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Experiments in interdisciplinary capacity-building

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Abstract

Research funding agencies in many countries support interdisciplinary collaboration in order to tackle the 'grand challenges' facing societies worldwide but there is uneven guidance as to its effective conduct: different kinds of interdisciplinarity require different approaches and there is no single model for success. Moreover, 'problem-solving interdisciplinarity' often runs contrary to academic conventions, structures and norms which are still predominantly discipline-based. The stability offered by public investment over the longer term may offer advantages for the personal research and publication strategies of interdisciplinary researchers. Support for relationship-building with a range of stakeholders through this type of research may also lead to a greater likelihood of research impact beyond the academy. The benefits of such experiments in research capacity-building can be both intellectually rewarding and confer added value to public investments by encouraging significant social and economic returns.

Keywords: Interdisciplinarity, capacity-building, research policy

1. The institutional context for interdisciplinary research

Interdisciplinary research[1] is increasingly called upon to generate innovative solutions to complex, multi-dimensional, policy-related problems. The ability of large-scale research programmes to deliver solutions to such challenges requires integration across disciplines. However, such problem-solving, interdisciplinary research often flies in the face of discipline-based academic conventions, structures and norms. The US National Academies and the UK Research Councils, amongst others, have recognised these challenges as they exhort institutional structures to change so that interdisciplinary research capacity can be developed. Many countries' research funding organisations now support funding schemes that require interdisciplinary collaboration but there is uneven guidance on the effective conduct of such research. Many researchers are finding themselves part of interdisciplinary teams working on major national or international projects, or are finding that the orientation of sources of funding for PhD research projects and beyond is increasingly interdisciplinary.

In Britain, Research Councils UK (RCUK) sees interdisciplinarity as a goal, recognising that research is critical to solving 'grand challenges' and that increasingly the solutions 'will require work across boundaries, crossing disciplines, and borders between nations'[2]. Examples of RCUK interdisciplinary programmes, each supported by multiple funding bodies (**Table 1**), illustrate the weight of investment that has been put into interdisciplinary research in the UK in recent years. In addition, individual Research Councils also support bi- and tri-lateral funding schemes, some of which are described elsewhere in this issue (for example, O'Brien et al. and Lyall et al. *this issue*).

Table 1 RCUK investments in interdisciplinary research (2008-2011)

Programme title	Programme funding	Lead Research	Research Council partners

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[1] There are many definitions of interdisciplinarity. For a further discussion, see Lyall et al. 2011b.
[2] http://www.rcuk.ac.uk/international/strategy/Pages/home.aspx (accessed 23/05/12).

		Council	
Ageing: Life long Health & Wellbeing	£486m	MRC	EPSRC, BBSRC, ESRC, NERC, STFC, AHRC
Living with Environmental Change	£363m	NERC	EPSRC, BBSRC, ESRC, STFC, MRC, AHRC
Energy	£319m	EPSRC	BBSRC, ESRC, NERC, STFC
Global Uncertainty: Security for All in a Changing World	£114m	ESRC	EPSRC, BBSRC, NERC, STFC, MRC, AHRC
Digital Economy	£53m	EPSRC	AHRC, ESRC, MRC
Nanoscience through Engineering to Application	£51m	EPSRC	BBSRC, ESRC, NERC, STFC, MRC

http://www.rcuk.ac.uk/documents/international/RCUKpresentationJuly2009.pdf (accessed 27/2/12)

This is an international phenomenon and there have been long-standing calls from national and supra-national funders (e.g. European Commission, 2007; ESRC, 2009b; NSF, 2006; National Academies, 2005; Barry, 2007; Lok, 2010) for interdisciplinary research, including collaboration between the social and natural sciences, as a means to promote scientific and technological advance (resulting in innovation-led economic competitiveness) and to foster its more effective acceptance and beneficial utilisation in society. There is, however, little consensus about how this can be achieved in different settings.

Many others have offered definitions and explanations of interdisciplinary research (e.g. Frodeman et al., 2010; Lyall et al., 2011b). What we would stress here is that interdisciplinary research does not occur automatically, even when public funding encourages it. It is not a simple case of aggregating several disciplines into one research project. Extra effort is needed to achieve the promise of synergy and to form a genuinely cohesive team which combines expertise from several specialisms. Yet, the sustained development of strategies to help researchers understand *how* to collaborate effectively and integrate soundly across different domains remains a key research gap (Bammer, 2008) and the publication culture on integration is poorly developed (Hirsch Hadorn et al., 2010). There are practical organisational steps that current and future large-scale, interdisciplinary research initiatives could take to promote and support collaborative working and integration. Awareness of these critical processes can benefit funders as well as practitioners if interdisciplinary research is to achieve its potential and justify public investments. This is especially important when public funding for research comes under pressure in times of recession, where there is the additional risk that such research may be seen as discretionary and expendable[3].

Integrative research requires a fuller understanding of interdisciplinarity and its relationship to the vital underpinning role played by disciplines. Disciplines, or perhaps more accurately sub-disciplines or schools of analysis, have resulted in stable epistemic communities within which researchers concentrate their experience into a particular worldview. This has benefits in terms of the efficiency of communication and interaction within the disciplines (including quality assessment and the verification of knowledge claims). However, it can

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[3] Or where the scale of funding may be pared down, resulting in shorter-term projects which allow insufficient time and resources for adequate interdisciplinary integration.

place serious limits on our research horizons by restricting the kinds of questions we can ask, the methods and concepts we use, the answers we believe and our criteria for truth and validity (Klein, 1990).

The work of Gibbons et al. (1994) and Nowotny et al. (2001) suggests that new relationships are emerging between discipline-based and interdisciplinary research, between 'basic' and 'applied' research. It has been argued that we now need to move beyond the 'Mode 2' model into a 'third wave of interdisciplinarity' where contemporary knowledge production involves, not only a horizontal axis stretching across academia, but also a vertical axis integrating academic research into society (Frodeman and Mitcham, 2007; Spinardi and Williams, 2005), linking integration and implementation (Bammer, 2012). This interlinking of interdisciplinary research and knowledge exchange with non-academic audiences is exemplified by, for example, the UK's Rural Economy and Land Use (Relu) programme and by the ESRC Genomics Network[4]. This approach is described by some scholars (e.g. Pohl, 2008) as 'transdisciplinarity' although this term does not currently have much currency within UK research policy[5].

Distinctions should also be drawn between long-term, interdisciplinary involvement for 'academic' reasons (to enable a discipline to move into new areas of research) and the shorter-term, situational interest where the primary aim is problem-oriented and discipline-related outputs are less central to project design (Lyall et al., 2011b; Bruce et al., 2004; Tait et al, 2002; Lattuca, 2001, p.217). Put another way, we need to balance the value placed on the 'scholarship of discovery' with the growing importance placed on the 'scholarship of integration' (Lattuca, 2001, p.263) and, increasingly, the scholarship of application as greater emphasis is placed on the processes of research impact and knowledge exchange (e.g. ESRC, 2009a).

Interdisciplinary interactions are clearly transforming the natural sciences and the social scientists who engage with them but there can be real challenges in forging synergies across disciplines (Greaves and Grant, 2010). Interdisciplinary integration rarely happens spontaneously: effective interdisciplinary research has to be catalysed, planned and continuously revisited (Lyall et al., 2011a). There is still much to learn in order to avoid 'naïve borrowings' of terms and methods (Lowe et al., 2009) and this requires better understanding by those working in and leading interdisciplinary teams and those funding such activities.

A crucial factor in shaping interdisciplinarity is the institutional context for science: as well as the obvious barriers to communication between different specialisms, university-based interdisciplinary researchers encounter multiple institutional barriers (Kahn, 2011; Klein, 2010). For example, the structure of, and relationship between, the disciplines is strongly influenced by national funding regimes (Lowe and Phillipson, 2006; 2009). Not only do these institutional relationships recreate disciplinary divides, they also form the rules, priorities and reward mechanisms that set the scope for both mainstream research and boundary-transgressing endeavours. Viewed from this perspective, understanding the nature of interdisciplinarity can illuminate allocative rules and agenda-setting mechanisms of research funding organisations. However, we know that financial incentives are important

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[4] www.relu.ac.uk; www.genomicsnetwork.ac.uk
[5] See Lyall et al. (2011b) pp. 172-180 for a further discussion of transdisciplinarity in different international contexts.

but not sufficient to cause lasting change within institutions (Sa, 2008). Ostrom observes (2005:3) that 'particular combinations of rules affect actions and outcomes in a particular ecological or cultural environment, rule changes may produce unexpected and, at times, disastrous outcomes'; policy-makers, funders and university leaders who shape the rules need a more effective understanding of these interactions if they want to achieve their goals.

2. Integrative approaches and boundary spanning

Effective interdisciplinarity calls for greater reflection (and greater effort) by those involved. These challenges also need to be addressed by research funders and senior university research leaders if individual researchers and centres are to build effective and successful interdisciplinary research programmes (Rhoten, 2004). In particular, institutions may need to develop more effective research leadership in order to grow the necessary talent to develop teams of experienced, interdisciplinary researchers who can, in turn, nurture interdisciplinary research capacity in future generations.

While disciplines can limit what we are required to know, they can also limit the questions we are expected to ask: shaping multi-faceted problems to fit narrow disciplines is not a very rewarding or creative approach. Interdisciplinary researchers therefore need to learn to cope constructively with a high degree of complexity in order to bring in knowledge from a wider range of disciplines and, potentially, knowledge that is not codified in terms of disciplines. One of the most important skills in interdisciplinary research is the setting of a constructive but manageable boundary around the research area. In the current stage of understanding of some emerging interdisciplinary research areas there are few guidelines that can help in this process and it is still largely regarded as a craft skill, best learned as an apprenticeship with an experienced interdisciplinary researcher.

Within this interdisciplinary research system, the increases in funding referred to in Table 1 are beginning to reshape the structure of, and relationship between, the disciplines (Lowe and Phillipson, 2006; 2009). The promotion of interdisciplinarity can be undermined if we fail to appreciate its contingent, institutionally dependent existence. Barry (2007) describes how such interdisciplinary research institutions 'often have a fragile existence, dependent on political circumstances, or on the patronage and energies of key individuals.' From a UK perspective, as Lowe and Phillipson (2009) explain, the challenge of working across disciplines 'is much more than about disciplinary barriers and crucially implicates the decisions, processes, and structures of research-funding organisations.'

3. Lessons for future large-scale interdisciplinary initiatives

In this special issue, authors describe a number of initiatives that have attempted to support positive incentives to undertake interdisciplinary research and to counter the disincentives that are still in evidence in all countries with strong publicly-supported research programmes. Through our own association with the UK Economic and Social Research Council (ESRC) Genomics Network, we have gained extensive experience of advising on and doing interdisciplinary research in both academic and consultancy contexts and now have a substantial track record in the evaluation and analysis of interdisciplinary research, as well as in the facilitation of interdisciplinarity and the training of early career researchers (see, for example, Lyall et al., 2011a,b; Lyall and Meagher, 2012; Lyall et al., 2009).

When developing an overarching strategy for an interdisciplinary research group or unit within an academic setting, this experience has taught us that consideration should be given to what motivates the researchers undertaking the work.   Interdisciplinary research can be geared towards advancing the knowledge base and/or tackling practical problem solving. The temporal dimensions of these two approaches (intrinsic knowledge or practical goals) also need to be considered in order to maximise the opportunities for advancing understanding by building synergies between what might otherwise appear to be one-off, problem-focused engagements. If interdisciplinary encounters remain narrowly pragmatic there is a risk that constant shifts in application areas between practical interdisciplinary enquiries will reduce the scope for expertise to accumulate (although the researcher will gain expertise in managing interdisciplinary projects per se). The learning costs will be high if the academic unit's strategy is based solely on a series of short interdisciplinary projects. It is therefore important to make sure that new knowledge and techniques are acquired in a cumulative manner, allowing individuals and centres to develop and demonstrate their capabilities in order to off-set these learning costs.

Interdisciplinary collaborations may fail when there is a lack of understanding of the roles that the contributing disciplines can play. This can lead to unrealistic over-expectations or a trivialised view, for example, of the role of the social sciences within an engineering-led project. The problems of collaboration are amplified where different research cultures have essentially incompatible approaches to research collaboration, funding and management. The clear advantage of a longer-term investment in interdisciplinary research is that it allows time for relationships and trust to build, enabling such possible obstacles to be overcome.

Research leaders need to be clear about their multiple goals and play a 'multi-level game' (Lyall et al., 2009) in order to satisfy a number of stakeholders including the sponsor, the parent institution, the research unit's objectives and the personal goals of the diverse researchers involved. Persistent (and well-rehearsed) institutional factors discourage interdisciplinary research, such as a lack of opportunities to publish in high-ranking, refereed journals and discrimination by referees against interdisciplinary proposals and publications. An individual researcher, or academic research unit, risks being reduced to a service or subordination role (Barry et al. 2008) where they provide specific, well-defined inputs (e.g. data sets, tools) to another domain without the need for significant interdisciplinary interaction or contribution to advance their own core knowledge. Research active staff may migrate away from such collaborations if they are not seen to benefit their own research. This means that long-term interdisciplinary researchers need to plan their personal development more carefully than colleagues with more conservative career paths. They may consequently need better mentoring so that they both respond to sponsors' requirements but also think strategically about their own personal research and publication strategy.   The stability offered by funding over the longer term can enable early career researchers to develop successful strategies for their interdisciplinary careers (e.g. Pfirman and Begg, 2012; Lyall et al., 2011b chapter 6).

In order to avoid becoming a 'nexus of loosely connected individuals' (Rhoten 2004), interdisciplinary research leaders should consider how best to define and create the unit's identity while at the same time maintaining individuals' intellectual flexibility. They should probably resist the temptation to encompass 'everything' but will need to negotiate multiple identities and roles in order to establish a common purpose. Adopting a multi-stranded research strategy can provide this flexibility within an overarching framework which helps to give a sense of identity or 'brand' to an interdisciplinary research unit.

In seeking to achieve this, it is worth considering that the different stakeholders in the interdisciplinary research unit may be motivated by different incentives and rewards. This will need to be factored in to the strategy for developing and sustaining that unit. Involvement in such a 'pioneering' research centre may bring individual academics greater recognition and enable them to engage more widely with other researchers and potential research users with consonant interests. But there may be issues to resolve regarding institutional governance structures to ensure that they are not disadvantaged, for example, by traditional, discipline-based promotion criteria.

The unit itself may be able to achieve a greater profile both internally within the parent institution and externally with research funders and research users (academic and non-academic). This can increase credibility with partners, particularly if the unit can achieve a degree of financial independence which will both enhance its intellectual flexibility and improve its chances of long-term influence and impact. Relationships with others, including potential sponsors and research users, can be enhanced if it is possible to support core staff with responsibilities for supporting communications, knowledge exchange and research development who are able to undertake relationship building.

The host university and various parent departments will also have a stake and may be more supportive if they can be persuaded that the return on investment may include access to new revenue streams, greater potential for innovative thinking, and wider engagement, which in turn may broaden the host institution's public profile. But tactics for strengthening institutional support can be problematic when, for example, the rhetoric of interdisciplinarity clashes with the reality of discipline-based governance structures within higher education institutions.

If the right balance can be achieved, then interdisciplinary research centres provide opportunities for knowledge-led collaborations which result in a 'win-win' situation: advancing knowledge and solving social problems through sustained engagement which in turn may develop into new interdisciplinary domains. As the articles in this special issue demonstrate, despite the challenges, such experiments in research capacity-building can be both intellectually rewarding and confer added value to public investments by encouraging significant social and economic returns.

4. Introduction to special issue

This special issue reports on the experiences of several large-scale, long-term interdisciplinary collaborations which have had significant global reach and impact. Individually, these papers offer conceptual and analytical advances as well as policy insights, crucially grounded in empirical study. Collectively, this series of papers aims to exploit this wisdom of practice, promote organisational learning and draw transferable lessons of relevance to new interdisciplinary programmes.

The work on which we report analyses the dynamics of interdisciplinarity within the research arenas of innovation studies and science and public policy. Competent interdisciplinary research needs to be intellectually stimulating as well as integrative of disciplines. It may also be intellectually original in policy terms as discussed in many of the articles that follow. Each of these papers offers original findings on substantive research issues related to these themes and reflects on the various experiments in interdisciplinary practice that underpinned

the research. Collectively, the papers will make a theoretical contribution to our future thinking about interdisciplinary capabilities and practices.

One of the unifying themes of the papers that follow is the capacity to govern new technology (both nationally and on the global stage) and the refinement of new governance approaches to appropriate stakeholder engagement. Our authors report on the outputs of interdisciplinary research and the practices and processes from which these outputs derive. It has not been the intention of this issue to preoccupy itself with the semantics or typologies of interdisciplinarity. We tend, following UK practice, to use the term "interdisciplinarity" to describe research that integrates across disciplinary boundaries and "knowledge exchange" to describe processes of engaging with external audiences. Others (e.g. Maasen et al, 2006 in a previous issue of *Science and Public Policy*) use "transdisciplinarity" to encompass both processes but this is not a term that is greatly used by the research communities with which we work. O'Brien et al. come closest to using this approach when they describe their research on "participatory interdisciplinarity".

As we outlined above, research funding agencies in many countries are investing significant amounts of money in interdisciplinary projects because it is seen that such research is necessary to address complex global challenges. The stability offered by public investment over the longer term can support relationship-building with a range of stakeholders which may lead to a greater likelihood of research impact beyond the academy. The benefits of such experiments in research capacity-building can be both intellectually rewarding and confer added value to public investments by encouraging significant social and economic returns. All of the authors have conducted this type of problem-focused research and are able to reflect on the practical challenges faced in the course of such research. For example, Huzair and her co-authors address the problems of achieving knowledge translation in rapidly changing situations with incomplete information and asymmetries in the equality of participation; O'Brien and her co-authors describe the protracted timescales required to develop the necessary trust between different groups of stakeholders in order that their participatory work could progress. As Lyall et al. conclude, successful interdisciplinary research programmes necessitate additional resources (both human and financial) and careful management if they are to achieve long-term success.

The papers that follow evince theoretical and methodological innovation as well as demonstrating the wide range of policy outcomes and impacts that can arise from interdisciplinary collaborations. Mastroeni et al. describe two different interdisciplinary approaches that they have devised to analyse European policies for 'smart specialisation' designed to foster the development of the bioeconomy at both national and supra-national levels. Wield et al. continue this connection with the growth of technologically innovative bio-industries in describing the ESRC Innogen Centre's work in three fields: food and energy, translational medicine and global health innovation. These authors argue that insights from social theories of the life sciences, innovation processes and the regulation of science and technology must be integrated in order to fully analyse such developments.

In their article, Harmon et al. assess the evolution of new governance systems for biobanks, such as the 'benefit sharing' approach of Generation Scotland, and call for the establishment of more such interdisciplinary governance regimes. Castle and Culver use the empirical example of aquaculture in Canada to outline how a method of contested exchange – discussions with interdisciplinary and inter-sectoral groups that involve continuous disagreement about a specific topic – may contribute to improved understanding in complex

policy areas, and therefore function as an alternative to more conventional engagement exercises.

Huzair et al. consider two case studies of knowledge translation in developing countries – AIDS vaccine trials and the harmonisation of biosafety systems in Africa – to analyse how sustained involvement in a research programme by stakeholders can put knowledge exchange at the core of interdisciplinary research programmes. O'Brien et al. elaborate further on the processes of stakeholder engagement with their concept of "participatory interdisciplinarity" in an article that compares two interdisciplinary projects - one on deer management and the other on the prevention of Lyme disease - which were part of the RCUK's Rural Economy and Land Use (Relu) programme

The final capstone article by Lyall et al. forms part of a growing literature on the strategic management of interdisciplinary research. Focusing on the practices and processes of interdisciplinary research rather than its outputs, the authors draw on the results of a commissioned study to provide practical guidance to funders and leaders of large-scale interdisciplinary projects who seek to develop a vibrant and stable community of interdisciplinary programmes and researchers. These authors highlight the role of funding bodies in shaping and supporting interdisciplinary programmes and the benefits that can accrue from continuity of funding. Such sustained interdisciplinary capacity building can be key to success in engaging with non-academic stakeholders, as outlined by Huzair, O'Brien and their co-authors; in establishing the robust institutional relations necessary to influence policy and governance in the ways described by both Castle and Culver and Harmon et al; and in promoting responsible innovation as addressed by Mastroeni and Wield and their co-authors.

Underpinning all of the research successes described in this issue is the prerequisite to maintain interdisciplinary scholarship, institutions and spaces (both in physical terms but also the 'intellectual space' afforded by favourable career structures). Interdisciplinary areas of scholarship cannot thrive without such provision but the combination of these three elements is hard to sustain within the context of a publicly-funded research system. The difficulty of achieving funding at the start of a new venture often accounts for the major problems of building interdisciplinary activity. Money may be injected at one level (usually programme funding for groups of researchers to work on a particular topic area) but such backing may not automatically bring institutional support, at least in the short term. Disciplinary activity usually has established space and institutional support within universities (and often defends them vigorously). New and emerging areas of interdisciplinary research take time to garner investment across these three levels (physical, institutional, and intellectual) and may, ironically, begin to look more like disciplinary areas as they mature: the challenge here is to retain interdisciplinary capacity without limiting researcher mobility and the renewal of research agendas.

Without such support it is hard to achieve major advances in scholarship towards addressing some of the complex, multi-factorial problems that we face, such as climate change or poverty alleviation. These types of research challenges require both interdisciplinary vision to integrate knowledge from different sources (both theoretical and practical as described above) and appropriate research infrastructure (including interdisciplinary journals, conferences, teaching programmes, and physical spaces designed to facilitate interaction). Such interdisciplinary capacity-building calls for sustained public investment over the long term.

Acknowledgements

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