars after they have returned to their own institutions.

There are other potentially supportive elements. For example, collaboration across disciplines is advantaged by the university's collegiate system. This provides excellent opportunities for cross-disciplinary conversations as well as enabling the social relationships foundational to successful collaboration. Colleges also help in a very practical way by hosting visiting fellows, which helps to integrate them with the wider academic community.

The IAS often works in partnership with the university's more specialised research institutes and centres: for example, the Hearing the Voice project (Box 3) emerged from close work with the Centre for Medical Humanities. A recent musical, historical and archaeological project*, In St Cuthbert's Time,* entailed collaboration with the Institute for Medieval and Early Modern Studies, and several projects (on the use of biofuels, on micro-hydro electricity generation and on fracking) have benefited from partnership with the Durham Energy Institute and its experience in bringing technical and social sciences together.

Under the umbrella of its annual research theme, the IAS undertakes to bring its IDR to academic and public audiences, and to policymakers. The institute therefore organises

approximately 80 public events a year, including several major public lectures, media engagements and London events such as panel discussions with leading intellectuals (most recently on topics such as democracy and species extinction). It also engages with local and regional organisations, as research partners and as avenues for the dissemination and use of research findings.

The IAS has recently introduced activities designed to extend its capacities to facilitate interdisciplinarity. A one-day introductory workshop brings each cohort of visiting fellows together with Durham scholars to carry out a series of innovative exercises designed to tackle the challenges of interdisciplinarity and open up the potential for creative conversations about the current research theme. This deliberately disrupts conventional discourses by requiring participants to represent research and collaboration in new ways. The workshop recognises the importance of social interaction in forming new disciplinary constellations and research communities, and a similar approach is being deployed in developing a series of practical activities designed to support the initiation and development of IDR projects. The IAS is also establishing an informal interdisciplinary network to tackle more advanced and complex issues over time; to enable researchers to exchange notes and seek advice; and to provide the university with a feedback mechanism on the efficacy of its support for interdisciplinary activities.

The future for IDR

The future development of IDR in our universities and wider communities will be fascinating as it unfolds – and there are indications that the reintegrative and transformative processes we have identified and discussed are far from complete.

The international dimension unlocked by the combination of support for IDR and the growth in global networks of universities and their partners, promises to bring more diverse cultural perspectives to research questions that are already extending beyond disciplinary boundaries. The urgent topics of disaster resilience and recovery, food security, land- and water use, for example, have yet to enhance their interdisciplinary efforts with genuinely transcultural approaches. Building research teams across continents and cultures is an exciting future prospect.

The culture change and methodology of IDR are currently located primarily in the post-doctoral academy, but there are promising indications of the benefits of graduate, PhD-level training in an interdisciplinary context. Fears that the acquisition of deep expertise in a single discipline will be diluted at this early stage of an academic career do not materialise if PhD students work in mentored interdisciplinary teams which share the integrated structures we have characterised as supporting high-quality IDR. There is increasing evidence that similar advantages may also apply at the undergraduate level, if exposure to interdisciplinary thinking is delivered at the right level.

Further reshaping of the disciplinary landscape must follow the cultural changes in thinking and the new collaborative relationships that IDR initiates. While mechanisms of review, assessment and governance may be slow to catch up, the acceleration of IDR's fluidity and reach, and its transformational effects on research, will change the way that universities and scholarly networks operate and engage.

Concluding thoughts

Our key messages, which we hope have been highlighted within this paper, are as follows:

- IDR needs to be foundational to academic practice rather than additive.
- The best IDR requires both structural support and deep cultural change within an academic institution.
- Leading such change requires awareness of the nature of disciplinary communities, their values and boundaries.
- IDR is best fostered by a participatory model of leadership.
- Interdisciplinary environments need deliberate planning, establishment and resourcing.

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Biographies

Professor Tom McLeish, FRS

Tom McLeish did a first degree in physics and PhD (1987) in polymer physics at the University of Cambridge. After lecturing in physics at the University of Sheffield, building a group working on the theory of dynamics of complex fluids, he took the chair in polymer physics at the University of Leeds in 1993. He has since won several awards both in Europe (Weissenberg Medal) and the USA (Bingham Medal) for his work on molecular rheology of polymers, and ran a large collaborative and multidisciplinary research programme in this field from 1999 to 2009, co-funded between the EPSRC and industry.

From 2000 to 2005 he was a Senior Research Fellow of the EPSRC (UK), and from 2003 to 2009 Director of UK Polymer IRC, a multidisciplinary consortium of over 100 polymer scientists from university and industry. From 2004 to 2008 he was also Director of the White Rose Doctoral Training Centre in Biomolecules and Cells. He has consulted for a number of chemical industries.

His research interests include: (i) molecular rheology of polymeric fluids); (ii) macromolecular biological physics; and (iii) issues of theology, ethics and history of science. He has published over 180 scientific papers and reviews, and is regularly involved in science-communication with the public, including lectures and workshops on science and faith. In 2014 OUP published his most recent book, *Faith and Wisdom in Science*.

In 2008 he was appointed Pro-Vice-Chancellor for Research at Durham University. In 2011 he was elected a Fellow of the Royal Society. In 2012 he was made Vice-President of Science by the Institute of Physics (IoP).

Professor Veronica Strang

Veronica Strang did a first degree in Design and Art History (1978) and a DPhil in Anthropology at the University of Oxford (1995). After three years with an interdisciplinary research team at Oxford's Environmental Change Unit (while also teaching at the Pitt Rivers Museum) she moved to the University of Wales to establish a new department in Anthropology. In 2000 she was awarded a two-year Royal Anthropological Institute Fellowship, then took up a Chair at Auckland University of Technology, heading up an interdisciplinary School of Social Sciences. In 2005 she was appointed Professor of

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Her research interests focus on diverse cultural engagements with water, land and resources, primarily in Australia, New Zealand and the UK. Her publications include *The Meaning of Water* (2004); *Gardening the World: Agency, Identity and the Ownership of Water* (2009) and *Ownership and Appropriation* (2010). She has just completed a book for Reaktion Press, *Water: Nature and Culture,* and is currently working on two interdisciplinary endeavours: a history of cultural beliefs in water beings; and a project developing a new interdisciplinary approach to river catchment research.

Since 2006 Veronica has been involved with Unesco's interdisciplinary International Ecohydrology Programme, and in 2007 she was awarded an International Water Prize as one of Unesco's, *Les Lumières de L'Eau*. In 2013 she was elected Chair of the Association of Social Anthropologists of the UK and the Commonwealth.