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!orthodoxies in multidisciplinary design-oriented degree programmes

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Abstract
In recent years there has been a rapid expansion of multidisciplinary degree programmes offered by Universities around the globe, with many being classified as design orientated or using the title Creative Technologies. This paper investigates one such degree programme and compares it to other discipline based programmes with which it overlaps. To obtain an understanding of the programmes, each is mapped in to Fink's Taxonomy of Significant Learning so that a comparison of the nature of the programmes can be made independently from the content. This analysis suggests that the multidisciplinary programme is in many ways an orthodox recombination of disciplinary approaches that potentially produces challenges in organising and structuring content so as to provide depth as well as breadth of coverage. This paper concludes with some open questions regarding curriculum development of design orientated, multidisciplinary degrees.
Design Education; Curriculum Design; Multidisciplinarity;

New multidisciplinary and design-oriented degree programmes are being established at a number of universities around the world. The work presented in this paper aims to contribute to the effort of understanding the best ways to define future programmes. To this end, this paper undertakes an analysis of the Bachelor of Creative Technologies (BCT) programme offered by Colab, the collaboratory for Design and Creative Technologies at the Auckland University of Technology (AUT). The goal of Colab is to develop new experimental alliances, research collaborations and learning experiences across overlapping disciplines. The BCT degree is seen as a key enabler of this goal. The flexible and experimental project-organised curriculum draws on philosophical notions of play, community and interaction to promote divergent thinking and to break, blur or transcend normative disciplinary boundaries (Connor, Marks, & Walker, 2015). In this context, the term Creative Technologies is used to refer to a multiplicity of design, communication, computing, engineering, entertainment, and manufacturing media. The BCT accepted its first intake of students in 2008 and has now gained sufficient maturity that a reflective consideration of its goals and achievements in the context of its origins is now appropriate to reshape and reframe its future. This paper outlines an attempt to classify and understand discipline-based programmes with a design orientation and poses questions regarding the nature of curriculum design for future extra-disciplinary degree programmes.

Background & Related Work

It has been argued that curriculum is the single most important concept in education, yet that established models of curriculum development have issues regarding their true validity, in part because they normally omit the needs of employers but also because such orthodox theories form a closed system where the development of curricula does not lead to new theories or models of curriculum development (Quinn, 1994). Whilst Quinn is specifically discussing curriculum development for healthcare, the same arguments apply to other disciplines as well as multidisciplinary programmes. In this paper, we acknowledge the definitions of multi-, cross-, inter- and trans-disciplinarity as defined in the literature (Bremner & Rodgers, 2013), however will consistently use the term multidisciplinary as the lowest common denominator to encompass all forms of “extra-disciplinarity”.
The need for multidisciplinary education can be traced in the literature to the 1960s and curriculum design approaches for these programmes emerged from the 1970s onwards. Jacobs (1989) presents some design options for multidisciplinary school programmes that predominately focuses on the reorganisation of existing units in different ways. The spectrum of design options presented range from purely disciplinary foci, through to parallel delivery and completely integrated programmes. However, the latter is best described more as a move towards a learning paradigm of problem based learning. In general, much of the early work on multidisciplinary curricula is very much focused on K12 education which confirms the observation of Quinn (1994) that curriculum design methods generally flow through from childhood education to adult education, without necessarily questioning the differences.

However, the move towards multidisciplinary teaching in universities has received some attention (Apostel, 1972), though many of the challenges noted in early literature still maintain a degree of relevance today. Newall (1990) discusses various different stances on how disciplines come together to form a multidisciplinary course and provides definitions around the differing levels of integration. However, Newall also goes on to observe that “Even the best team-developed interdisciplinary course can degenerate into a disciplinary course when it is taught by one faculty member from one disciplinary perspective.” (Newell, 1990, p. 77). The concept of disciplinary egocentrism (Connor, Karmokar &Whittington, 2015) is perhaps one of the most significant issues in the delivery of multidisciplinary curricula.

Newall goes on to describe the relationship between discipline based and multidisciplinary courses as “Since interdisciplinary study builds directly on the disciplines while offering a holistic counterbalance to the reductionist perspectives they afford, a curriculum that intersperses disciplinary and interdisciplinary courses allows each to build on the strengths of the other” (Newell, 1990, p. 79), which in a way echoes the views of Jacobs (1989) that multidisciplinarity is an extension of the disciplines achieved by combining elements of the disciplinary knowledge in ways that are driven by a particular focus.

More recent work on multidisciplinary curriculum design continues to express the stance that multidisciplinary education is predominately a case of integrating disciplinary knowledge in different ways (Drake, 2007) and this is normally through the use of problem based learning. This raises a question that given the relatively limited timescale of most degree programmes, typically 3 or 4 years, how do curriculum designers select the most appropriate problems for deployment in the programme such that the most appropriate disciplinary knowledge is integrated in such a way that graduates of the multidisciplinary degree have an appropriate coverage of breadth and depth of knowledge, meet the professional expectations, and are prepared to undertake life-long learning of emerging knowledge and skills. Following Darbellay (2014), an underlying question of this work is whether multidisciplinary degree programs can be more than a combination of existing disciplines, and in what ways may the future development of such programmes “embody rethinking disciplinary identities that calls for the *dedisciplinarisation* of academic structures”.

The work presented here fits in a dynamic landscape where new multidisciplinary programmes are being established in universities across the world, in particular a ‘design-oriented’ type, i.e., with a strong focus on the hands-on synthesis and development of tangible or virtual artefacts, in contrast to analysis-oriented degrees (Gupta et al., 2003). Such programmes include: Integrated Design and Management –MIT (idm.mit.edu), Design-Centric Engineering -NUS (www.eng.nus.edu.sg/edic/dcp.html), Dyson School of Design Engineering - Imperial College (www.imperial.ac.uk/design-engineering-school), Segal Design Institute - Northwestern University (segal.northwestern.edu), MBA in Design Strategy - California College of the Arts (www.cca.edu/academics/graduate/strategy-mba), and Singapore University of Technology and Design (www.sutd.edu.sg). The following section outlines the design of a preliminary investigation into multidisciplinary curriculum design based on a retrospective analysis of an existing multidisciplinary programme.

Research Design

This paper presents an analysis of degree programmes across disciplinary boundaries as a preliminary step for the evidence-based development of future undergraduate and postgraduate degrees. The aim here is to map a number of more ‘traditional’ programmes, i.e., those that have been offered for decades in universities around the world with minor variations across curriculum and graduate profiles. The study also includes one recent degree programme explicitly conceived to integrate knowledge and skills across disciplines, as a way to capture the presumed differences between the traditional and more recent degrees.

The main selection criterion for programmes in this analysis is design-orientedness (Gupta et al 2003). Although each of these degrees has a strong disciplinary origin, in many regards they share a focus on project-based instruction where students engage in hands-on synthesis of artefacts. The taxonomy of significant learning depicted in Figure 1 (Fink 2013) is adopted here as a means to structure the analysis of these programmes, focusing on the graduate profiles described for each case. Six levels or types of learning are captured in this framework starting with foundational knowledge (F) or understanding and remembering facts, terms, formulae, concepts, and principles. Each kind of learning in this framework can stimulate higher kinds of learning. Application (A) is the second type of learning, encompassing skills and reasoning (critical, creative, practical), problem-solving and decision-making. Communication, technology, and project teamwork are included in this level. Integration (I) refers to the third type of learning, making connections, finding similarities, establishing links among ideas and people within a field, and across domains and experiences. Human dimension (H) refers to learning about one's self as well as understanding and interacting with others. Caring (C) includes identification and modification of one's feelings, interests and values. The highest level is learning to become a self-directed learner (L), and to formulate and tackle new questions.

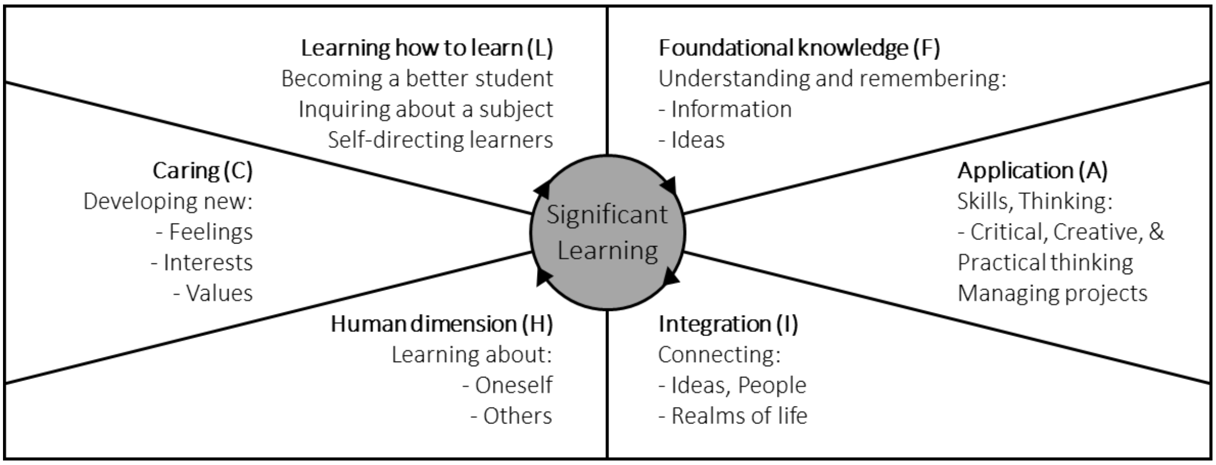


Figure 1. Six types of learning form significant learning: Foundational knowledge, Application, Integration, Human dimension, Caring, and Learning to learn (Fink, 2013)

Research Question

The main research question that drives this study is: "What types of learning are addressed by multidisciplinary degrees compared to more traditional degree programmes?" Derived from this, "Do multidisciplinary programmes show a combinatorial or summative character where types of learning from traditional degrees are aggregated?", and "What are the types of learning covered and overlooked in design-oriented degrees that can be addressed in future multidisciplinary programmes?"

Methodology

The data collected for this study consists of the graduate profiles (GP) listed for six undergraduate degree programmes offered in the Faculty of Design and Creative Technologies (DCT) at Auckland University of Technology. This Faculty encompasses the schools of: Art and Design, Communication Studies, Engineering, Computer and Mathematical Sciences, and Colab: Creative Technologies. The six undergraduate degrees selected here have a duration of three years full-time (360 points), Table 1 shows their full names and their acronyms.

Table 1. Degree programs analysed in this study

Degree programme	**Acronym**
Bachelor of Communication Studies - Creative Industries Major	BCS
Bachelor of Engineering Technology - Computer and Mobile Systems Major	BEngTech
Bachelor of Computer and Information Sciences	BCIS
Bachelor of Design - Digital Design major	BDes (Digital)
Bachelor of Design - Product Design major	BDes (Product)
Bachelor of Creative Technologies	BCT

The GPs collected for these programmes vary in length from 10 to 37 statements describing the intended graduate attributes. A total of 114 entries were classified using a lexical approach conducted individually by the co-authors of this paper. An initial inter-rater agreement level of 0.87 increased to 0.97 after cross-checking and deliberation. Most GP attributes map directly onto the types of learning, for example the statements "*graduates have a broad understanding of business and the relationships between different disciplines*" and "*graduates have sound knowledge of the theoretical basis for the operation of instruments, devices and apparatus*" fall under the Foundational knowledge (F) type. Similarly, "*graduates have practical skills to use pilot plant, laboratory and workshop equipment proficiently*" and "*graduates have the ability to think laterally and develop creative ideas*" are representatives of the Application (A) type.

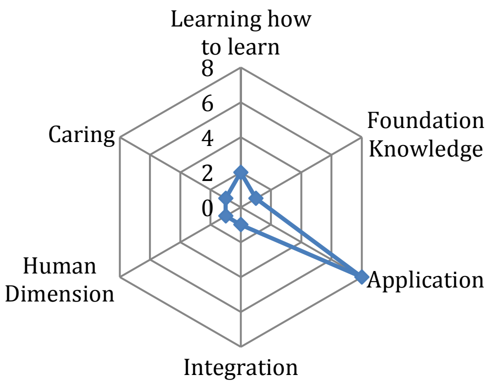
The main source of disagreement in the lexical analysis consisted in statements that conflate more than one attribute, for example "*graduates have the ability to work effectively with others, to formulate and express views appropriately, to evaluate the performance of oneself and colleagues in a realistic and constructive manner. This requires the application of specific techniques and the development of qualities (e.g. sensitivity to others, self-awareness) that enhance awareness and communication*", which in its initial formulation falls under Application (A) but the second half aligns with Human dimension (H). A uniform decision was made that higher levels of abstraction in the taxonomy subsume lower levels, so that particular statement is classified as H. As a result, each GP statement has a single classification. The following section presents the profile for each degree programme.

Results

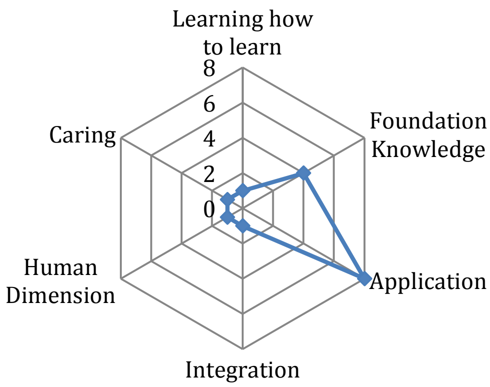
The lexical analysis approach outlined in the previous sections was applied to a set of degree programmes offered in the Faculty of Design & Creative Technologies, as outlined in Table 1. One of the challenges in this analysis has been the degree of variation in how GPs are constructed for different programmes. Some programmes have a significantly higher number of graduate attributes and so a simple normalisation is applied to the degrees that have a significantly greater number, the BCS and BEngTech. This normalisation involves scaling the number of classified attributes in each category such that the highest number of reported attributes is 8, which is comparable to other programmes. Such a normalisation can be supported by analysis of the graduate attributes of the programmes which indicates that there is some degree of overlap. For example, the Creative Industries major in the BCS degree has two graduate attributes; namely to "*demonstrate practical and creative skills in a variety of media to a level acceptable for entry into careers in communication*" and "*be familiar with skills required across the broader communication industry and be able to meet requirements for specialist competency in the area in which they intend to make their career*". Whilst a reduction of the overlapping graduate attributes is perhaps a more exact approach, the normalisation is utilised at this stage as an approximation method.

The outcomes of the lexical analysis are presented here in graphical form, where the high level components of Fink's Taxonomy of Significant Learning are represented as axes on a radar diagram. On each axis is marked the number of graduate attribute statements that have been classified as representing that element of the taxonomy. The total number of graduate attribute statements in the GP can therefore be calculated by summing the values reached on each individual axis. The overall shape of the resulting plot can be viewed as describing the "flavour" of each degree. Figure 1a shows the results of the lexical analysis for the Creative Industries Major of the BCS degree. This degree has the most detailed GP, with a total of 37 graduate attributes and a maximum of 23 statements in one class prior to normalisation. Sample statements are given for the main types of learning in the BCS degree, namely:

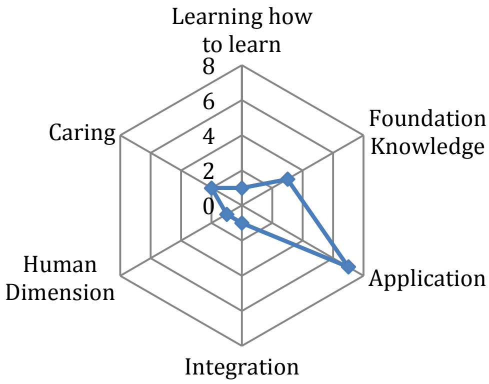
- "*Graduates demonstrate practical and creative skills in a variety of media to a level acceptable for entry into careers in communication*" (A)
- "*Recognise the importance of cultural difference and respond to such differences in a sensitive and supportive way*" (H)
- "*Understand and apply knowledge gained as a basis for a life-long process of learning*" (L)



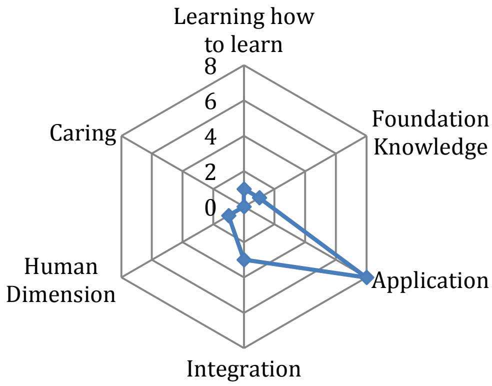
(a) BCS (Creative Industries)



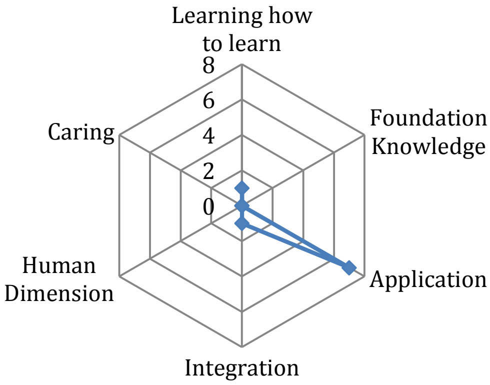
(b) BEngTech (Mobile & Computer Engineering)



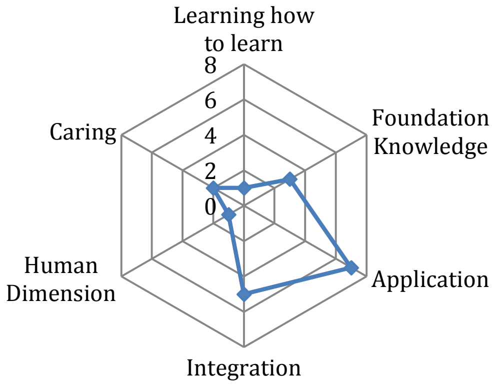
(c) BCIS (Software Development)



(d) BDes (Product Design)



(e) BDes (Digital Design)



(f) BCT

Figure 1: Bachelor of Communication Studies (Creative Industries Major)

Figure 1b shows the outcomes of the same analysis when applied to the Mobile & Computer Engineering major of the BEngTech degree. This degree also has a relatively high number of graduate attributes listed in the GP, reaching a maximum of 12 in one class prior to normalisation. Sample statements are given for the main types of learning in the BEngTech degree, namely:

- "*Graduates have sound knowledge of the methods of design in order to produce efficient and effective design solutions*" (F)

- “*Develop skills, understanding and operate sophisticated instrumentation and precision devices and interpret their results and readings*” (A)

Figure 1c represents the classification of the Software Engineering major of the BCIS degree. Sample statements are given for the main types of learning in the BCIS degree, namely:

- “*Graduates have independent, critical and reflective judgement*” (A)
- “*Graduates have a sound understanding of software development methodologies and practices*” (F)
- “*Graduates have an understanding of the role of information technology and its impact on the environment*” (C)

Figures 1d and 1e describe the results of two majors within the BDes degree, namely the Product Design and Digital Design majors. The two majors share the same general graduate attributes of the Bachelor of Design to which are added a number of major specific attributes. Sample statements are given for the main types of learning in the BDes (Product) degree, namely:

- “*Graduates have the ability to think laterally and develop creative ideas*” (A)
- “*Graduates can communicate and effectively collaborate with a range of individuals, groups and/or related companies during the product design process*” (I)
-

Sample statements are given for the main types of learning in the BDes (Digital) degree, namely:

- “*Graduates be vocationally valuable by preparing graduates for professional and business practice*” (A)
- “*Graduates provide a mix of theoretical concepts and knowledge and practical application within national and global contexts*” (I)
-

The implications of these classifications will be discussed later in this paper, following the presentation of results for a multidisciplinary degree. Figure 1f shows the outcomes of applying the lexical analysis approach to the BCT degree. Sample statements are given for the main types of learning in the BCT degree, namely:

- “*Graduates demonstrate skills of self, colleague and task management*” (A)
- “*Graduates work within and between a range of interlinking technological domains*” (I)
- “*Graduates develop specialised knowledge and capabilities*” (F)
-

The following section discusses the results of the lexical analysis for all of the programmes analysed in this paper, with specific reference to the implications for the curriculum design of future multidisciplinary design programmes.

Discussion

The analysis of the raw results of the lexical analysis is problematic due to the differences in scale of the GPs. It is acknowledged that lack of consideration of the relative weighting of different GP statements based on scale and scope of the profile is a limitation of the current work. At the time of writing, all GPs at the university are being rationalised and updated which will result in more coherent GPs which will address this limitation.

Analysis of both the raw and normalised results can show similarities in that all programmes demonstrate a definite spike in terms of a bias towards Application (A), which can be considered as early validation of the selection criterion applied here. Design-oriented degrees are expected to have a strong emphasis on hands-on synthesis activity, delivered via project-based and problem-based pedagogies. Further work needs to be carried to confirm this as a defining factor, for example by direct comparison to other, more analytical, degrees. It is assumed that a greater number of attributes may imply more detailed definition of graduate outcomes rather than a thinning of actual coverage of material during the delivery. An alternative approach to using GPs would be to consider the use of learning outcomes (LO) in the course descriptions that provides a different level of granularity in the analysis that is likely to result in outcomes that are more comparable. This was carried as part of this preliminary study with 40 LOs extracted from the core elements of BCT, obtaining a profile slightly different to that obtained by analysis of the GP as shown in Figure 2.

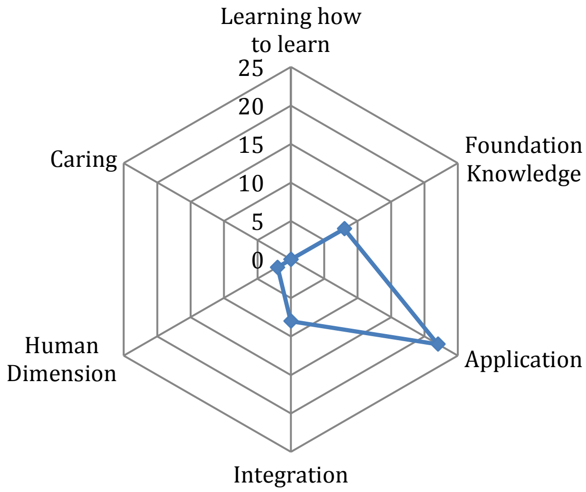


Figure 2: Learning outcome based analysis of the BCT degree

Whilst this difference is small, it does suggest a possible difference between the stated goals of the programme and the actual delivery. Further analysis of all programmes based on LOs would provide additional insight in the nature of the programmes.

Both the BCIS and the BEngTech stand out as having a higher focus on Fundamental Skills than other programmes. Given the common perception of the disciplinary nature this is not unexpected, though many researchers are arguing that the traditional body of knowledge associated with engineering programmes needs to be rethought in order to prepare graduates to solve problems that have no recognisable disciplinary boundaries (Rugarcia, Felder, Woods & Stice, 2000). Similarly, the higher focus on Integration of the Product Design major in the BDes is also explained by the use of principles from different fields to solve design problems

Whilst there are minor variations in “flavour” across this set of disciplinary programmes, surprisingly in many regards they show very little distinctiveness with a very strong focus on Application (A). The generalised low scores in Human dimension (H) and Caring (C) may be viewed as an opportunity to integrate sustainability principles into the curriculum of future programmes.

Envisioning future multidisciplinary programmes

An orthodox approach to designing a multidisciplinary degree would be to combine elements from existing programmes in such a way that common ground isn’t repeated and distinctive elements are integrated. One possible outcome of such an orthodox approach can be constructed from the data collected by aggregating the maximum value on each type of learning in Fink’s taxonomy. The outcomes of such an exercise are shown in Figure 3, where the aggregated outcomes are compared directly to the BCT degree.

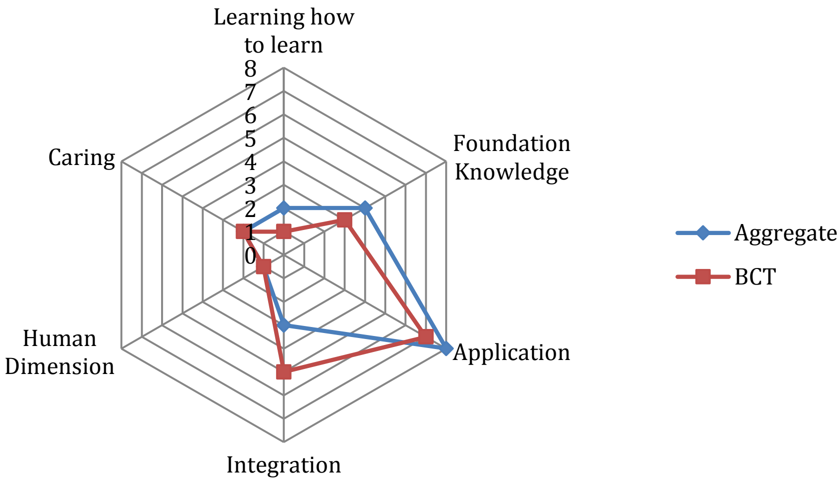


Figure 3: A fictitious aggregate degree compared to the BCT degree

Whilst this paper explicitly avoids the question as to whether a graduate profile with more attributes results in less depth of coverage, the comparison of the fictitious programme with a real multidisciplinary degree poses a similar question. When elements of existing programmes are recombined using orthodox thinking:

a) Is there sufficient time within a single degree to provide adequate depth to a graduate?
b) What are the opportunities to innovate in terms of breadth/depth and learning experiences?

c) How may future degrees incorporate new elements, beyond combining previous parts of traditional degrees?
d) Are multidisciplinary degrees producing graduates that have the correct profile to address complex, societal needs?

It is arguable that a disciplinary degree should focus on Foundation Knowledge, Application and to some extent Integration. In contrast, by definition, a multidisciplinary graduate is likely to have a stronger role in integrating work across domains, and ensuring that it meets human, societal and environmental needs while doing so. It is also possible to regard multidisciplinary degrees as more dynamic, continuously evolving as knowledge and skills from different areas are recombined in practice, therefore requiring a stronger capacity of graduates to develop self-directed learning.

If orthodox thinking in terms of recombining existing elements produces graduates that do not have these abilities, it may be time to invert the curriculum design process. This could be achieved by starting with an understanding of how the graduate attributes should map in to the taxonomy of significant learning (Fink, 2013), and then construct the graduate profile and learning objectives accordingly.

Conclusion

This work was initiated by asking whether multidisciplinary degree programs can be more than a combination of existing disciplines. In these early stages, the types of learning experience across a set of related degree programmes was analysed in order to identify the similarities, differences and gaps in the graduate profiles of future design professionals across disciplines. Based on the early results presented above, a number of questions are raised and a modified curriculum design process is framed.

From a theoretical viewpoint, distinctions have been formulated between combinatorial and transformative change. Two alternative lenses co-exit: the first group distinguishes between combination from mutation and analogy (Gero, 1996; Cross, 1997) or transformational (Boden, 2001; Buchanan, 2001) or discovery (Roskos-Ewoldsen et al., 1993). Adopting these views, the design of future multidisciplinary programmes requires approaches beyond aggregating attributes and objectives across disciplines. A second group argues that all novelty comes from combination, for instance new concepts emerging from the interaction of old concepts in new situations (Schön, 1963), and all creativity modelled by combinatorial processes (Ward et al., 1997; Simonton, 2013; Weisberg, 1993; Koestler, 1964). Either way, the initial step presented here based on the analysis of the types of learning across design-oriented degrees serves as a platform to examine and negotiate open curriculum design challenges. Whether the distinction is one of type or degree, the creative construction of successful multidisciplinary design degrees is likely to emerge at “the intersection of individuals, domains, and fields” (Csikszentmihalyi, 1999).

Much work remains to be done. According to Fink (2013) the triad that shapes significant learning includes types of learning, teaching and learning activities, and assessment. A thorough analysis will require the inclusion of these important, albeit less explicit characteristics of a university degree.

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