Interdisciplinary Research: A Review of Contextual and Process Factors

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ABSTRACT

This review paper considers the drivers that explain recent calls for interdisciplinary research, and the barriers that can obstruct such projects. We consider the barriers that potentially obstruct successful interdisciplinary research in two classes: those that have an impact on the establishment (or otherwise) of such projects; and those that affect such projects once they are established. Given the considerable learning and knowledge generative potential of interdisciplinary research, our aims here are twofold. First we aim to provide a review of contextual and process factors that is of immediate utility to others seeking to study (or enact) such research projects and initiatives. Second, we aim to identify theoretical and empirical lines of investigation for future research in this area.

Keywords: individual learning; organisational learning; group processes; organizational culture

Interdisciplinary research (IDR) has attracted a considerable amount of attention from both academia and policy makers for a number of years, as evidenced by a number of studies and reports encapsulating its benefits and challenges (e.g. Sung et al 2003, CoFIR 2004, EURAB 2004). This trend has continued in recent years, with the establishment of new interdisciplinary (ID) courses, research centres and programmes (e.g. Eagan, Cook & Joeres 2002; Aboelela et al 2007), building on policies and funding structures that encourage cross-disciplinary collaboration (Sanz-Menéndez, Bordons & Zulueta 2001). The trend for the development of IDR seems understandable as addressing increasingly complex socio-environmental problems often involves expertise from many fields of knowledge. Such problem-oriented collaboration, across multiple fields, has considerable potential to support both inter-organizational learning and the generation of new knowledge (Hibbert & Huxham, 2005; Ingram 2002).

If IDR undoubtedly has significant potential for learning and knowledge development (as evidenced in some successful initiatives – see Eagan et al 2002, Sanz-Menéndez et al 2001, Sjolander 1985), the complexities, benefits and problems associated with IDR are still not well characterised and thus its full possibilities are yet to be realised. In particular, in order to understand and support its
generative potential, there is a need to integrate and develop research insights about the process and practice of IDR, in three particular areas. First, there is a need to look behind common-sense notions about the benefits of IDR by considering the drivers that promote this kind of work in a clearer conceptual framework. Second, there is a need to develop an integrated picture of the barriers to IDR to begin to reveal why getting such initiatives started may be problematic, despite its evident potential. Third, there is a need to consider the process issues that can still impact on the success of an IDR project once it is underway. Accordingly, the remainder of this paper addresses each of these three areas in turn, followed by brief concluding discussion outlining future research directions.

**Key Drivers: Why Get Started with IDR?**

The process of constant fragmentation, recombination and hybridization of disciplines is often considered as one of the mechanisms for accelerated growth in interdisciplinarity (Dogan 1996; Klein 1990; Morillo, Bordons & Gomez 2003), but more generally the literature suggests three categories of drivers for IDR: **complexity and applicability**, **productivity and creativity**, and **knowledge development**. Each of these is discussed in detail below, followed by a consideration of more pragmatic factors.

*Complexity and Applicability*

This category of drivers is the most fundamental class, particularly in relation to policy contexts, and comprises two overlapping themes of complexity and applicability. The former one asserts that “real-world problems do not come in disciplinary-shaped boxes” (Jeffrey 2003:539) and often require cross-disciplinary knowledge integration to be resolved (Klein 1990; 2000). This is evidenced in: business and socio-economic issues such as poverty, global trade and innovation (Aram 2004; Gibbons & Novotny 2001; Lawrence & Després 2004; Pettigrew & Knight 2007); public management fields such as health care (Aboelela et al 2007) and environmental studies (Lawrence & Després 2004); or in areas of science (Welsh, Jirotka & Gavaghan, 2006).

The intrinsic complexity of many problems is also exacerbated by the range of different stakeholder interests and the breadth of actors involved in any particular issue context (Horlick-Jones
& Sime, 2004). As Nowotny, Scott and Gibbons (2001) put it, scientific research and its social settings are interdependent – and the latter undermines perceived disciplinary boundaries and homogeneity. They therefore suggest that this necessitates research focussed on the production of more socially robust, epistemologically eclectic and highly contextualised knowledge. Thus the increasing complexity of both the modern world and science itself leads to increasing calls for knowledge unification. For example, Kafatos and Eisner (2004) conclude that biological knowledge domains, if isolated, cannot deliver on the full promise of biology. Similarly, Balsinger (2004) following Nowotny et al (2001), concludes that increasing interaction between science and society can signal the emergence of contextualised, as opposed to compartmentalised, science.

This recognition of the innate complexity of ‘real world problems’, and the stakeholder connectivity necessary to the development of contextualised and relevant research output, leads to the second overlapping theme in this group of drivers – namely applicability. Following the work of Gibbons, Limoges, Novotny, Schwartzman, Scott and Throw (1994), a number of authors started to call for a more relevant type of academic research, referred to as Mode II (Pettigrew 2001; Starkey & Madan 2001; Tranfield & Starkey 1998; van Aken 2001, 2004). This kind of approach seeks to acknowledge that the knowledge arising from complex research contexts cannot be simplistically reduced to disciplinary concepts, and thus bears the hallmarks of IDR (Balsiger 2004; Gibbons et al 1994; Weingart 2000), with the additional requirement that the ‘exploitation of knowledge requires participation, in its generation, discovery and application are more closely integrated’ (Klein, 2000:14). This kind of approach suggests that IDR necessarily undermines the relevance and importance of disciplines. However, Bruce et al (2004) suggest that Mode I IDR, mostly focused on overcoming the blockages to further development within disciplines and explore new productive areas of research, can be considered as “one of the primary engines of the evolution of disciplines” (Bruce et al, 2004:460) and thus it should not be regarded as invalid.

Productivity and Creativity

IDR is frequently thought to be more creative, often leading to break-through ideas, new perspectives on research problems or new research questions, and even new fields. Where this kind of advance is
evidenced it may lead to shifts in intellectual perspectives and have an impact on attitudes towards IDR (Carayol & Nguyen Thi, 2005; Morillo 2003; Knight & Pettigrew 2007; Frost & Jean 2003, Gooch 2005), amplifying the support for this mode of research. As a neuroscientist in Gooch’s (2005: 188) paper explains, ‘It [collaboration among different persons from different disciplines] is advantageous because you have more brains to draw upon. The number of neurons firing increases. No two people see the problem alike; it’s like having a multi-faceted cube’.

Gooch (2005) further refers this kind of insight as “cortical depth of bench” or collective mind. More prosaically, Lukkonnen, Persson and Siverstein (1992) link increased efficiency to better access to resources, both information and equipment, whereas Pettigrew and Knight (2007:6-7) point out that successful collaborative research projects can also generate a range of ancillary benefits, including social and human capital in the form of new skills, relationships and trust; infrastructural capital and access to equipment, databases and methodologies; and perhaps even access to further research funding. However, the potential for creativity and productivity in IDR teams derives in part from the positive tension between different standpoints, which means that productivity in such situations should not be seen as a given; potential negative issues associated with process conflict can arise (Amabile et al 2001; Kochan et al 2003). Indeed, diversity in IDR can lead to increased creativity and breakthrough research results (Carayol & Nyugen Thi 2005; Morillo, Bordons & Gomez 2003) but also further enhancements within native disciplines (Bruce et al 2004; Frost & Jean 2003), however, if unattended and mismanaged, diversity can have adverse effects on creativity and group processes (Kochan et al 2003).

The debatable character of knowledge (and related) productivity gains from IDR also relates to academic publications. On the one hand, it has been suggested that interdisciplinary articles show higher citation rates and, therefore, researchers may enhance the impact of their research by exploring literature from other fields (Steele & Stier 2000). On the other hand, Carayol and Nguyen Thi (2005) found that publishing in other fields does not significantly increase one’s publication impact. Moreover, Luukkonen, Olle and Sivertsen (1992), following Price (1986), suggest that collaborative authorship is actually a result of economic rather then intellectual factors as co-authors try to compile a full paper from the fractional work of each contributor. However, this strategy bears additional, and
often overseen, coordination costs (Cummings & Kiesler 2007) and may also suffer from particular problems in evaluation and review processes, where inappropriately narrow review criteria can sometimes be applied (Boix Mansilla & Gardner 2003; Neiman 1999). Nevertheless the potential for knowledge development has become a key driver for IDR.

**Knowledge development**

Extant literature suggests that interdisciplinary knowledge is one of the main components of knowledge based society; by some, it has been seen as a rule rather than an exception and a focal point of interest for scholars, policy makers and practitioners (Aboelea et al 2007; Balsinger 2004; Carayol & Nguyen Thi, 2005; Duncker 2001; Gibbons et al 1994; Jeffrey 2003; Kafatos & Eisner 2004; Pettigrew & Knight 2007; Rhoten & Parker 2004). IDR is often characterised as leading to scientific advances (Bruce et al 2004) or break-through innovations (Morillo et al 2003). Furthermore, through novel approaches to questions, theories and generalisations it is argued to open up completely new frontiers of research (Marcina 1995; Pickett, Burch & Grove 1999) and new fields of knowledge (e.g. bioengineering, nanosciences). Mittelstrauss (1987 in Weingart 2000) notes that interdisciplinarity often starts by asking previously unasked questions in order to learn something that the discipline itself does not know. Such boundary crossing questions often have a personal, curiosity driven angle, as one realises the limits of ones own discipline (Aboelela et al 2007).

Personal motivation behind the conduct of IDR can go beyond intellectual curiosity as IDR can be (at least in part) driven by personal or career motives (Beaver 2001; Knight & Pettigrew 2007). However, there are two more substantive, knowledge-development drivers for IDR that have a degree of ‘personal’ character. First, a realisation of the increasing relevance gap, resulting from the compartmentalisation of scientific and professional knowledge, may lead individuals to undertake IDR as a reaction to these problems which are inherent in formal scientific enterprises (Rhoten & Parker 2004).

Second, personal motivations which mix knowledge development and career development have been evidenced, such as the potential for IDR to support the establishment of new perspectives and new theoretical frameworks (Knight & Pettigrew 2007); personal intellectual development (Frost
& Jean 2003); or the fact that IDR is simply more interesting and stimulating (Bruce et al 2004). In contrast, in some cases the motivation may be linked to easier access to funds (Schummer 2004) – a driver that can certainly advance one’s career but are not necessarily concerned with addressing IDR problems or progressing knowledge.

*Other – pragmatic – drivers*

The groups of drivers discussed above are key themes in the IDR literature. However, other drivers, not often reported directly in the reviewed literature, can be suggested. Most pragmatically and prosaically, increasing pressures from academic institutions or the requirements of funding bodies may frequently lead to increased interdisciplinary cooperation or, equally, participants may decide to write interdisciplinary proposal as a risk management strategy to access a particular stream of funding (Massey et al 2006). However, in many such cases the work tends to be associated with a collection of disciplinary researchers assembled merely for the purposes of obtaining such funding, rather than a real IDR (Amabile et al 2001; Rhoten 2004; Schummer 2004).

**Initial barriers to IDR: why is getting started so tricky?**

Despite recognition of the benefits of IDR, there is an abundance of literature providing examples of various barriers to it, including systemic, institutional, organisational and personal factors (Bruce et al 2004; Butcher & Jeffrey 2007; CoFIR 2004; Duncker 2001; Naiman 1999; Sung et al 2003; Welsh et al 2006). Some of the barriers can be thought to be path-dependent, originating from the evolution of knowledge and disciplines and resulting in certain institutional, disciplinary or cultural lock-ins (See Martin & Sunley 2006; Grabher 1993). More generally, it can be observed that the list is long and literature identifies a wide range of barriers confronting researchers about to traverse the field of IDR. As will be discussed later in this paper, some of the initial barriers can affect the developing interactional processes; thus the distinction between initial and continuing process problems is not necessarily clear cut. However, in a similar manner to the drivers discussed earlier, barriers to IDR can be collated into a number of distinctive groups. Whereas some authors claim that the success of IDR depends on personal traits and, consequently, the personal barriers are the main ones (Bruce et al
2004; Duncker 2001), others pay particular attention to institutional barriers (Aram 2004; Lesher 2004; Rhoten 2004), the disciplinary and cultural differences between participants (Carayol & Nguyen Thi 2005; Duncker 2001; Jeffrey 2003; Massey 2006; Sung et al 2003) and resulting issues related to communication (Lattuca 2002; Frost & Jean 2003; Fay et al 2006; Duncker 2001; Lawrence & Després 2004). In contrast, others focus on problems concerned with process factors, such as a lack of formal planning and evaluation, rather than intrinsic and unavoidable problems (Boix Mansilla & Gardner 2003; Rhoten 2004). Below, we discuss such barriers in relation to the four main groups alluded to above - personal factors, disciplinary differences, institutional factors, and process related factors – but it is important to point out that there is often a degree of overlap between them.

**Personal factors**

Personal factors often overlap with institutional or disciplinary differences, as we shall see later in this section. However such factors include: potential disadvantages in career development associated with IDR; tensions arising from time constraints, defensiveness and intolerance (Aram 2004; Frost & Jean 2003) or, perhaps more importantly, a lack of the necessary skills and experience for IDR (Aram 2004; Bromme 2000; Bruce et al 2004; Carayol & Nguyen Thi 2005; Welsh et al 2006). Perhaps connected to such factors are the potential fear, uncertainty and doubt associated with traversing the field of IDR endeavours (Golde & Gallagher 1999). Such doubts can lead to prematurely terminated engagement in IDR processes. As Wood (1999) has suggested, early, informal discussions with researchers from different disciplines are often open and relaxed; however, once they become formal and specific and the possibility of commitment arises, individuals often back out. These doubts and uncertainties are therefore strongly related to (actual or perceived) disciplinary differences.

**Disciplinary differences**

As the number and difference of the involved disciplines in a (potential) IDR project increases, the complexities and uncertainties increase; this is exacerbated by the complex challenge of trying to communicate in a range of differing disciplinary ‘languages’. As a result, such challenges can lead to obstructive behaviours, emotional insecurity and even conflict (Frost & Jean 2003, Finkenthal 2001). These problems are partially rooted in the particular modes of engagement favoured within
disciplinary communities. As disciplinary communities encourage IDR in different ways and with differing degrees of enthusiasm, the uncomfortable realisation that approaches to IDR may be, to a degree, discipline-specific arise (Carayol & Nguyen Thi 2005). Similarly Duncker (2001) suggests that many of the problems arising in IDR are often deeply embedded in the character of the involved disciplines, each of which has roots in their particular paradigms and associated ontological and epistemological values (Finkenthal, 2001; Klein, 1990; Kuhn 1974). Loyalties to these fundamental tenets can be profound, and often researchers are unwilling to abandon their particular, disciplinary perspective developed over years of experience (Gooch 2005). Sung et al (2003) refer to the problems that result as cultural – or tribal – barriers and point out that they can be as significant as institutional ones. This tribalism is exacerbated by the view that learning another field of knowledge reduces the researcher’s time for achieving mastery of their own discipline; there is thus an almost automatic assumption that interdisciplinary scientists are less competent than focussed specialists (Naiman 1999).

Norms regarding disciplinary cultural dynamics can also be of importance. For example, the execution of research in teams may be a norm in some disciplines but much more infrequent and unusual in others (Massey et al 2006) – in other words, each discipline, treated as a community, has well developed practices for conducting research which may differ from other disciplines (Amin & Roberts 2008). Undertaking an IDR project may therefore require the development of a new set of practices and, indeed, a certain interdisciplinary community. Thus as Jeffrey (2003) observes, the skills necessary for interdisciplinary collaboration are different from those needed for disciplinary research. It is unsurprising, therefore, that another important aspect of the cultural dynamic relates to the differing stances towards fostering of the relevant skills to undertake IDR, and related perceptions of the cost-benefit equation underpinning such skills developments. Indeed, developing such ‘extra’ skills requires additional resources in terms of time and effort, whereas, as discussed in the next subsection, reward systems may not offer a sufficient incentive for researchers to develop these skills.
Institutional factors

As Carayol and Nguyen Thi (2005) point out, since universities and other research structures are organised, operated and evaluated on disciplinary lines, academic reward systems do not adequately incentivise IDR. Indeed, the evaluation mechanisms for research are amongst the most significant and influential barriers to IDR. Carayol and Nguyen Thi (2005) found that the discipline-based peer review evaluation system which dominates the sciences leads to a strong preference for disciplinary research. Similarly, Leshler (2004) points out that most research institutions are not positioned to support IDR, but rather operate under review and reward systems that can actually penalise it. This problem is not necessarily lessened when IDR involves groups with relatively small disciplinary differences, as in such cases competition for the same resources may then become an issue (Welsh et al 2006).

At a broader institutional level, many authors highlight the influence of funding structures on the prospects for IDR (Carayol & Nguyen Thi 2005; Pettigrew & Knight 2007; Schild, Sörlin & Sigfridsson 2002). On the one hand it is reported that it is difficult to obtain money for IDR (for example public research funding agencies are often organized along disciplinary lines). On the other hand, some funding agencies seem to require (either or both) international and interdisciplinary collaboration whatever the needs of the research problem at hand, which can result in the brokering of artificial pseudo-relationships between parties that are not familiar with each other (Pettigrew & Knight 2007; Schummer 2004) to ‘tick the right boxes’ that the agency requires. Overall, the manner in which institutional structures shape the way that universities, departments and individual academics are rewarded and funded is a strong contributor to ‘disciplinary parochialism’ (Pettigrew & Knight 2007) and ‘pseudo-IDR’.

Institutionalized learning and development approaches may also tend to militate against effective IDR, and these may have effects on a range of scales (Welsh et al 2006). This begins with the development of doctoral researchers; since IDR is often perceived to lead to slower career progress (Rhoten & Parker 2004), doctoral programmes are often inhospitable to IDR (Golde & Gallagher 1999; Sung el al 2003), affecting the future willingness (attitude) and ability (skills) of researchers to engage in this mode of research. At a broader level, it can be argued that IDR does not simply require
that individuals develop new skills and approaches, but rather also necessitates a degree of organisational learning to change cultures, structures and strategies (Lattuca 2002). In contrast, even when the institutional climate is nominally favourable towards IDR, if this is not reflected in organisational strategies it can simply add to the pressures on the individual researcher as they are expected to maintain teaching loads and the output from ‘normal research’ and do ‘double duty’ by finding additional time for IDR (CoFIR 2004).

Process factors: issues along the way

It can be difficult to know how to determine if IDR is proceeding successfully, since as Boix Mansilla and Gardner (2003:1) point out, the validation of interdisciplinary work can be obscure and challenging for three reasons. Firstly the existence of various, often conflicting, standards of validation brought to the table by each discipline; secondly lacking conceptual clarity about the nature of IDR; and, finally, a lack of precedents resulting in the need to developing new validation criteria as a part of the research project itself. Thus conceptual barriers to IDR also arise during the process of developing and implementing a project. In addition, the process itself can pose a number of additional problems to an IDR team. These process problems are – like the issue of validation discussed above – often related to problems of understanding, and three underlying causes for such problems can be suggested. First, it is typical for those taking part in an IDR project to still be firmly rooted in their own disciplinary traditions and culture, which can dominate their values and behaviours (see Frost & Jean 2003; Klein 1990; Wallerstein 2003; Massey et al 2006).

Second, there is a strong symbolic and linguistic core for any given discipline, which consists conceptual and discursive particularities which define the way in which problems and potential solutions are defined and described (Aram 2004; Lattuca 2002; Wallerstein 2003). This has implications for dialogue in IDR, when the problem of ‘talking past’ each other can become protracted and troublesome. Essentially, disciplines can vary not just in terms of subjective values (as discussed earlier) but also in terms of what they consider to be ‘objective facts’, potentially leading to a “dialog between the deaf” (Martin 2003).
Third, the cultural and intellectual distinctiveness of each discipline enables each to function as a community, resourcing and enabling the collective and individual development of methodological approaches for the development of knowledge within them. However, IDR project groups lack this kind of community structure support, and individuals within such teams, as they develop new approaches, may find it difficult to locate appropriate and supportive peer networks that can critically evaluate their work (Golde & Gallagher 1999). Thus it is possible for IDR processes to be developed (at least to a degree) in a vacuum, which increases the risk of the enterprise at the same time as it (potentially) decreases its efficiency. A degree of cultural integration is therefore necessary for the development of an IDR project team, and perhaps – in time – an IDR project community (Hollingsworth & Hollingsworth 2000; Turpin & Garret-Jones 2000).

Such process issues need not be overwhelmingly obstructive, and to a degree reflect the challenge of any knowledge developments that truly lean towards the ‘cutting edge’. However, they do mean that the challenges of developing mutual understanding, organizing around a collectively developed conceptual language and building an appropriate modus operandi are, to a degree, unique to each IDR project – and thus extended time is needed to allow this process development, when compared with simpler disciplinary projects (Naiman 1999). Indeed, if a discipline rejects certain modes of research, IDR may prove impossible to achieve.

**Concluding discussion**

In this concluding part of our paper, we wish to draw out the key lines of attention for future research on IDR that are suggested by our review. The first point to make is that it seems that the case for IDR seems to be well made; the drivers discussed earlier include both societal needs and recognition of the generative knowledge potential of such endeavours. To put it another way, IDR seems to be appropriate in addressing complex problems, in terms of the potential to generate ‘solutions’, but also as an intellectually satisfying academic challenge. Yet we have also seen that the barriers to IDR are not inconsiderable; in particular, institutional constraints and their ‘dampening’ effect on individuals’ motivation to participate in such projects are particularly problematic. Overcoming institutional barriers is a matter for those with influence in the policy setting agenda. As researchers convinced of
the potential benefits of IDR, the question that presents itself to us is: how can we better understand (and support) the successful execution of IDR, so that those with influence can have better process and case evidence to support the burgeoning calls for such initiatives?

Our review suggests that culture and language issues – that affect the initial constraints and ongoing process problems – are at the heart of this. In addressing these issues, we suggest that there is a need for two particular lines of action. The first is concerned with drawing insights from other bodies of research that have addressed similar issues. In particular, the growing corpus of research on communities and networks of practice (Adams & Freeman 2000; Brown & Duguid 1998, 2001; Gherardi et al. 1998; Ormrod et al. 2007; Tagliaventi & Mattarelli 2006) may have much to contribute to an understanding of how new symbolic-linguistic resources, rooted in shared practices, may help new IDR cultures to form, as also implied by Lattuca (2004). In particular, works focussed on rather transient, project-based collectivities of practice may be particularly salient (Lindkvist 2005). Unpacking and exploring this literature, and considering its application to IDR contexts, is thus an objective for a future review.

The second line of action that is suggested is the need for empirical research that studies IDR project(s) as they emerge, so that the practices that either help to overcome the barriers elaborated earlier, or reinforce them, can be identified and characterized. The kind of work that is envisaged here is longitudinal, qualitative work that seeks to develop understandings in two areas: first, an exploration of how cultural and linguistic particularities associated with disciplines are enacted, so that the ways in which these barriers ‘dampen’ IDR can be understood more clearly; second, an understanding of any new practices that emerge and how these relate to the formation of (perhaps more-or-less transient) IDR cultures or collectivities of practice.

We recognize that there are many other theoretical and empirical lines of investigation that might be usefully explored, and welcome further discussion on the issues and merits of such approaches. This paper has merely served to delineate our current understanding of the potential and problematics of IDR, and set out our own, particular, planned future contributions to this lively and important area of study.
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