Chapter 1: Interdisciplinary Higher Education

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Abstract

In higher education, interdisciplinarity involves the design of subjects that offer the opportunity to experience "different ways of knowing" from students' core or preferred disciplines. Such an education is increasingly important in a global knowledge economy. Many universities have begun to introduce interdisciplinary studies or interdisciplinary subjects to meet this perceived need. This paper explores some of the issues inherent in moves toward interdisciplinary higher education. Definitional issues associated with the term "academic discipline", as well as other terms, including "multidisciplinary", "cross-disciplinary", "pluridisciplinarity", "transdisciplinarity", and "interdisciplinary" are examined. A new nomenclature is introduced in the paper to assist in clarifying the subtle distinctions between the various positions. The paper also outlines some of the pedagogical and epistemological considerations which are involved in any move from a traditional form of educational delivery to an interdisciplinary higher education, and recommends caution in any implementation of an interdisciplinary curriculum.

1. Introduction

The global knowledge economy is the knowledge-based economy where "knowledge technologies"—including knowledge management—produce substantial economic benefits. This is the economy that the higher education sector is now required to service and help to shape. In an increasingly interconnected, globalised world with common issues and challenges, expertise from a range of disciplinary and professional perspectives has become critical to the identification and management of new and emerging global concerns. Examples of global issues that require interdisciplinary study include global warming, water allocation at a time of resource shortage, the AIDS crisis, and the prudent management of financial markets. As the world has become more connected and integrated, interdisciplinarity has gained an increasingly central place in higher education. Although it may be central, this place in higher education may not necessarily be overt, in terms dedicated subject areas. It can also be covert, in terms of time spent on interdisciplinary practices (Chettiparamb, 2007, p. 12)

This chapter explores both the different forms and understandings of interdisciplinarity and the ways in which interdisciplinarity might be best integrated into higher education. While interdisciplinary studies are flourishing in some areas of higher education—as the contributions to this book demonstrate—interdisciplinarity studies are far from the norm in higher education globally. A discussion of the term "academic discipline" is outlined in the paper, in the context of an examination of the notion of a "discipline". Following this discussion, the terms "multidisciplinarity", "cross-disciplinarity", "interdisciplinary" as well as the terms "pluridisciplinary" and "transdisciplinary" are examined. Some of the pedagogical issues inherent in a move from a traditional form of education to interdisciplinarity education are outlined, and epistemological considerations relevant to interdisciplinarity are also discussed. The chapter concludes with a section outlining important considerations in preparing for and managing change in higher education that is aimed at increasing the role and place of interdisciplinarity.

2. What is an Academic Discipline?

There is a growing body of literature on the nature of academic disciplines and interdisciplinarity. In a recent extensive critical review of the literature, Aboelela et al. (2007) have determined there are over 500 published papers related to interdisciplinarity in the Health Sciences alone, of which 42 articles are concerned with interdisciplinary research and the remainder concerned with other aspects of interdisciplinarity (e.g., examples of interdisciplinary practice) (Aboelela, Larson, Bakken, Carrasquillo, Formicola, Glied, Haas, & Gebbie, 2007). In this section, some distinctions in this field are clarified and a new nomenclature is proposed to understand the distinctions in various options available to a university if it is to go down a path of being "interdisciplinary". In order to explore interdisciplinarity and other variations, it is first necessary to understand the term "academic discipline".

2.1 Academic Disciplines

The academic disciplines as they are known today are widely considered to be largely discrete and autonomous, although not homogeneous (Becher, 1981). The traditional view of an academic discipline is an area of study 'with its own theories, methods and content … distinctiveness being recognised institutionally by the existence of distinct departments, chairs, courses and so on' (Squires, 1992, p. 202). An academic discipline has also been defined as 'a branch of learning or scholarly instruction' (OECD, 1972). However, this definition is somewhat circular in that "branch of learning" requires further explanation. Disciplines are generally considered more discrete than "fields of study" or "fields" in that a field is generally outlined when undertaking a course of study in a discipline. Thus, a "field" of study has a wider meaning than "discipline". Discipline experts or practitioners, and universities in general, provide a framework for students by setting out fields of study for students to follow. A "discipline" thus defines and delimits a "field" of study, rather than the other way around.

Beyer and Lodahl have defined "disciplines" in more general terms. They suggest that a discipline provides the "structure of knowledge" that trains and socialises members of a university department. This training and socialisation includes the ability to carry out the appropriate tasks of teaching, research, and administration that are germane to the discipline. It also includes the production of relevant research, the process of peer-review, and the development of a system of academic rewards (Beyer & Lodahl, 1976; Reich & Reich, 2006). Becher (1981), likewise, defines disciplines broadly as "cultural phenomena": 'they are embodied in collections of like-minded people, each with their own codes of conduct, sets of values, and distinctive intellectual tasks' (Becher, 1981, p. 109).

Following Boisot (1972) and Lattuca (2001), Chettiparamb (2007, pp. 2-3) attributes disciplinarity to three concurrent and simultaneous forces: cultural, organizational and scientific. In particular, 1) man's natural tendency to classify and conceptualise the word around him; 2) the need for science to take advantage of different kinds of knowledge (and the parallel need to ensure that individuals are educated within knowledge areas); and 3) the desire for society to develop economically, which can only be done in a society that is highly structured and organised.

2.2 The Traditional View of Academic Disciplines

The traditional view of the nature of academic disciplines as discrete and autonomous began with the development of universities in Europe. The earliest universities began with only four disciplines: Medicine, Philosophy, Law and Theology. The Department of Physics at Oxford still retains the name "Department of Natural Philosophy" in recognition of this heritage. The "sciences"

as they are known today did not exist in earlier times. Over the centuries, increasing specialisation has resulted in more disciplines being added, and by the 1950s one report noted around 1,100 scientific disciplines (Schultz, nd. cited in Max-Neef, 2005). More recent attempts to classify academic disciplines have resulted in more, not fewer, "disciplines" being included ("Classification of Instructional Programs," 2000; List of Academic Disciplines," 2007). Codification of academic disciplines is a widespread practice in academic institutions but this codification occurs only at the level of the body of knowledge in a discipline, as opposed to the type of scholarly practices and activities and the behavioural features of its practitioners. The Australian Research Council Research Fields, Courses and Disciplines (RFCD) classification codes are an example of such a codification system.

This evolution of academic disciplines continues apace. There are calls to create new academic disciplines from a variety of unlikely candidates, for example, Business Succession Planning and from Genealogy (Ip & Jacobs, 2006; Wagner, 2006). Similarly, there are questions about whether traditional academic disciplines—for example, Accounting—should continue to be described as such (Fellingham, 2006). There have been various attempts to undertake anthropological study of academic disciplines, and to describe these unique cultures, with limited success (Becher, 1981, 1989). While there is general agreement about what an academic discipline is, it is also clear that many have porous borders.

While academic disciplines are, to some degree, porous, there are certain features that can be agreed upon. The following features are among those often attributed to an academic discipline:

- the presence of a community of scholars;
- the existence of a tradition or history of inquiry;
- the presence of a mode of inquiry that defines how data is collected and interpreted;
- the existence of a definition of the requirements for what constitutes new knowledge; and
- the existence of a communications network.

Of course, the differences among the disciplines are as important as the things that bind them. Art historians, geologists and economists all differ markedly in terms of how they substantiate their knowledge and their methodologies (Hofer, 1997, 2000, 2001). Academic disciplines also differ markedly in regard to standards of justification and evidence, degrees of certitude in what constitutes knowledge, and in their understanding of the structure of knowledge itself. Epistemological issues are discussed further below.

Over time, new disciplines naturally gain their independence from their original disciplinary homes, especially once a defined and unique methodology is employed to determine the subject matter of each. For example, Cognitive Science, once the province of philosophers, and part of the discipline of Philosophy (and, in particular, the field of the philosophy of mind), has taken on a life of its own, and is now considered to be on its way to becoming a discipline, if it is not a discipline already. International conferences are held in the new "discipline", there are Centres of Cognitive Science in universities around the world, and there are specialised peer-reviewed journals dedicated to the area. We shall return to this example shortly.

There is a view of the disciplines as "horizontally" structured along a continuum, with "hard" or empirical sciences at one end, the "softer" social sciences in the middle, and the "soft" humanities at the other end (see Figure 1 below). In between the extremes (the dotted lines) are various disciplines of a greater or lesser degree of methodological "hardness" or "softness". Figure 1 shows the standard view of the relationship between the disciplines on the "hard-soft" continuum. This

view has been supported and validated by empirical studies (Biglan, 1973b; Creswell & Bean, 1981; Donald, 1986; Sinclair & Muffo, 2002; Smart & Elton, 1978).

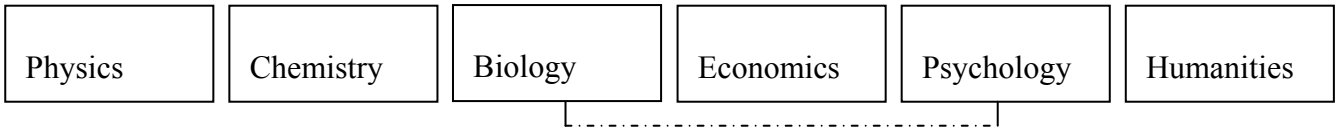

Figure 1: The "Hard"- "Soft" Continuum of Academic Disciplines

Despite the intuitive appeal of homogeneous, autonomous and discrete disciplines arranged along a continuum, this simple account is clearly not adequate. In particular, it does not fully capture the complexity of academic disciplines. In particular, it does not account for the growth and development of disciplines. There are many instances of an apparent lack of clarity in what might be ordinarily called a "discipline". For example, before WWII, the discipline of Physics was characterised by the quest for immutable and unchanging laws of nature; after the war it became more focussed on industrial applications (Becher, 1981); some parts of Economics and Psychology are empirical ("hard") in nature and others are not. In the 1960s, it was considered important that Psychology was a "hard", empirical discipline (e.g., B. F. Skinner's work); more recently, it has been thought to be more accommodating of alternative positions. It is clear that the simple "hard-soft" dichotomy lacks the subtlety to adequately describe some characteristics of the disciplines.

Under the traditional notion of academic disciplines as discrete and autonomous entities, there is a standard undergraduate educational pathway for students in countries such as Australia. With few exceptions and double degrees aside, students begin their studies in one of the broad faculty divisions (the sciences or Arts, for example). The student experiences the disciplines within that faculty grouping, and eventually specializes in one of them. This discipline influences students' views about what is known, what is valued, and what is capable of investigation". The discrete nature of disciplines means that by the end of their studies, a student of one may not know much about another discipline. For example, a student of Accounting may not know much about Finance; a Biology student might not know much about Physics; a Psychology student may not know much about Neurology, and so on, though students may have passing familiarity with cognate disciplines.

"Disciplinarity", then, describes the traditional view. It is a term used to describe academic disciplines as autonomous and discrete areas of study which do not normally cooperate or coordinate their academic efforts across disciplinary boundaries. Disciplines can be seen as discrete "boxes" (albeit with porous boundaries at times).

2.3 Limitations of the Traditional Notion of "Academic Disciplines"

As noted by Squires (1992), one of the limitations of the traditional notion of academic disciplines is that it fails to acknowledge that disciplines are not historically fixed; that they evolve and change over time. Like everything else, of course, academic disciplines are culturally and historically situated. In addition, disciplines are not defined by one attribute but by many, and the relative emphasis on these different attributes can differ from discipline to discipline, and even within disciplines. Again, a discipline such as Psychology has undergone great changes from its inception as an introspective discipline with the work of William James, Sigmund Freud, Carl Jung and others, to its current empirically-based concerns, though there remain different "branches" where, for example, psychoanalytic research is still discussed, and more speculative ideas (e.g., in

philosophical psychology) are considered. There have been attempts to redefine the notion of "academic discipline" to recognise these points (Becher, 1989; Biglan, 1973b; Donald, 1986; Kolb, 1981; Squires, 1992).

Squires (1992) has helpfully defined an academic discipline in terms of three "dimensions": their *object* (what they are concerned with, their current problems and issues); their *stance* (their current epistemic concerns, that is, what they consider to be their framework of knowing and how they do things—their methodology); and their *mode* (that is, how they reflexively consider themselves as a discipline, for example, the extent to which they are "normal", "mature", or "revolutionary" in the Kuhnian sense). Many disciplines go through periods of "normal" science (that is, business-as-usual using an unchallenged, commonly agreed-upon theoretical framework), to "revolutionary" periods where these frameworks are questioned, thrown into doubt and/or replaced, for example, Einsteinian physics replacing Newtonian physics (Kuhn, 1962).

Squires has a more sophisticated understanding of "discipline" that acknowledges these dimensions. He claims that all disciplines are 'multidimensional spaces which define, protect and enlarge themselves along any of those dimensions, and in so doing, come into conflict or cooperation with other disciplines' (Squires, 1992, p. 203). See Figure 2 below.

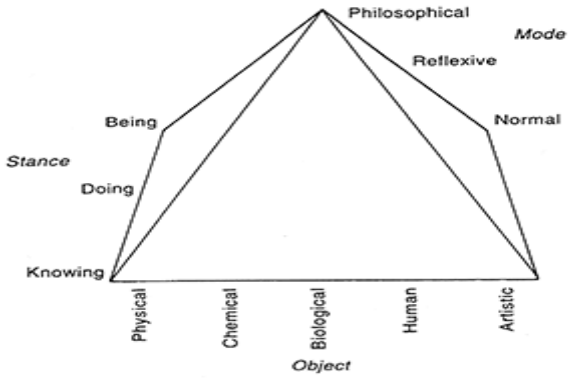

Figure 2: Squires' (1992) Account of a Discipline

On Squires' account, friction and permeation can occur at the borders of disciplines, and influences can be widespread among them. An example of the latter is the empirical methodology of the hard sciences. This has had a lasting effect on other disciplines that are traditionally remote from the concerns of the sciences (for example, disciplines such as Linguistics). However, powerful influences on disciplines of this nature are seldom bi-directional.

More recently, Aram has described disciplines as 'thought domains—quasi-stable, partially integrated, semi-autonomous, intellectual conveniences—consisting of problems, theories and methods of investigation' (Aram, 2004, p. 380; Chettiparamb, 2007, p. 3). The description of a discipline as an "intellectual convenience" may seem overly instrumentalist, but it does capture the "looseness" of discipline boundaries. Useful definitions that recognise the subtlety of the notion of "discipline" have been provided recently by others (Parker, 2002; Turner, 2000a). For a review, see Chettiparamb (2007).

2.4 Multidisciplinarity

Multidisciplinarity recognises the fact that there are many discrete and autonomous disciplines. In higher education, while undergraduate students normally specialise in one discipline, they can study several over the course of a typical degree program. For example, an Accounting student also

studies some subjects in Finance in addition to accounting subjects, and may also study Economics, or even subjects in unrelated disciplines, such as History or Music.

In terms of research, in some areas of investigation there may be multidisciplinary contributions from several discipline areas to a joint research program. Often, however, in practice, each of the disciplines contributes from its own perspective. In both a practical and intellectual sense, each of the disciplines stands alone. Multidisciplinarity has been described more simply as the view that: 'everyone [does] his or her thing with little or no necessity for any one participant to be aware of any other participant's work' (Petrie, 1976, p. 9). Multidisciplinarity is simply the co-existence of a number of disciplines.

2.5 Cross-Disciplinarity

Cross-disciplinarity is another variation of disciplinarity. The term cross-disciplinarity is often confused with "interdisciplinarity" but in the former, a topic *normally outside* a field is investigated with no cooperation from others in the area of study. Two examples are the physics of music and the politics of literature ("Interdisciplinarity," 2007). While sometimes informative and interesting, this type of inquiry involves the use of techniques and tools from those normally that are foreign to those used to study the phenomenon under consideration. Cross-disciplinary work rarely involves any transfer of methodologies. Taking one of the examples above, musicians do not necessarily learn any physics and physicists do not necessarily learn much about music.

3. Interdisciplinarity

Interdisciplinarity has been described as 'a remedy to the intellectually deadening effects of excessive specialization'("Interdisciplinarity," 2009). A number of sophisticated definitions are available in the literature (Boisot, 1972; Chandramohan & Fellows, 2009; Heckhausen, 1972; OECD, 1972). One recent definition is given as follows: 'the emergence of insight and understanding of a problem domain through the integration or derivation of different concepts, methods and epistemologies from different disciplines in a novel way' (Rogers, Scaife, & Rizzo, 2005, p. 3). The key terms here are "integration" and "novel". As will be demonstrated, it is insufficient merely to look at an issue from the point of view of different disciplines. A number of types of "integration" are possible, and therefore a number of different kinds of interdisciplinarity, as outlined below.

Building on an earlier paper (Davies & Devlin, 2007b), we claim that there are a number of variants of interdisciplinarity that can be located on a continuum from benign to radical. Here we propose new nomenclature for these variants. The new terms: *relational, exhange* and *modification* interdisciplinarity are introduced below, alongside the standard terminology of *pluridisciplinarity* and *transdisciplinarity*. While disciplines have traditionally been regarded as discrete and autonomous, interdisciplinarity recognises the subtleties of the nature of academic disciplines. The argument in this chapter is that there are a number of possible forms that interdisciplinarity can take and that naming them can be useful for discussion. Some unique terminology is provided in this chapter to assist in understanding the differences.

3.1 Relational Interdisciplinarity

At the benign end of the interdisciplinary spectrum, interdisciplinarity is regarded as elective subjects taken from a variety of disciplines that in some way relate to a general topic—an example might be Women's Studies. Here there are 'two or more disciplines … contributing their particular disciplinary knowledge on a common subject' (Garkovich, 1982, p. 154; McGrath, 1978). Related topics can be—and frequently are—discussed from different angles or points of view. This variant

of interdisciplinarity might be referred to as *relational interdisciplinarity* and its similarity to multidisciplinarity is clear. The differences are that, in multidisciplinarity, there is no acknowledgement of the work of others at all; whereas in relational interdisciplinarity, there is an explicit acknowledgement of—but no implicit willingness to learn from others. Heckhausen (1972) refers to this form as "indiscriminate interdisciplinarity", that is, the form of interdisciplinarity that often results in "curriculum mix-ups" (Heckhausen, 1972, pp. 87-89). This form of interdisciplinarity amounts to looking at an issue from different disciplinary perspectives, with little or no attempt to integrate those perspectives in any meaningful sense.

3.2 Exchange Interdisciplinarity

Moving along this continuum of variants of interdisciplinarity, another variant involves 'entrench[ing] discipline boundaries' yet 'leaving open mutually radical dialectic-critique of opponent territories' (Davidson, 2004, p. 308; Rowland, 2001). This view implies critique and the critical exchange of views while maintaining robust disciplinary integrity. This variant might be referred to as *exchange interdisciplinarity.* Heckhausen calls this variant, "psuedo-interdisciplinarity" because disciplines may share analytical tools, but otherwise remain untouched by the exchange of views between discipline experts (Heckhausen, 1972, pp. 87-89). In this variant, there is both an explicit and implicit acknowledgement of other disciplines, and a critical exchange of views (and possibly methodological tools), however there is no real integration toward a common purpose. This might be considered a curriculum mix-up "with attitude". Participants to such an exchange are willing to critique, or perhaps even attack, each other's positions from the point of view of their own. But they are unlikely to develop anything novel; nor integrate the insights of others toward a mutually common aim or objective.

3.3 Pluridisciplinarity

Another variant of interdisciplinarity further along the continuum is sometimes known as *pluridisciplinarity* (Max-Neef, 2005). This variant requires two or more disciplines to combine their expertise to jointly address an area of common concern. Heckhausen calls this "composite interdisciplinarity" (Heckhausen, 1972, pp. 87-89). Pluridisciplinarity is often seen in areas of study where the topic under investigation is too complex for a single discipline to address. Examples include the AIDS pandemic and climate change. Topics such as these require the efforts of many specialists. Indeed, discipline experts *have* to learn from each others' expertise; the nature of the problems under consideration demands that this occurs.

An issue such as "land use", for example, is seen differently from economic, geological and environmental perspectives. In the health sciences, a pressing social concern such as obesity requires the *integrated* views of behavioural scientists, molecular biologists, and mathematicians (Aboelela et al., 2007). This "integration" satisfies one of the two conditions of true interdisciplinarity (the other condition is developing something "novel" from this integration). Where in disciplinarity and multidisciplinarity there is no cooperation at all between disciplines—and in relational and exchange interdisciplinarity there is minimal interaction, and only a degree of acknowledgement—pluridisciplinarity involves an explicit degree of cooperation.

A recent example of pluridisciplinarity is the new "discipline" of Cognitive Science. Here philosophers, linguists, computer scientists, artificial intelligence experts, neurologists and brain scientists cooperate in the production of papers for dedicated conferences and journals, for example, *Journal of Consciousness Studies* and *Behavioral and Brain Sciences*. This cooperation is toward an understanding of topics of common concern, in this case, the scientific study of consciousness. However, while there is a strong amount of cooperation, a common objective, and genuine mutual

interest in pluridisciplinarity, there is no sense in which, say, computer scientists, neurologists, and philosophers do research that is independent of their respective disciplinary areas. Entire encyclopaedias are now published in the area of Cognitive Science, but they are still partitioned into the relevant (and discrete) discipline areas (Wilson & Keil, 1999). The degree of integration is limited to merely discussing a common problem, it does not extend to integrating the disciplines toward a novel outcome. As Rogers, et. al., put it:

> In practice, many self-styled interdisciplinary enterprises actually work at the level of being multidisciplinary (or pluridisciplinary): where a group of researchers from different disciplines cooperate towards a common goal, but continue to do so using theories, tools, and methods of their own discipline, and occasionally using the output from each other's work. They remain, however, essentially within the boundaries of their own disciplines both in terms of their working practices and with respect to the outcomes of the work (Rogers et al., 2005, p. 3).

There is often a transfer of techniques and methodologies in pluridisciplinarity research, but as Rogers et. al., note, this is quite different from using the perspectives of different disciplines to provide insight in a *novel* way. In pluridisciplinarity, the research is discipline-based, and researchers may discuss with, and inform each other about, an issue that is of common concern from their different respective academic positions (see Figure 3 below). For example, unlike in the past, philosophers of mind now openly discuss empirical methods used by neuroscientists, and neurologists now openly discuss philosophical terminology and concerns (Dennett, 1991). There is also a seriousness of purpose in such exchanges. This is not "pseudo" interdisciplinarity, or "indiscriminate" interdisciplinarity, so it is distinct from the versions of interdisciplinarity mentioned earlier. Participants in such projects have a genuine willingness in the perspectives and insights of academics from other domains.

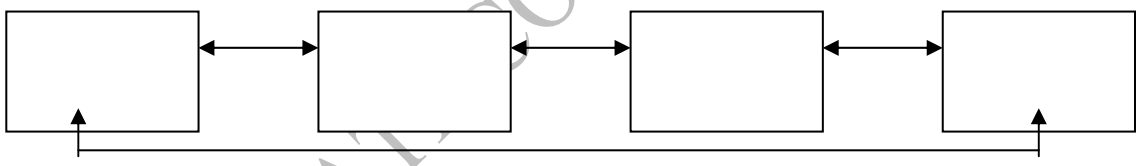

Figure 3: Pluridisciplinarity (Cooperation between disciplines)

(Max-Neef, 2005, p. 7)

However, even in what would seem to be a paradigmatic example of interdisciplinarity—such as Cognitive Science—true interdisciplinarity is difficult to achieve in practice, and has been described as an "elusive goal" (Rogers et al., 2005, p. 3). This is because, while one of the conditions of true interdisciplinarity has at least been partially satisfied (integration), the second (developing novel outcomes), has not. True interdisciplinarity, it seems, is difficult to achieve.

In Heckhausen's account, there are degrees of composite interdisciplinary influence, so this category of interdisciplinarity in itself represents a spectrum. In some areas, there is considerable overlap on subject matter between different disciplines; in other areas, there may be no overlap at all, or only partial overlap. Where there is "partial" overlap, he describes this as "supplemental interdisciplinarity" (e.g., the example of Cognitive Science). Supplemental interdisciplinarity occurs 'at the borderlines of disciplines' (Chettiparamb, 2007, p. 20). Where there is more substantive overlap, and a legitimate need to solve a pressing problem—e.g., different disciplines addressing the AIDS crisis, obesity, or global warming—this is considered true "composite" interdisciplinarity (Heckhausen, 1972).

Figure 3 shows the autonomy of discrete disciplines that may cooperate with each other when circumstances demand. This cooperation may involve the sharing of methodologies, techniques or concepts or it may involve a pressing need to solve a problem using insights from various disciplinary perspectives. This diagram should perhaps be shown with shaded two-way arrows to indicate the degree of strength of disciplinary overlap.

There is a plausible case to be made for pluridisciplinary relationships between the disciplines in higher education. Some issues and topics appropriate for undergraduate university level study are simply too complex to be properly investigated within a single traditional discipline. If interdisciplinary relationships are fostered, traditional disciplinary structures can be retained, and interdisciplinary relationships formed for the purposes of teaching and learning. These relationships might go some way to promote critical dialogue between the disciplines of complex topics that are beyond the resources of individual disciplines alone.

Petrie (1976) makes an interesting point in this context. He notes that the history of the disciplines teaches us that disciplinary specialists themselves seek interdisciplinary relationships when the demands of their subject warrant it, and not before. Certain conceptual issues demand new perspectives to provide breakthroughs. These insights can certainly come from different disciplines. The history of thought provides many examples where disciplinarians have themselves welcomed interdisciplinary relationships. Biology needed Physics at a certain stage of its development. Ecologists use mathematics when necessary. Philosophers of mind began to seek relationships with neuroscientists and computer scientists when their *a priori* speculations about internal representations led to a need to understand what an internal "representation" might be. There are numerous cases in which the nature of a problem has necessitated the insights of another discipline (Petrie, 1976). Interdisciplinarity, therefore, occurs naturally among disciplinary specialists at times.

Like relational interdisciplinarity, however, pluridisciplinarity is not especially different from what typically occurs in university education. It is something academics do as a matter of course. Interdisciplinary exchanges—such as those presupposed under pluridisciplinary relationships—occur as a matter of course.

3.4 Modification Interdisciplinarity

Moving further along the continuum, there is yet another variant of interdisciplinarity. Unlike multidisciplinarity—where disciplinarians need not discuss things with each other—this variant requires 'more or less integration and even modification of the disciplinary sub-contributions while [an] inquiry is proceeding. With this version, there is often coordination from a higher hierarchical level to the levels lower down. The disciplines at the lower levels are subordinated to the coordinating level higher up. In this variant of interdisciplinarity, different participants need to take into account the contributions of their colleagues to make their own contribution' (Petrie, 1976, p. 9).

Within this view, the latter point is crucial as one of the criticisms of some interdisciplinary work is that it is "interdisciplinary" in name only. This variation might be called *modification interdisciplinarity* or, in Heckhausen's terms, "unifying interdisciplinarity" (Heckhausen, 1972, pp. 87-89). This variant is outlined in Figure 4 below. Modification interdisciplinarity involves more than cooperation and integration. It requires that disciplines are *changed* in some way by the association with other disciplines, and that there is a degree of consistency in the disciplines in terms of their subject matter. The arrows below indicate that the hierarchical concerns are influencing in some way the structural integrity of disciplines below. An example of this might be when Medicine harnesses the concerns of Biology, Physics and Psychology to serve "higher"

pragmatic purposes, or when disciplines such as Agriculture, Forestry and Commerce serve the needs of disciplines such as Politics (Max-Neef, 2005). In this instance, something "novel" is occurring. A coordinating discipline is guiding and integrating the insights of disciplines lower down. As noted earlier, this is certainly not yet happening in disciplines such as Cognitive Science, and therefore modification interdisciplinarity represents a distinct, and more extreme, variant on the positions already mentioned.

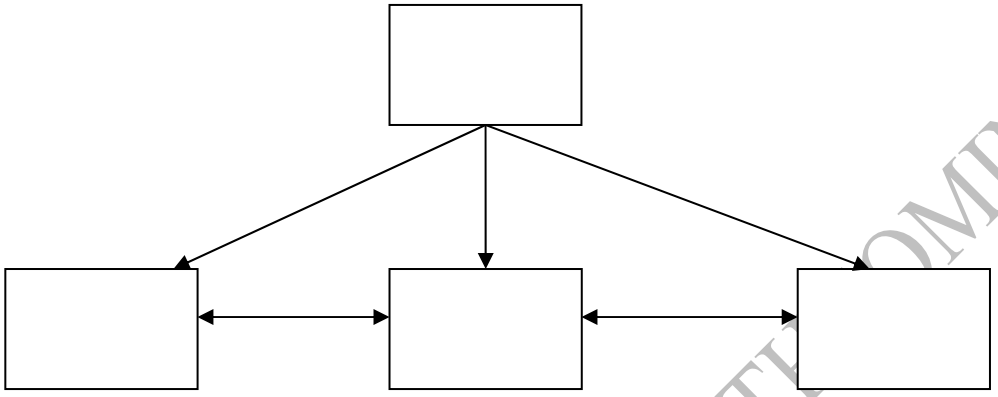

Figure 4: Modification Interdisciplinarity (Coordination from a Higher Hierarchical Level)

(Max-Neef, 2005, p. 7)

3.5 Transdisciplinarity

Moving yet further along the continuum of variants of interdisciplinarity, at the extreme end is a view of interdisciplinarity as involving the 'collapse of academic borders and the emergence of a new discipline' (Davidson, 2004, p. 308; Rowland, 2001, p. 3). This is sometimes known as *transdisciplinarity* (Max-Neef, 2005). However, this extreme variant of interdisciplinarity may be more a theoretically possible position than a practical reality. It is not clear what would count as an example of a new discipline that has emerged from a process of transdisciplinary evolution and left its parent discipline behind, that is, emerged from traditional disciplines that have since "dissolved". To take the case of Cognitive Science mentioned earlier, this has certainly emerged as a new quasi-discipline, but in no sense has there been dissolution of its parent disciplines: Philosophy, Neuroscience, Computer Science —and nor is it likely that this would ever occur.

There are other unanswered questions with this variant of interdisciplinarity. Dissolving academic boundaries would seem to go against the gains won in terms of the basic research productivity of individual disciplines. But, even if this is considered desirable, one wonders how this variant would work in practice. And how, in a practical sense, would disciplines continue work done in dedicated disciplinary areas of concern if boundaries were "dissolved"? What does the dissolving of boundaries mean exactly? How would disciplinary integrity be maintained? How would traditional academic concerns be maintained in attempts to reorganise the curriculum to meet more pressing global challenges? If boundaries between disciplines are ever dissolved it becomes unclear to what extent traditional disciplines would survive.

The various forms of "disciplinarity" can be represented as follows (see Figure 5 below):

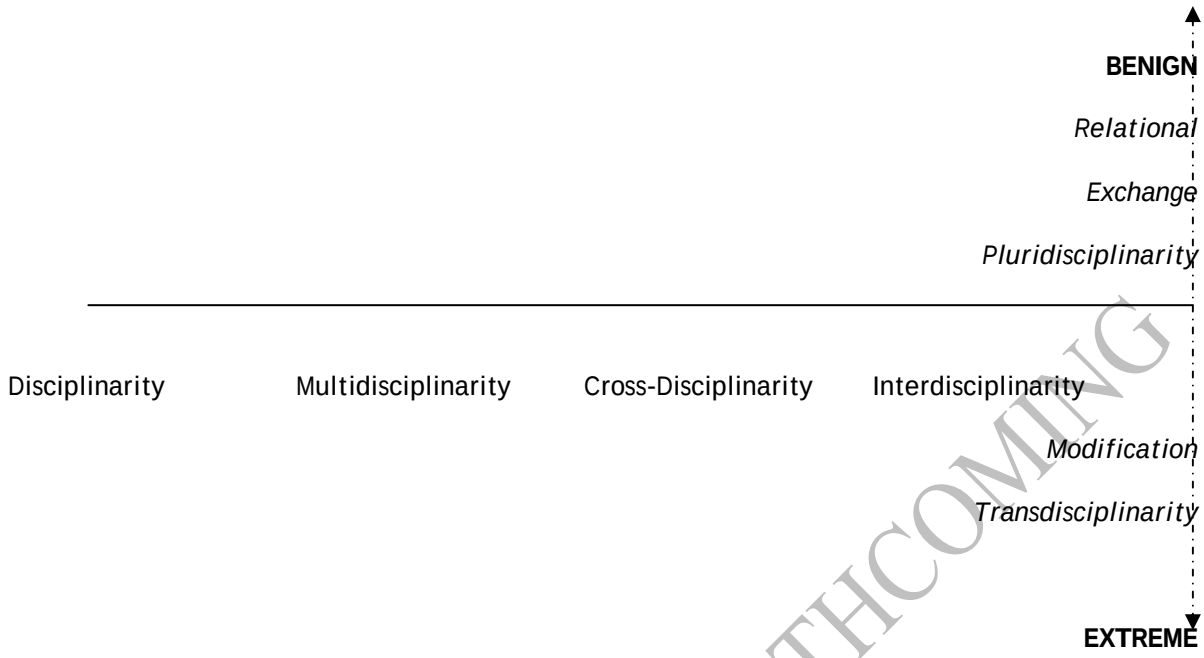

Figure 5: Various Forms of "Disciplinarity"

Figure 5 shows the various forms of disciplinarity (horizontal axis) with the vertical axis showing the forms of interdisciplinarity along a continuum from benign to extreme.

There is a considerable literature indicating that interdisciplinarity, in its various forms, is widespread in a diverse range of traditionally academic domains. These include: Health Sciences (Aboelela et al., 2007); Engineering (Froyd & Ohland, 2005); Sociology (Garkovich, 1982); Higher Education (Davidson, 2004; Field & Lee, 1992b; Kezar, 2005; Newell, 1992; Petrie, 1976; Wolman, 1977); Ecology (Golde & Gallagher, 1999), Music (Ellis & Fouts, 2001); Environmental Studies (Steiner & Posch, 2006); Community Studies (Suarez-Balcazar, Hellwig, Kouba, Redmond, Martinez, & Block, 2006); Management (Tress & Tress, 2005); and Science (Wolman, 1977). In addition, there have been sustained discussions on the role of interdisciplinarity in academic research (Feller, 2006; Reich & Reich, 2006; Schommer-Aitkins, Duell, & Barker, 2003). The academic literature on interdisciplinarity is volumous. For a recent publication, see Chandramohan and Fellows (2009).

However, it is not often clear from this literature just what type of "interdisciplinarity" is under discussion—the term "interdisciplinary" is often used without definition and, therefore, without much clarity. Nor is it always clear which variant(s) is/are desirable, and under which contexts the variant(s) of interest might be applicable, or useful, (though see Chettiparamb, 2007, for a useful account of the vagueness and inprecision of existing terminology). It is hoped that the nomenclature outlined above will contribute to clarifying further discussions in this area.

4. Pedagogical and Epistemological Considerations

This section considers some of the implications of interdisciplinarity for higher education teaching and learning. Given that some interdisciplinarity will be desirable in a global knowledge economy, the questions of how best to incorporate it into students' learning experiences are key considerations in a changing global context. There is a commonsense case for suggesting that the best education that can be provided to university students is a sound discipline-based education, with opportunities for interdisciplinarity. The appropriate mix between local, disciplinary content and interdisciplinary

content would be critical if this argument was accepted. An education that is too broad might not allow for sufficient expertise in the core discipline for an adequate appreciation of when interdisciplinary work is needed and when it is not. Sufficient local disciplinary content will ensure that students themselves see the need for interdisciplinary understanding when the occasion demands it, just as disciplinarians seek interdisciplinary relationships when they see a need to do so. The following epistemological issues deserve attention in any move toward interdisciplinary higher education.

4.1 The Issue of Cognitive Maps

It is well known that different disciplines have their own way of viewing the world. These ways of viewing the world are also known as mental models, cognitive maps, frameworks, or "paradigms" (Kuhn, 1962). Individuals understand the world in terms of the cognitive models they possess; in an important sense they "see" things differently to those with different cognitive models. Disciplinary-based concepts are necessary for viewing the world in a particular way. In the normal course of events in higher education, students learn these cognitive maps when they are inducted into a discipline—this is part of what it means to become "educated". As Davies and Devlin (2007b) point out, once a student has learned a discipline-specific cognitive map, it becomes difficult for the student so inducted to "see" things any other way. Unless one learns music theory, for example, it is difficult to recognise a plagal cadence for what it is; without music theory, one may just hear sounds. As Hanson puts it, 'the visitor [to the laboratory] must learn some physics before he sees what the physicist sees' (Hanson, 1975, p. 17). Polanyi outlines the way in which a medical student comes to "see" in a new way. His example of a medical student attending a course in the X-ray diagnosis of pulmonary diseases illustrates the notion of 'ways of seeing the world':

> … He watches, in a darkened room, shadowy traces on a fluorescent screen placed against a patient's chest, and hears the radiologists commenting to his assistants, in technical language, on the significant features of these shadows. At first, the student is completely puzzled. For he can see in the X-ray picture of a chest only the shadows of the heart and ribs, with a few spidery blotches between them. The experts seem to be romancing about figments of their imagination; he can see nothing that they are talking about. Then, as he goes on listening for a few weeks, looking at ever-new pictures of different cases, a tentative understanding will dawn upon him; he will gradually forget about the ribs and begin to see the lungs. And eventually, if he perseveres intelligently, a rich panorama of significant details will be revealed to him: of physiological variations and pathological changes, of scars, of chronic infections and signs of acute disease. He has entered a new world. He still sees only a fraction of what the experts can see, but the pictures are definitely making sense now and so do most of the comments made on them (Polyani, 1973, p. 101).

But concepts are not just important in seeing specialized things in the disciplines; they are also important for common, everyday "seeing". The following example from H. I. Brown (1977) makes this clear:

> Consider a relatively common, everyday instance of perception such as my seeing my typewriter. Now, in order to see that this object is a typewriter it is not sufficient that I just look at it; it is necessary that I already know what a typewriter is. Simply glancing at objects with normal eyesight will undoubtedly stimulate my retina, initiate complex electro-chemical processes in my brain and nervous system, and perhaps even result in some conscious experience, but it will not supply me with meaningful information about the world around me. In order to derive information from perception it is necessary that I be able to identify the

> objects that I encounter, and in order to identify them it is necessary that I already have available a relevant body of information (Brown, 1977, pp. 81-82).

Even ordinary, everyday "seeing" requires conceptual resources of some kind. The phenomenon of the "theory dependence of observation" (the notion that "seeing" requires a battery of theoretical concepts) and the notion of "cognitive maps" occurs, without exception, in all academic disciplines (Polyani, 1973). This being the case, a focus on interdisciplinarity raises challenges for higher education students and higher education providers.

If interdisciplinarity is part of a student's higher educational experience, this will, by necessity, put limits on what can be accommodated within a degree program. It will naturally result in fewer topics being taught and learnt in traditional, discipline-based ways. However, disciplinary "depth" is important to ensure that students develop the required cognitive maps ("paradigms") in both disciplinary and interdisciplinary studies. One of the great ironies of moving toward interdisciplinary higher education is the potential sacrifices that have to be made: "depth" in core discipline areas run the risk of being compromised in the pursuit of "breadth" achieved through interdisciplinarity.

Careful consideration and management of the pedagogical implications around cognitive maps are necessary as, without this, it is possible that some students may find it challenging to learn the cognitive maps in both the core discipline(s) and the interdisciplinary studies. Arguably, undergraduate higher education should provide education that both prepares students for the changing world of employment, and that provides a pathway into graduate programs. According to Golde and Gallagher (1999), depth of understanding is critical for those leaving university after undergraduate studies to take up a profession as well as for intending graduate students who will have to eventually make research contributions. But in a time-pressed curriculum, careful consideration must be given to how this is achieved in practice when more attention is devoted to interdisciplinary studies. University pedagogy around interdisciplinarity must be able to accommodate both development paths. This is certainly a challenge.

4.2 The Issue of Disciplinary Language

Disciplinary language is another important point related to the notion of cognitive maps. It has been recognised that in addition to providing the requisite cognitive maps for students, a discipline must also teach a distinct, discipline-specific vocabulary(ies). This raises a number of pedagogical issues. It is as important to teach the language and technical terms of the disciplines, as it is to teach the methodologies, procedures and concepts. Indeed, they cannot be taught *without* the language. There are significant differences in language, even within disciplines that are naturally grouped together. For example, the language of Accounting is very different from the language of Management, Finance or Law. In disciplines not usually grouped together, these differences are even more pronounced. The language of Accounting, for example, is very different from the language of Chemistry or History.

This raises significant epistemological, as well as practical, challenges for academic teaching staff and for students. Some of the disciplinary "vocabularies", and the assumptions behind them, are impossible to compare with vocabularies from other disciplines. For example, the term "mass" means something quite different to a Physicist than it does to an Engineer or Architect. Further, the notion of a "fact" or "evidence" are largely matters of disciplinary definition. If there are differences in the use of single words, it is likely that differences in the understanding of theoretical concepts will be vast (Feyerabend, 1993).

The language of disparate disciplines may need to be explicitly taught in interdisciplinary university environments. While achieving breadth and depth of study is not an inconsistent aim, it is very challenging to achieve without risking the loss of the strengths of a well-grounded education in the language of single disciplines. An inadequate background and understanding for both employment and graduate study can be the result of mixing the unique languages of Commerce and Engineering, for example, if not undertaken with care. Students will need to graduate from university with the appropriate discipline-specific vocabulary in each of the disciplines in which they have studied (Davies and Devlin, 2007b).

4.3 Interdisciplinarity and Idea Dominance

Petrie (1976a) has claimed that a central feature needed for interdisciplinary success in research, but also—albeit to a lesser extent—teaching, is *idea dominance*. Viable projects require a key "idea" without which, success of the project is threatened. It has been noted that over 50 percent of interdisciplinary collaborations fail (Doz, 1996; Kezar, 2005). Failure might be because of inconsistent or incompatible key ideas, or because no key idea emerges. The key idea needs to be mutually agreed upon as being important by all involved. In teaching, dominant ideas are closely aligned with eventual success and achievement in results that all parties to a project or curriculum regard as being illuminating, and as offering some degree of intellectual progress.

In contrast to interdisciplinary settings, in independent, "traditional" disciplines, idea dominance is not a critical issue. The reason for this concerns the history of the discipline. The ideas that, for example, Economists, Engineers or Psychologists regard as being important are, over time, filtered from weaker ideas and the latter are abandoned. The dominant ideas become viable and become the focus of investigation and learning, that is, of research and teaching, respectively.

However, interdisciplinarity is different. By necessity, and by definition, a variety of ways of seeing, cognitive maps and vocabularies are involved. With issues such as "global warming", for example, the problem or idea is mutually agreed upon as being important by participants from various disciplines. However, these cases are rare.

In terms of pedagogy, the concept of idea dominance highlights the importance of students coming from interdisciplinary undergraduate studies with a clear idea of the dominant ideas of their discipline(s). Graduates should be able to distinguish ideas that belong to certain disciplines from those that are interdisciplinary in nature and to recognise a dominant idea from a weaker idea. They must also be able to raise appropriate questions, that is, "legitimate" questions from the perspective of their discipline, in order to critique ideas from both disciplinary and, if appropriate, interdisciplinary perspectives (Davies and Devlin, 2007b). This is a hard task, and a hard *ask,* as well.

4.4 The Effects of Breadth on Depth

It is likely that students will usually want to study a discipline in which they are interested and/or in which they believe they have some natural talent. For example, students who have skills in mathematics are likely to be attracted to the study of Mathematics, Physics, Engineering or similar subjects. Likewise, students with talents in language-rich subjects are likely to want to study in the Humanities, Law, the Social Sciences, and related areas. Therefore, if interdisciplinary study is, or becomes, compulsory at an institution, this may disadvantage students who do not have broad interests. It has been noted that: '… disciplinary competence is sometimes at odds with broad interests and imaginative speculation' (Petrie, 1976, p. 10). These observations may be more

relevant to research efforts than to the teaching and learning arena but they are worth noting in the latter context.

There is evidence that individuals who are outstanding in a particular discipline—as opposed to being very good—tend to be very narrowly focussed in their skill area. Petrie (1976) asserts that: '…one tends to see good disciplinarians uninterested in interdisciplinary efforts, and many who are interested seem to have marginal disciplinary competence' (Petrie, 1976, p. 10). It is possible that becoming an excellent disciplinarian demands undivided focus. Expertise is also the result of substantial amounts of training, and the empirical evidence suggests that this training is not transferable (Chi, Glaser, & Farr, 1988; Johnston, 2003).

Johnston (2003) claims that disciplinary experts perceive 'meaningful patterns in their own domains better than non-experts. They also use more higher order principles to solve problems, work faster and more accurately, are better self-monitors, more easily comprehend the meaning of data, recognise the relative weighting of variables and have better domain-specific short and long term memory (Johnston, 2003). It may be that expertise is a necessary requirement in disciplinary studies in order for "excellence" in a discipline to occur. This degree of specialisation, single-mindedness and focus required for expertise to occur brings challenges in a university that has the stated aim of pursuing interdisciplinary education. However, as Marginson (2007) has noted "expertise" among mature scholars and "expertise" among undergraduate students are very different notions (pers. com. 15/6/07).

The balance between disciplinary focus and interdisciplinary relationships is difficult to navigate practically and demands careful judgement. As noted elsewhere:

> If one is not … extremely adventurous and extremely interested in the project, the rewards which accrue simply due to disciplinary competence are likely to pull an [extremely competent] individual away from the interdisciplinary effort. Likewise, the person of extremely broad interests but lesser disciplinary talent may feel the project is going well, when it, in fact, never gets beyond the superficial (Petrie, 1976, p. 11).

While cutting edge work does go on in the margins of disciplines, basic and foundational work remains within a discipline. Students need enough exposure to key disciplines to learn key ideas, and to be able to move outside their discipline to obtain interdisciplinary perspectives when necessary or appropriate. Again, this is challenging to achieve in higher education.

4.5 Valuing Interdisciplinarity within the Institution

Another important pedagogical issue is the institutional setting in which interdisciplinary work goes on (Petrie, 1976). It is important to set up institutions appropriately for interdisciplinary exchanges. More specifically, an appropriate system of rewards and institutional support, promotion, seed funding, release time, teaching and innovation grants and recognition, and the like are necessary in order that purposeful and directed interdisciplinary work in teaching and learning can occur. These rewards need to be directed specifically to *interdisciplinary* work. At present, the principal recognition and rewards systems for academic staff at most universities are by means ofthrough disciplinary channels such as publication in top-tier disciplinary journals, evidence of having advanced their discipline, teaching awards for teaching undertaken in a discipline, and so on.

While there is some evidence that this is beginning to change with, for example, the emergence of a number of interdisciplinary journals, in the meantime, staff existing recognition and rewards systems will continue to drive behaviour and interdisciplinary work may not flourish. Without the necessary institutional policy settings for interdisciplinarity, students, too, may perceive that the

work that "matters" is being done in the disciplines and not the *inter*-disciplines. In such circumstances, there is a risk that interdisciplinary work might be seen as token parts of the educational experience and may not be taken seriously (Davies and Devlin, 2007b).

5. Preparing for and Managing Change in Higher Education

As an increasing number of universities begin to consider (or, in some cases, reconsider) moving toward interdisciplinary higher education, issues related to change management become critical. There are a number of considerations in preparing for and managing change if the traditional disciplinary focus of universities begins to shift to a more interdisciplinarity focus. This chapter concludes with a brief outline of some of these challenges and some ways in which they might to managed and/or addressed.

- *Induction and preparation of students for entry into new disciplines:* When students take subjects outside the broad discipline area towards which they may have a natural inclination and in which they have chosen to focus their efforts, particular attention must be given to the preparation of students for such multidisciplinary and interdisciplinary experiences. Because students may not be naturally inclined toward, or adequately prepared for, these subjects, they are likely to need explicit induction into the academic discourse of unfamilar disciplines. This is particularly important if students are taking interdisciplinary subjects that are very different from their core discipline(s). It should not be assumed that, for example, a student undertaking a Physics major can seamlessly adapt to studying Art History.
- *Language checklists:* The requisite vocabularies are likely, in many cases, to need to be explicity taught within each disciplinary and interdisciplinary setting. The preparation and use of "checklists" or glossaries of key terms designed for each discipline and appropriate to each level of study might be helpful. These would be useful to both students focusing in the disciplines concerned and to students taking interdisciplinary subjects.
- *Cognitive maps:* Induction into an academic discourse and particular way of knowing and seeing the world will, of course, take much more than checklists. As a pre-cursor, it may be necessary for academics from Faculty disciplines to devise minimal levels of disciplinary competence in the cognitive maps required for a graduate from each discipline so that a staged process toward building those maps may be possible through disciplinary and interdisciplinary study. The introduction of "bridging" or intensive preparatory programs that are integrated into the curriculum may need consideration. And clearly, particular attention will need to be paid to the ways in which assessment practices will ensure and uphold standards and help determine student understanding and readiness to advance to the next level of study and to graduate.
- *Benchmarking disciplinary knowledge:* It may also be necessary to put in place mechanisms to benchmark standards with students and/or graduates studying elsewhere where an interdisciplinary focus is *not* emphasised in the curriculum. This would ensure that students participating in interdisciplinary higher education are not being penalised in terms of their learning, or being given a less rigorous education in core discipline areas. One way such quality assurance might be achieved is to ensure graduates meet benchmarked standards in the conceptual requirements of the discipline by comparing their learning outcomes with those of with "single discipline" graduates from other comparable institutions.
- *Fostering interdisciplinary exchanges:* In order to encourage interdisciplinarity, it might also be beneficial for the university to put in place mechanisms to recognise when interdisciplinary exchanges occur naturally—that is, when discipline problems demand them. These exchanges might be between students, staff and/or staff and students. Processes to detect viable exchanges and ways to foster them would be helpful. In order to create and

maintain an environment where such exchanges might occur, processes also need to be put in place to allow students to gain enough expertise to recognise the value and need of interdisciplinary study and work. Formal "fieldwork" programs, on-site experience, mentoring arrangements in real work situations, involvement in undergraduate workshops and conferences, and similar mechanisms will be likely to assist in the creation of such an environment.

- *De-centring programs:* In terms of preparing and supporting the on-going development of staff for multidisciplinary and interdisciplinary environments, new academic development programs may be necessary. These might focus on developing a "de-centring" of the academic self of the participants and facilitating an appreciation of different world views. This would, perhaps, promote critical 'conversations between disciplines, whilst retaining the integrity of those disciplines' (Davidson, 2004, p. 302). One possible effect of such a program would be to encourage interdisciplinary teaching and learning across the curriculum. This should occur in a manner that does not violate disciplinary culture and values, and instead promotes dialogue between protagonists from different disciplines.
- *Evaluating interdisciplinarity:* The evaluation of interdisciplinary teaching and learning also needs careful thought. Recommended ways of undertaking this are outlined in detail elsewhere (Field & Lee, 1992b)**.** It has been noted that quantitative assessment measures are least valuable where the outcomes cannot be easily specified (as in the case with interdisciplinary studies). Qualitative measures which focus on student maturational development involving portfolio analysis, for example, have been useful in some contexts in determining the development of appropriate skills (Field & Lee, 1992b). Measures need to be discussed and agreed upon within an institutional context and the systems used must feed into both recognition and reward, and quality assurance programs in the particular universities in which this interdisciplinary activity is occurring. Appropriate evaluation and quality assurance processes in place would allow interdisciplinary exchanges to flourish within an appropriate regulatory framework while ensuring that the learning aims in academic disciplines are not compromised.

6. Conclusion

Any move by universities toward the incorporation of interdisciplinarity education involves a number of complex considerations. Such a move is likely to bring several advantages to student learning, and added institutional advantages to the enterprise of teaching and learning in higher education. These advantages are not typically found in traditional approaches to higher education through a focus on the discrete study of the disciplines. However, interdisciplinary higher education is also likely to bring considerable challenges, including the unique epistemological and pedagogical issues outlined in this chapter. It is hoped that the points raised in this chapter will promote and contribute to discussion to further advance interdisciplinary higher education into the future.

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