

The Surprising Persistence of Biglan's Classification Scheme

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Abstract

In a rather simple and narrowly focussed study in 1973, Anthony Biglan developed a classification scheme for academic disciplines that has become a standard part of educational vocabulary: for example, researchers commonly refer to mathematics as “hard-pure” or education as “soft-applied”. However, the evidential base for this scheme is weak. The small number of attempts at validating the scheme have relied on discriminant function analysis with small samples. Almost all of these studies have been in the US and few have been undertaken in the last twenty years. However, this paper will demonstrate that Biglan’s scheme appears to be an extremely close fit for the current higher education system in the UK. It suggests that the scheme remains at the heart of the organization of subjects at universities and, contrary to recent existing literature heralding the death of disciplines, they remain key for understanding how higher education is organized.

Keywords: Disciplines; Higher Education Systems; Biglan Classification Scheme

1 Introduction

In the early 1970s, faculty at a small US liberal arts college received envelopes in the mail. Inside were around thirty slips of paper with subject titles (ranging from “mathematics” to “dairy science”) on them. They were instructed to staple groups of slips together, based on similarity of subject matter and to mail them to the researcher, Anthony Biglan. On the basis of this (and a similar card sorting task at one US university), he developed a scheme for classifying subjects into discipline groups that has since become widely adopted.

The Biglan classification scheme (Biglan, 1973a) is probably the most cited organisational system of academic disciplines in higher education. While Jones (2011) places it alongside the model from Smart, Feldman, and Ethington (2000), Biglan’s scheme is cited more than five times as often, even accounting for its earlier publication. It has received widespread use in many analyses within higher education including teachers’ reflective practice (Kreber & Castleden, 2009); the relationship between class size and grades (Johnson, 2010) and even the proportion of positive result reported in hypothesis testing papers (Fanelli, 2010).

The scheme was developed by asking academics at two US institutions to group together disciplines according to their perceived similarity. These groupings were then analysed using a multi-dimensional scaling technique to identify ‘dimensions’ along which the disciplines appeared to differ. The first of these dimensions was interpreted by Biglan as ‘hard/soft’ which he interpreted in terms of Kuhn’s notion of ‘paradigm’ (Kuhn, 1962) – distinguishing ‘hard’ subjects which have a body of theory ‘subscribed to by all members of the field’ (Biglan, 1973a, p. 201) from ‘soft’ ones in which ‘content and method . . . tend to be idiosyncratic’ (p. 202). The second was interpreted as ‘pure/applied’ and distinguished concerns with application to practical problems. The final dimension was described as ‘concern with life systems’ (but is often labelled ‘life/nonlife’ e.g. Stoecker, 1993) differentiating those dealing with human or other biological systems and those dealing with abstract or inanimate systems.

Despite Biglan’s identification of continuous dimensions on which disciplines vary, the analysis has been almost universally used as a system of dichotomies in which the planes splitting the octants of the resulting three-dimensional pattern of disciplines neatly cleave them into hard vs. soft; pure vs. applied and life vs. non-life categories. Indeed, in a companion piece published the same year, Biglan himself set the pattern of compressing the continuous into the discrete (Biglan, 1973b). Moreover, the third dichotomy (life/non-life) gets much less recognition than the other two, with less than 10% of the research citing the classification scheme adopting that split.

The value of the classification scheme has been shown repeatedly through its application. Various studies have shown that hard/soft and pure/applied differences correlate with differences in many other properties: differences in students’ theories of knowledge (Paulsen & Wells, 1998); job stress (Barnes, Agago, & Coombs, 1998) even variation in training for academic leadership roles (Del Favero, 2006).

Some research has set out to test Biglan’s scheme empirically. At its simplest, empirical support for the validity of Biglan’s distinctions has been claimed in research that has shown differences between disciplinary groups: for example, Muffo and Langston (1981) claimed that differences in salary across

pure/applied, hard/soft and life/non-life splits supports Biglan's categorisation. Other research sets tougher tests for the classification scheme by showing that the three dichotomies can be recovered from an analysis of the eight groupings formed by their Cartesian product. For example, Smart and Elton (1982) used responses from 800 faculty (100 each in disciplines from the eight groups defined by the three dichotomies) to a survey on their attitudes and academic activities. Using discriminant function analysis, they uncovered three dimensions that distinguished the centroids of seven of those eight groups in the ways expected. A similar approach was taken by Stoecker (1993) who used discriminant function analysis to examine faculty responses to a widely circulated survey. She not only recovered seven of the eight groups from her analysis, but was also able to begin to classify previously unexamined disciplines.

Indeed, one concern with Biglan's original study is that he classified only 35 different disciplines at two institutions. These later validations of the scheme used academics from a far wider range of institutions, but took Biglan's classification as given. Stoecker (1993) was able to reliably classify two further disciplines (nursing as soft/applied/life and dentistry as hard/applied/non-life) but noted concerns that she was unable to reliably classify other disciplines. However, Drees (1982) undertook a discriminant analysis of data from a wide survey of US academic and used the discriminant function to classify a total of 76 disciplines into the three dichotomies. This appears to be the most comprehensive classification of disciplines into Biglan's categories.

Such expansions of the scheme are not without criticism: Stark (1998) noted that while the underlying distinctions may be valuable, not all authors agree on the match between disciplines and the groups defined by Biglan's dichotomies and some categorisations based on the extracting discriminating function may not fit with one's usual interpretation. For example, it may make sense that Stoecker (1993) classified dentistry as both hard and applied, but it is not clear that it fits with the interpretation of 'non-life'. However, the approach of Drees (1982) and Stoecker (1993) to testing Biglan's scheme is important in providing evidence of some level of predictive validity of their discriminant functions: they show that their analysis not only recovers almost all of the eight groups into three dichotomies, but that unclassified disciplines can be classified in ways which, at least partially, fit the existing interpretation.

However, discriminant function analysis is not the hardest test for Biglan's scheme. It does not directly recover the subject-to-discipline-group relationship. For example, it does not check whether mathematics, chemistry and physics group closely but separately from a group containing history, philosophy and literature. It presupposes the existing eight groupings and tests to see if extracted combinations of independent variables produce three dimensions which neatly cleave the centroids of those groupings into hard/soft, pure/applied and life/non-life. They do not recover the classification scheme itself: that is, they do not recreate the relationship between the particular disciplines and the dichotomies.

Moreover, the studies have all been conducted in similar contexts. Concern was raised about Biglan's original work being applicable even across the range of US institutions (Smart & Elton, 1982) and while many of the studies detailed above cross different institutional types, they have all been conducted in the US higher education system. Indeed, many non-US studies apply the Biglan scheme to other contexts without comment on the potential differences in culture. For

example, Mastekaasa (2005) uses it in the analysis of gender differences in recruitment to Norwegian doctoral programmes. In addition, although he noted clear differences between higher education in different countries, Becher (1989) merges Biglan’s classification scheme (based on analysis of academics) with the one developed by Kolb (1981) – also derived in the US, but based on quite different sources of data¹ – to provide a framework for distinguishing disciplines to place disciplines into categories in general.

This paper describes a surprising recovery of parts of the Biglan classification scheme with very different (and simple) data, a different form of analysis and in a different educational context. Moreover, it goes beyond existing validations of Biglan’s model by recovering not just the dimensions, but an accurate re-creation of the discipline-to-dichotomy relationship.

2 Disciplines and Institutions

In the UK, undergraduate degree courses are delivered by a wide variety of institutions. There are some specialist institutions which deliver a restricted range of subjects such as arts or music and some colleges of further education deliver a small number of degree programmes alongside their main predominantly vocational further education provision. Even institutions which deliver courses across a wider range of disciplines (and thus fit the part of the definition of ‘university’ from Denman, 2005 concerning the variety of programmes) have differing patterns and emphases.

In 2009, the UK government mandated universities to provide to the central Higher Education Statistics Agency (HESA) a range of data for each degree programme which they deliver. This data (the so called ‘key information set’ or KIS) includes information ranging from the number of university managed beds through to the proportion of written assessment in each year of each degree programme. The KIS data is coded, at course level, by discipline based on the ‘Joint Academic Coding System’ (JACS). This has three nested levels: for example, a degree course which is called a BA in History is coded at the broadest level (which has 21 codes) as ‘historical and philosophical studies’ and the second level (which has 42 codes) as ‘history and archeology’ and at the finest level (with 108 codes) as ‘history’. It is open to institutions to code their degree courses as they feel appropriate within this system and can code joint or combined degrees against up to three codes: for example, BA in Drama and Film Studies might be coded twice in the nested system as ‘creative arts and design’/‘performing arts’/‘drama’ and ‘mass communication and documentation’/‘media studies’/‘media studies’.

The approach taken in this paper is simply to analyse the pattern of disciplines (examined at the finest level in the JACS system) across institutions using a statistical method called ‘correspondence analysis’.

¹ Kolb’s model is often highlighted for its similarity to Biglan’s, though its development is starkly different: one of his two dimensions is based on the analysis of graduate students’ questionnaires on the importance of mathematics to their subject and the other on faculty engagement with consultancy. It is hard to imagine the rationale for combining two such different measures as an orthogonal axis system.

3 Correspondence Analysis

A simple, two dimensional contingency table might consist of entries which count how many objects in a sample fit into the different categories. For example, how many men and women play each different sport offered by a given sports centre; how many of eight different relevant breeds of fish are found in twenty different rivers or, in this case, how many different courses in each discipline are taught at different higher education institutions. Correspondence analysis shares some similarities with principal component analysis, in particular its aim is to reduce the number of dimensions which might represent the data to a particular degree of accuracy. In a contingency table in which one dimension has a relatively low number of different categories (such as gender in our fictional gender \times sports example) examining the structure of the table is simple: looking across the two rows of the table quickly shows which sports may be more popular with men or women, which have similar patterns of gender balance etc. When the number of categories increases, this is harder to accomplish: answering the question of whether some rivers might be grouped together in having similar patterns of fish or some fish might be seen as grouped because their proportions are similar in different rivers is hard to accomplish by eye in an 8×20 table.

The analysis was popularised in social studies after Bourdieu adapted the then little used correspondence analysis to examine relationships between different types of capital, such as social capital, economic capital and cultural capital (Lebaron, 2009). By working with a contingency table, correspondence analysis makes few assumptions about distributions and particularly avoids problems of using principal component analysis in situations where the data type and distribution do not warrant it; it directly relates row (or column) categories on the basis of similarity; it is model-free and can suggest underlying structure in the data which may be difficult to discern otherwise.

Like principal component analysis, it extracts dimensions in decreasing order of their contribution to the overall variance within the data (in the case of correspondence analysis, the analogue of variance is ‘inertia’) and by recoding the data against these new dimensions one can plot the data so that the distance between the points represents their similarity (two rows are close together if the inter-row χ^2 distance is small). This paper applies this technique to reduce the dimensions in the discipline \times institution table to see what similarities between disciplines can be discerned purely on the basis of their distributions across institutions.

The KIS data for courses starting in the academic year 2013-14 contained 26591 different degree courses. The nature of correspondence analysis means that disciplines taught at a small number of institutions, or institutions with a small number of courses will have disproportionately large influence. In particular, courses which are almost always taught in specialist institutions will have a very large ‘leverage’ in this sense. For example, an analysis with all 229 institutions which deliver any higher education courses and all 107 disciplines resulted in a primary solution in which agriculture, veterinary sciences and animal sciences lie in one corner of the resulting primary dimension solution and all the other disciplines were massed in the centre. Similarly a small number of specialist agricultural colleges dominated the primary institution dimension solutions. These are the results of an inappropriate heterogeneity of variance, so courses and institutions with very high leverage were considered outliers and

Table 1: Dimensions contributing more than 2% to the inertia of the correspondence analysis model

dimension	value	inertia (%)	cumulative interia (%)
1	0.321318	17.6	17.6
2	0.146521	8.0	25.7
3	0.091230	5.0	30.7
4	0.069890	3.8	34.5
5	0.067433	3.7	38.2
6	0.057522	3.2	41.3
7	0.052371	2.9	44.2
8	0.048724	2.7	46.9
9	0.047405	2.6	49.5
10	0.045890	2.5	52.0
11	0.043948	2.4	54.4
12	0.042319	2.3	56.7
13	0.038560	2.1	58.8
14	0.036828	2.0	60.9

removed.

This paper focusses attention on disciplines taught at more than 20 institutions and institutions which delivered at least 20 different programmes. In addition, only degree courses were considered (excluding foundation degrees and other diplomas and certificate routes). Thus the analysis involved 23734 degree courses split into 82 different disciplines and delivered at 113 institutions. Not all of these different disciplines are classified into Biglan’s scheme, even under the most extensive list compiled by Drees (1982). In all, 51 of the disciplines did adapt directly from the list and 31 did not. However, as noted below, this gives the opportunity to check the predictive validity of the solution by examining how it classifies these previously unclassified disciplines.

4 Results

A correspondence analysis was conducted on the 82×113 contingency table representing course count across disciplines and institutions. Joint courses were weighted (for example, a history and philosophy degree was counted as 0.5 under history and 0.5 under philosophy).

Table 1 shows the eigenvalues for each dimension which contributed more than 2% to the inertia of the model, along with their contribution. It is clear that no small number of dimensions can account for the majority of the structure in the contingency table (nor would one expect it to in this case), but the first two dimensions do account for over a quarter of the inertia.

What is more surprising is that these first two dimensions extracted, from the simplest of discipline by institution table, seem to correspond with great accuracy to two of the Biglan dimensions.

Restricting the view to disciplines which have already been classified into the Biglan scheme, table 2 gives a measure of how well each of the extracted

Table 2: Fit between extracted dimensions and Biglan categories

dimension	pure/applied		hard/soft		life/non-life	
	$\chi^2(1)$	p	$\chi^2(1)$	p	$\chi^2(1)$	p
1	33.6020	0.0000***	1.1802	0.2773	8.5478	0.0035
2	0.7737	0.3791	57.4983	0.0000***	0.9850	0.3210
3	0.0057	0.9400	0.7566	0.3844	0.2759	0.5994
4	0.1742	0.6764	0.0147	0.9035	2.2582	0.1329
5	0.5794	0.4465	0.4656	0.4950	2.4525	0.1173
6	0.6056	0.4364	2.3804	0.1229	3.0229	0.0821
7	0.0200	0.8875	2.4776	0.1155	0.6905	0.4060
8	0.9710	0.3244	2.4050	0.1209	1.5513	0.2129
9	0.3998	0.5272	0.0297	0.8631	0.4266	0.5137
10	0.7250	0.3945	0.1451	0.7033	0.4223	0.5158
11	2.2394	0.1345	0.0103	0.9192	1.0450	0.3067
12	0.0144	0.9046	0.1728	0.6776	1.8826	0.1700
13	1.4070	0.2356	0.6679	0.4138	0.3012	0.5831
14	0.1255	0.7231	0.0842	0.7717	0.5809	0.4460

dimensions fits with Biglan's. This strongly indicates that the first extracted dimension fits very closely with Biglan's pure/applied dimension ($\chi^2(1) = 33.6$, $p < 0.0001$) and the second fits very closely with Biglan's hard/soft dimension. ($\chi^2(1) = 57.5$, $p < 0.0001$). While the first dimension also appears to fit closely with life/non-life classifications, applying a Bonferroni correction for the number of tests being used in table 2 suggests this is not a significant fit and, indeed, it is worth noting that no other dimension in the model appears to fit the life/non-life classification.

Figure 1 shows the biplot of the 51 disciplines classified by Drees into hard/soft and pure/applied on the first two dimensions in the correspondence analysis model. It provides further supporting evidence that these two dimensions distinguish the disciplines very accurately. The logistic plots at the sides of the figure show how accurately the sign of the co-ordinates of the points in the model match the existing classification: in dimension 1, the sign of the co-ordinate accurately distinguishes pure from applied in 89% of disciplines and in dimension 2, the sign of the co-ordinate accurately distinguishes hard from soft in 95% of disciplines. Recall that the validity examinations of Smart and Elton (1982) and Stoecker (1993) by discriminant function analysis amounted to seeing if the dimensions extracted in the analysis correctly reclassified the eight groups into three dichotomies and both did so in seven out of the eight cases. In this analysis 51 disciplines are reclassified into two dichotomies with 89% and 95% accuracy. Moreover, a few of the courses which appear to have been inaccurately distinguished are those for which the literature does not have full agreement. For example, Law is classified as pure/soft by Drees, but as applied/soft by Stoecker. This analysis places it amongst applied/soft disciplines. Economics is classified as applied/soft by Drees and as pure/soft by Biglan. The analysis here places it close to pure/hard disciplines.

Recall, too, that Stoecker (1993) extended her validation of Biglan's scheme from her discriminant function analysis by seeing if the extracted function would

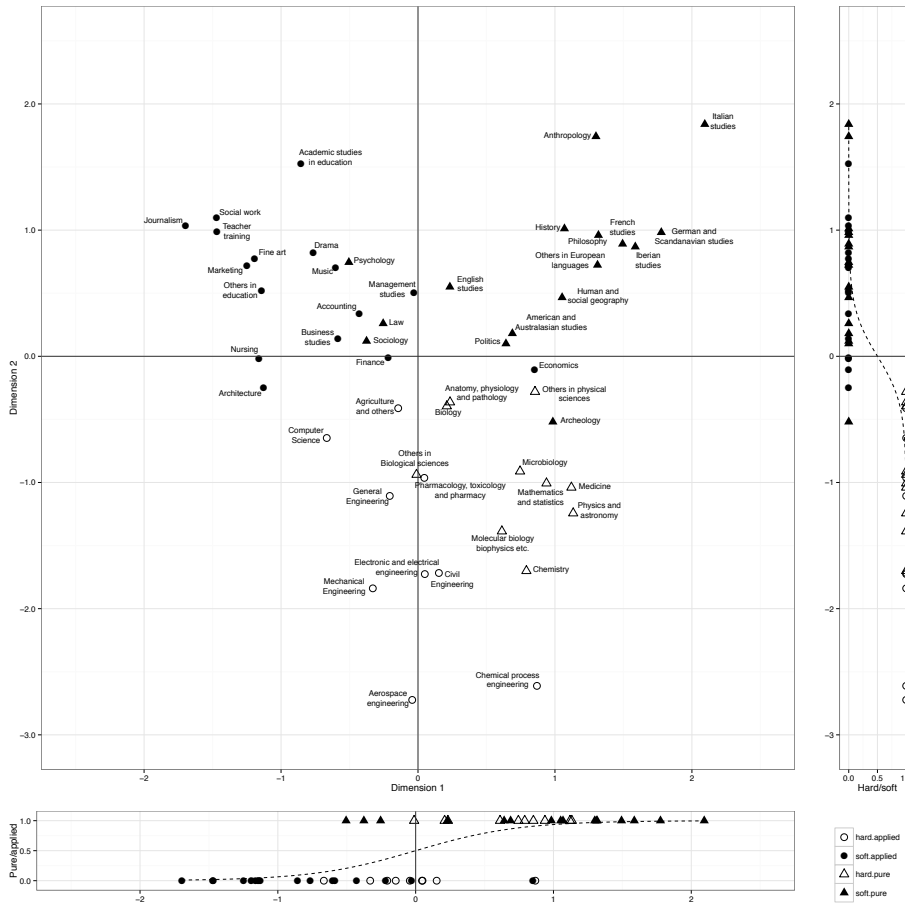


Figure 1: Correspondence analysis biplot on first two dimensions, with logistic plots, of disciplines with existing classification

classify previously unclassified disciplines. The correspondence analysis was conducted on the full discipline by institution contingency table (not just on those which had previously been classified) and so attention can be shifted to seeing where the unclassified disciplines appear on the biplot. Figure 2 shows the biplot with the unclassified disciplines identified by a cross and named (with the classified disciplines plotted, but unnamed to prevent the plot becoming unreadable).

The classification of these previously unclassified disciplines has some obvious face validity: theology and classics being identified in the soft/pure quadrant; geology and genetics in the hard/pure quadrant and so on. Note that the discriminant function analysis approach taken by Stoecker (1993) resulted in her only being able to claim a clear classification for two previously unclassified disciplines, but the correspondence analysis approach taken here gives relatively convincing positions on the biplot for a further 31 disciplines.

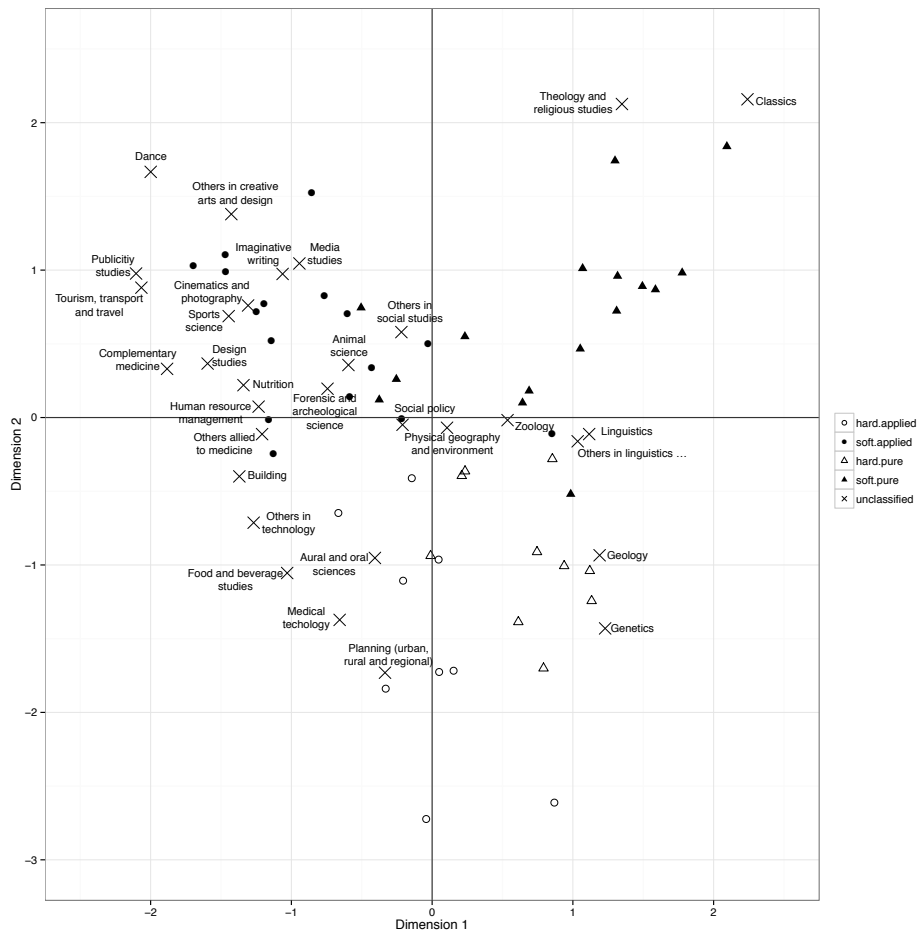


Figure 2: Correspondence analysis biplot on first two dimensions of previously unclassified disciplines

5 Discussion

This result is surprising. The analysis undertaken is very simple: correspondence analysis (like principal component analysis) reduces dimensions while retaining structure. It splits information from noise in the sense that the principal dimensions extracted contain as much of the ‘information’ from the structure and the later dimensions extracted contain the ‘noise’. In this case, the only information in the system is the distribution of disciplines across universities and the two principal dimensions which are extracted appear to correspond very closely to Biglan’s pure/applied and hard/soft respectively. Moreover, those two extracted dimensions not only distinguish previously classified disciplines accurately, they also distinguish previously unclassified disciplines in a way which has, at least, strong face validity.

Previous validations of Biglan’s dimensions have all come from analyses of independent variables derived from *within* a system. Smart and Elton (1982) used only academics from research institutions (which they described as “re-

search universities I or II in the Carnegie Commission (1973) typology of post-secondary institutions” p. 219), Stoecker (1993) used “faculty in research and doctoral-granting institutions” and Muffo and Langston (1981) used the same institution as Biglan (1973a), the University of Illinois. Indeed, all three noted concerns about the applicability of the classification scheme beyond these types of institution.

However, the analysis here comes from looking at patterns of discipline delivery *across* all (non-specialist) institutions: it is precisely the pattern of discipline delivery at different institutions which results in the model which matches the Biglan classification scheme so closely.

Of course, it should also be noted that the previous validations of Biglan’s scheme were all undertaken in the US higher education system. While the scheme has been used for research in countries as varied as Korea (Shin, 2011), Australia (Smith & Miller, 2005) and Canada (Kreber & Castleden, 2009), there appears to have been little previous attempt to see if the same classification scheme applies in these other countries, let alone see if the link between disciplines and the classification scheme matches up. This study provides strong support for suggesting that the pure/applied and hard/soft classifications do retain validity in the UK context and that the match between disciplines and classification is very close. In addition to being a different country, it is also a different time: the higher education system in the UK is radically different from that of the 1970s (when Biglan was developing his scheme) or even the 1980s and 90s (when the most comprehensive validations were undertaken) which makes the appearance of two of his dimensions as the most influential in the structure of disciplines across institutions all the more surprising.

We should note, however, that the third dichotomy – life/non-life – did not appear as an extracted dimension in this analysis and there could be many reasons for this. It could be that this aspect of the classification has less validity in the UK system than in the US. It could be that the life/non-life dimension is not truly orthogonal: Malaney (1986) noted a correlation between life/non-life and hard/soft and in our analysis there is a superficial (and non-significant) fit between pure/applied and life/non-life. It also appears that the distinction does not resonate with researchers: as noted above, less than 10% of research citing Biglan’s original paper uses the life/non-life distinction.

The question remains why we should see the other Biglan dimensions represented so accurately in the first two principal dimensions from the analysis of disciplines across institutions. Many factors are likely to influence the distribution of disciplines across institutions and one would expect to see *some* regularities emerge: laboratory based science courses are expensive to resource and it may be that wealthier institutions or those who can cross-subsidise laboratory space resource between teaching and research are more likely to deliver a full range of these degree programmes. It may be that as institutions decide to expand degree programmes, those with fewer resources tend to begin by seeking synergies with existing programmes, while those with more resources may take more risks and develop new departments with substantial new academic hiring.

It may also be that some distributional structure emerges from institutions choosing how to categorise their own courses. Similar courses at different institutions may be classified differently for reasons of image; for example, one institution may classify its course as a single honours in ‘economics’ and another similar course at another institution may be classified as joint ‘economics

and business' because the former wishes to give an image of an academic programme and the latter the image of a more vocational orientation.

However, none of these factors would align so precisely with the Biglan dichotomies. Indeed, the presence of factors which would not align so well with Biglan makes it all the more surprising that the dichotomies emerge as the two most influential on the discipline/institution distribution.

It may be that the answer lies in examining the delicate intertwining of disciplinary culture and knowledge structure which Becher (1994) argued is at the heart of Biglan's scheme. Becher uses an analogy with biology (of 'genotype' – the core instructions for an organism – vs. 'phenotype' – the manifestation of those instructions in a particular organism in a particular setting) to describe this:

...this isomorphism between knowledge fields and knowledge communities is not the only significant feature of the study of disciplinary cultures. Another important characteristic is their high degree of universality. Disciplinary cultures, in virtually all fields, transcend the institutional boundaries within any given system. In many, but not all, instances they also span national boundaries To say this is not to deny that there may be differences in research traditions, profiles of undergraduate programmes and the like between one national system and another [E]ven between different institutions in the same system, the phenotypical variations can be substantial, but that one can nonetheless clearly identify genotypical cultures endemic to each discipline. [pp. 153-155]

The evidence here may suggest that these cultures do not simply transcend the institutional boundaries, to some extent they *define* them. The genotype-phenotype analogy may apply not just to disciplinary cultures but to the relationship between disciplines and institutions as well. While an institution is much more than the sum of the disciplines it teaches, at its core, the institution may be the manifestation of the genes of its disciplines. Some have argued that in recent years non-disciplinary factors may have come to outweigh disciplinary ones (Trowler, Saunders, & Bamber, 2012). The evidence here suggests the contrary: Biglan's discipline dimensions re-emerge with high accuracy as the critical dimensions from an analysis of simply which institutions teach which courses. Rather than the death of discipline groups, this analysis suggests, surprisingly, a classification scheme developed forty years ago from some stapled sheets of paper still represents a powerful underlying organizational mechanism in higher education.

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