

# Multidimensional Mapping of Book Circulation in a University Library

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*Circulated books classified according to academic subject areas and student majors were used to determine relative subject similarities in forty academic departments. Multidimensional scaling was used to compute a best-fit solution of the similarities in three dimensions for undergraduate circulation, and two dimensions for graduates. Similarity, or "distances," between departments is shown in two-dimensional maps. The meaning of the dimensions and the tendency of departments to cluster within them is discussed. One dimension can confidently be regarded as "hard-soft," a second may be regarded with much less confidence as "pure applied," and a third is not readily interpreted. Five principal clusters are strongly apparent: quantitative; social services; chemistry and life sciences; humanities; and engineering and earth sciences. Implications for collection development and storage are discussed, including applications for area bibliography, allocation of the budget to departments, organization of the collection, and online retrieval.*



In university administration, academic departments are almost universally treated as independent and homogeneous units. Each has a department head, separate budgets, an allotment of faculty, enrollment quotas, objectives, and so on. Academic libraries also recognize this practice, primarily by budget allocation for books.

From a democratic point of view, the system works and is practical. Yet, faculty members are the first to observe that each has interest in or some relationship to the work of other departments. So too, students take courses outside of their major. A political scientist, for example, may assign readings in history, anthropology, sociology, psychology, or other subjects, and will want to be assured that the library has appropriate materials in those areas. This is true to some extent for many other disciplines. One measure of this cross-disciplinary activity is the extent to which

students charge out books in disciplines other than their own major. An earlier paper analyzed this cross-disciplinary circulation, defining the extent that students from the University of Southwestern Louisiana (USL) charge out books in disciplines not their major as *ethnocentricity* after Donald T. Campbell,<sup>1</sup> and the extent to which books in a discipline were used by students in other disciplines as *supportiveness*.<sup>2</sup> In that study and in this one, "department" and "discipline" are used interchangeably.

Theoretically, each discipline has something to offer, and accordingly, books in every discipline have some probability, ranging from 0 percent to 100 percent, of being used by the other disciplines. In fact, of the forty-three disciplines analyzed in the USL study, these percentages were wide-ranging, from 0 percent to 70 percent, and 2 percent to 87 percent for undergraduate and graduate ethnocentricity; and 25 percent to 100 percent, and

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13 percent to 98 percent for undergraduate and graduate supportiveness.

If each discipline were to use the knowledge of every other, the total number of ways they could combine or permute is very large, far too many to comprehend individually. Of the forty in the USL study, the number of permutations just two at a time was 1,560. To consider larger permutations—three at a time, or four or five, and so on—is unthinkable. The numbers become astronomical. Actually, the matrix of circulation data for the forty USL disciplines showed a large number of instances in which a discipline showed zero use by others and a few disciplines that were used by many others. Skewness of this sort is to be expected, but not apparent on simple inspection of the matrix combinations because there are so many, and because of the great variability in the extent to which any two disciplines are used by each other. These are the more complex cluster patterns. A well-defined cluster would be one in which all disciplines in it were used by each other to the exclusion of all others. It is these clusters that offer the more intriguing aspects in the exploration of this type of data. Certain quantitative disciplines such as physics, engineering, and mathematics, for example, should cluster. On the other hand, some clusters may be hidden and revealed only by extensive analysis.

Knowledge of these clusters should be highly useful in providing library service, particularly in collection development, allocation, organization, and storage of the collection and perhaps in retrieval from online catalogs.

One could hypothesize, prior to their discovery, about the existence of clusters, such as a physical science cluster, but such hypotheses would be trivial in the sense that such clusters could either be found or not. We know so little about clusters and other hidden patterns that whatever analysis is undertaken (and whether or not explicit hypotheses are stated), findings are certain to uncover new knowledge. Therefore, it would be better to reserve such statements until the actual discovery of clusters.

This type of study is sometimes de-

scribed as data-descriptive and hypothesis-generating. It is analogous to focusing a new telescope on the heavens and, for the first time, observing nebulae, globular clusters, galaxies, or other phenomena. Their explanation awaits their discovery. Not until then would it be appropriate to formulate and test hypotheses. This paper then is data-descriptive and will focus on the discovery of patterns.

Many studies have been published on patterns of journal use, but few on patterns of book use. In recent years, these journal studies have employed citation data to examine the extent to which one or a group of authors is cited, or one or a group of journals is cited. Most of this research was intended to identify the most highly cited authors or journals, those with the highest impact factor and so on. Some of that research has employed novel ways to uncover patterns, notably the work of Henry Small and Belver Griffith in which they employed co-citation data; that is, the number of times two authors or two papers were cited together to map clusters of authors within a discipline or an invisible college.<sup>3</sup> Their work and that of others has done much to discover internal structure of disciplines and subdisciplines and, to some extent, to identify new disciplines. But little work has been done on the interrelationships among many disciplines from the broad-based organization of a university. Furthermore, little work has been done on the cross-disciplinary use of books as opposed to journals. Yet the largest percentage of use, perhaps as high as 70 percent to 80 percent in some libraries, is with books rather than journals. This is because students constitute the largest population of book users in a university library. Both undergraduates and graduates make heavy use of the book collection, and in most universities undergraduates far outnumber graduates.

To contrast, co-citation analysis examines dynamic patterns of interdisciplinary and cross-disciplinary research, whereas cross-disciplinary book use analysis examines the existing patterns of interdisciplinary content. A simpler way of saying this

is that journals point to where disciplines are going, whereas books describe where disciplines are. Accordingly, this study describes cross-disciplinary patterns at one point at one university as revealed by student book circulation.

### METHOD

Two interesting data-descriptive techniques are multidimensional scaling analysis (MDS) and cluster analysis. They are used to reduce large numbers of combinations and permutations to something more comprehensible and to discover hidden patterns of the data. MDS, developed in recent years to a high state of sophistication by Torgerson,<sup>4</sup> Kruskal and Wish,<sup>5</sup> Shepard and others,<sup>6</sup> Schiffman, Reynolds, and Young,<sup>7</sup> et al., is used to map distances computed from similarities data between objects in space in as many as six dimensions.

The objects are located in space by their Cartesian coordinates among the various dimensions. The map will also show any tendency of objects to cluster. Other techniques, such as tree-fitting and hierarchical clustering, can be used to confirm or enhance any clusters found in the MDS configuration.<sup>8</sup> Both clusters and dimen-

sions have meaning and can be submitted to hypothesis testing for explanation.

Multidimensional scaling is sometimes described as a technique in which the statistician is able to regenerate a map showing distances between cities or points while knowing only the mileages between every pair, as in the table of miles in a road atlas. Likewise, a map can be generated whatever the data. In an interesting and innovative paper, Anthony Biglan generated a three-dimensional map from faculty perception of similarities between every pair of academic departments at the University of Illinois.<sup>9</sup> This paper, on the other hand, tabulates similarities between departments using the number of books charged out in each discipline by the students in every other discipline. (See table 1.)

The method of data collection is described in the paper cited above.<sup>10</sup> The data are arrayed in two asymmetric matrices, one 40 × 40 for undergraduates, and one 40 × 17 for graduate students. "Asymmetric" means that data above the diagonal are not the same as data below the diagonal, representing two measures of similarity between each pair of disciplines. In order to obtain a symmetric ma-

TABLE 1  
NAMES OF USL DEPARTMENTS AND ABBREVIATIONS

Department	Abbreviation	Department	Abbreviation
Accounting	ACCT	Horticulture	HORT
Agriculture	AGRI	Industrial & Vocational Education	INDVOC
Applied Art	APPLART	Journalism	JOUR
Architecture	ARCH	Management	MGMT
Biology	BIOL	Marketing	MARK
Chemical Engineering	CHEMENG	Mathematics	MATH
Chemistry	CHEM	Mechanical Engineering	MECHENG
Civil Engineering	CIVENG	Medical Records	MEDREC
Computer Science	COMPSCI	Microbiology	MICROB
Economics	ECON	Music	MUSIC
Education	EDUC	Nursing and Health	NUHLTH
Electrical Engineering	ELENG	Petroleum Engineering	PETROLENG
English	ENGL	Philosophy	PHILOS
Finance	FINAN	Physics	PHYSICS
Fine Arts	FINART	Political Science	POLSCI
French & German	FRENGER	Psychology	PSYCH
General Business	GENBUS	Sociology	SOCIOL
Geography	GEOG	Spanish*	SPAN
Geology	GEOL	Special Education	SPECED
History	HIST	Speech	SPEECH
Home Economics	HOMECE		

\*Graduate circulation only.



trix, necessary for the MDS computations to take place, the two measures for undergraduate circulation were averaged. For example, psychology majors charged out fifty-four biology books, while biology majors charged out eighteen psychology books; hence the average circulation similarity between psychology and biology is thirty-six. This similarity has meaning, of course, only in relation to the similarities between every other pair. (By convention, when large numbers are taken to mean more similarity, they are called "similarities"; otherwise they are "dissimilarities," as in mileages.) In these data, the number of books charged ranged from 0 to 2,629.

To obtain a symmetric matrix for graduate circulation, every possible pair of majors was correlated. Thus, the input matrix contained correlation coefficients. From these two new matrices, one undergraduate, one graduate, the MDS program then computed "distances" between every pair of disciplines. The program used in this study is called ALSCAL and was written by Young and Lewyckj.<sup>11</sup> It is available as a package. The Cartesian coordinates obtained from ALSCAL were later used as input data to a cluster analysis program in the BMDP Biomedical Computer Programs package.<sup>12</sup>

In MDS programs, Pythagorean distances are computed in any number of dimensions from one to six, specified by the program user. The several solutions are printed out in two-dimensional configurations. More than four dimensions are rarely needed to explain the data and cannot be visualized in a single configuration. (A three-dimensional solution requires three two-dimensional displays, a four requires six, a five requires ten, and a six requires fifteen.)

The "goodness" or "badness" of each solution is evaluated either by the familiar  $R^2$  or a statistic called STRESS. These two statistics are approximately but inversely equivalent; the larger the  $R^2$  (up to 1.0), or the smaller the STRESS (down to 0.0), the better.

## RESULTS AND INTERPRETATION

Preliminary results of this study were reported in another paper by this author in which it was suggested that the Cartesian coordinates of the dimensional solutions might be used as quantitative descriptors to augment subject headings in an online database or for approval plans with book vendors.<sup>13</sup> The data used in that paper have been more extensively analyzed here. Table 2 gives the values for STRESS in three solutions for undergraduate circulation and four for graduate circulation.

STRESS values for undergraduate circulation show steady improvement from two to four dimensions. Improvement drops off sharply from three to four dimensions, indicating that four dimensions do not provide enough improvement to warrant interpretation and probably contain much statistical error or noise.

### Clusters

A one-dimensional solution for undergraduates was not obtained. For a large number of objects, inadequacy of the one-dimensional solution can be demonstrated by analogy with a map of the United States. It is not incorrect to say that one must travel 900 miles west to go from Boston to New Orleans. One does indeed travel that many miles westward. But one also travels 900 miles southward. Two

TABLE 2  
STRESS FOR MULTIDIMENSIONAL SOLUTIONS FOR  
UNDERGRADUATE AND GRADUATE CIRCULATION

Dimensional Solution	Undergraduate		Graduate	
	STRESS	STRESS Improvement	STRESS	STRESS Improvement
Four	0.188	}	0.077	}
Three	0.226		0.121	
Two	0.327		0.182	
One	Not Computed		0.416	
		0.038		0.044
		0.101		0.061
				0.234

pieces of information, west and south, are needed to show that the best course is along the hypotenuse. Likewise, distances can sometimes be better explained in three dimensions. A trip to Denver, for example, requires traveling one mile vertically, the third dimension in geography.

The two-dimensional solution for undergraduate circulation has considerable pattern, though not entirely satisfactory (see figure 1). Three fairly dense, homogeneous, and well-separated clusters can be seen: a *business* cluster, an *engineering* cluster, and a *mathematics/physics* cluster, with an *English/sociology/history* cluster in the center. The remaining disciplines are more diffuse, and except for several close proximities, the clustering is less apparent. Some anomalies are apparent: journalism and microbiology appear in the math/physics cluster, for example, and biology appears with music and philosophy.

The three-dimensional solution is more satisfactory. The presence of journalism near electrical engineering and other sci-

ence disciplines (see figures 1 and 2) can be explained by viewing the configuration from another perspective, Dimensions I and III in figure 3, in which journalism now appears with philosophy, music, and others. And in figure 4, journalism appears somewhat off by itself. None of the two-dimensional figures display the clusters in a thoroughly satisfactory way. Figure 2 perhaps best displays their homogeneity, while figures 3 and 4 show them to overlap. Clusters would be best perceived, of course, in a single three-dimensional display.

Labeling of the clusters was helped by the tree diagram shown in figure 5. The diagram, of all forty disciplines, was obtained from the BMDP Biomedical Computer Programs cluster analysis using the Cartesian coordinates of the MDS three-dimensional solution as input data. The tree diagram enhances our comprehension of the clusters by positioning pairs of similar disciplines, subclusters, and larger clusters adjacent to each other. The degree of similarity is indicated by the length of

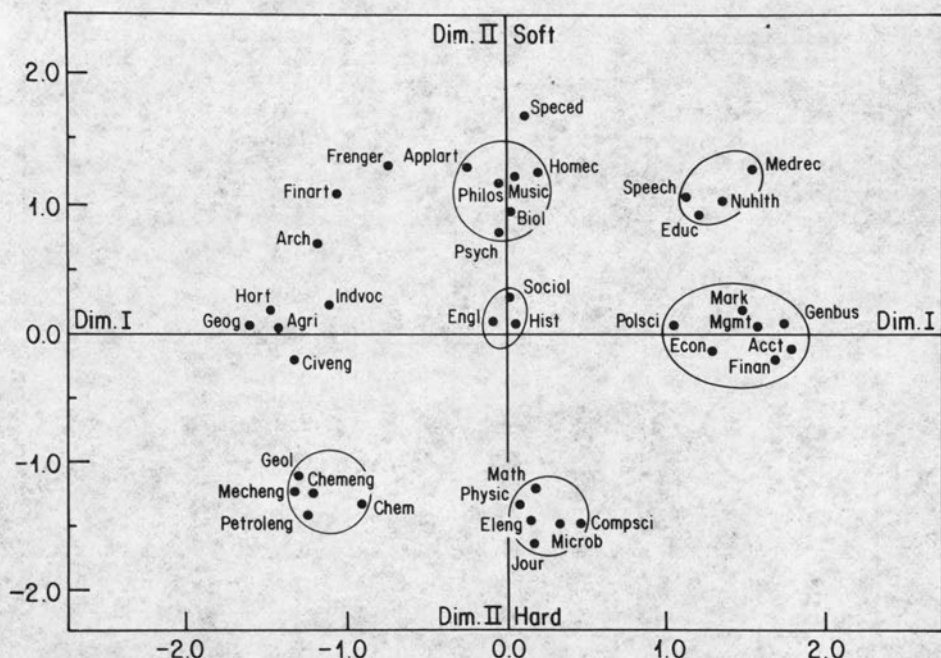


FIGURE 1  
Two-Dimensional Map of Undergraduate Circulation, with Tentative Clusters

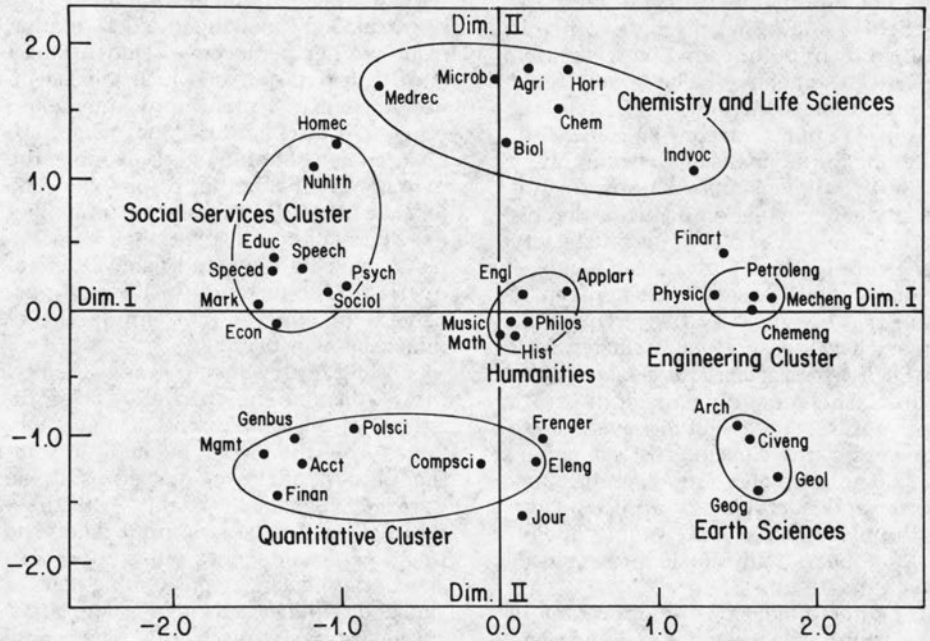


FIGURE 2

Dimensions I and II of Three-Dimensional Undergraduate Circulation, with Improved Clusters

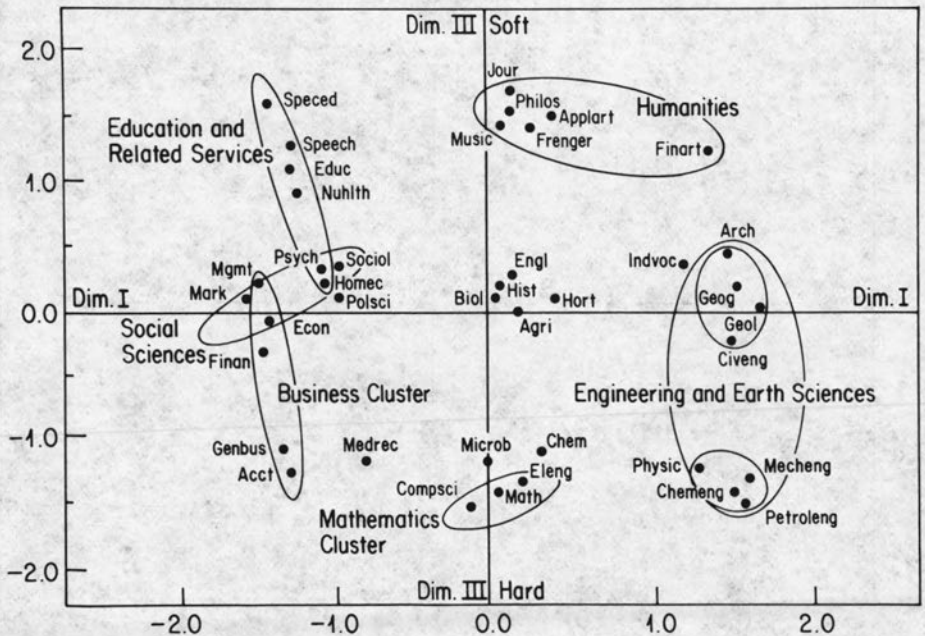


FIGURE 3

Dimensions I and III of Three-Dimensional Undergraduate Circulation, with Overlapping Clusters

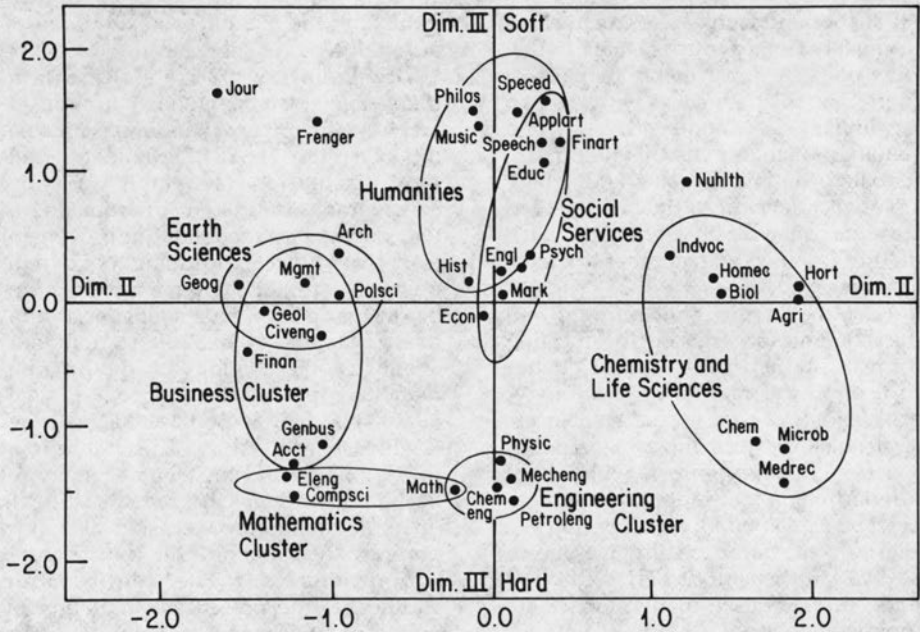


FIGURE 4  
Dimensions II and III of Three-Dimensional Map of Undergraduate Circulation, Showing Cluster Overlap from Another Perspective

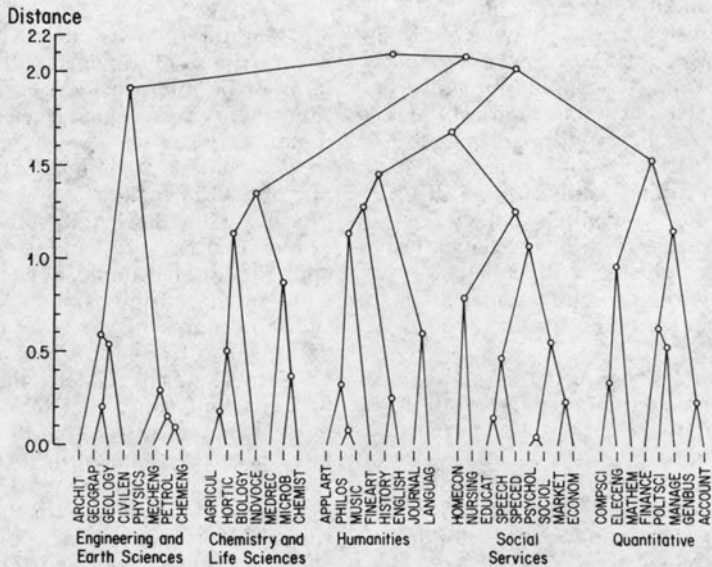


FIGURE 5  
Tree Diagram of Departmental Clusters Derived from Cluster Analysis of Three-Dimensional Coordinates of Undergraduate Circulation



the branches and trunks (vertical lines) of each cluster. The diagram is binary in that it joins pairs of departments or pairs of clusters. The diagram starts with the two most similar departments, sociology and psychology. It then joins this pair to another pair, economics and marketing, and so on at each level until they are merged into a large pair-wise cluster, and this cluster in turn is joined with another to form a still larger one.

Note, for example, that nursing and home economics are adjacent to education and are contained in the larger cluster with economics, marketing, sociology, and psychology—that is, social sciences, whereas history, normally categorized as a social science, is grouped with liberal arts departments. These apparent anomalies can be explained by recalling that the similarities are based on the average of "use by" and "use of." Thus, though nursing students used many more home economics books than home economics students used nursing books, they are treated in this analysis as if they were used equally. Also, a great many home economics books were used by other departments in the cluster. Although some improvement of the clustering might be obtained by distinguishing between "use by" and "use of" and by going to four dimensions perhaps, we should remember that we are dealing with empirical data and that the results may bring some surprises. Thus, these results suggest that nursing and home economics, at USL, could be classified with the social sciences in a larger cluster which can be called the social services cluster, and that history should be regarded as a humanities discipline. A summary of the clusters appears in figure 6.

These clusters are not unlike those found by Allan, who counted Dewey decimal classification numbers shared by pairs of academic departments at a midwestern university, then used a critical probabilities method to measure their similarity.<sup>14</sup> Though the correspondence between the author's study and that of Allan's is not exact, the results suggest that similar clusters would be found from one university to another. It would be interesting to ex-

plore how and in what context this generalization would take place.

Circulation by graduate students in nineteen major areas is shown in a considerably less complex two-dimensional solution in figure 7. STRESS values for graduate circulation (see table 2) show considerable improvement from one to two dimensions and little improvement from two to three, indicating that two dimensions are quite enough for this number of disciplines. Five simple and intuitively acceptable clusters are apparent: chemistry/microbiology/biology, mathematics/computer science, geography/geology, psychology/political science, and English/speech/history. The simplicity of these clusters and their homogeneity reflect a sharper focus by graduate students on their major, a conclusion also supported in the paper on ethnocentricity and supportiveness.<sup>15</sup> The configuration should be interpreted as circulation by majors in subject space, slightly different than the interpretation for undergraduate circulation, which entails use of each other's materials by any pair of majors.

### *Dimensions*

Just as important as clusters in the analysis of the multidimensional configurations is the interpretation of the dimensions themselves. Biglan labeled his three dimensions *hard/soft*, *pure/applied*, and *life/nonlife*. That is, disciplines at one end of one of his dimensions can be considered "hard," while those at the other end can be regarded as "soft," and so on for *pure/applied* and *life/nonlife*. I obtained measures of these dimensions in an earlier study through a survey of faculty at USL using an entirely different method.<sup>16</sup> Those measures correlated quite well with Biglan's, but somewhat less well with those in this study (see table 3). However, there is one dimension in each of two-, three-, and four-dimensional solutions, that agrees fairly well with the *hard/soft* variable of the earlier USL faculty survey, with correlations of  $-0.61$ ,  $0.72$ , and  $0.44$ , respectively. (The negative sign is meaningless since it is an arbitrary orientation of the plot.) On the other hand, there are



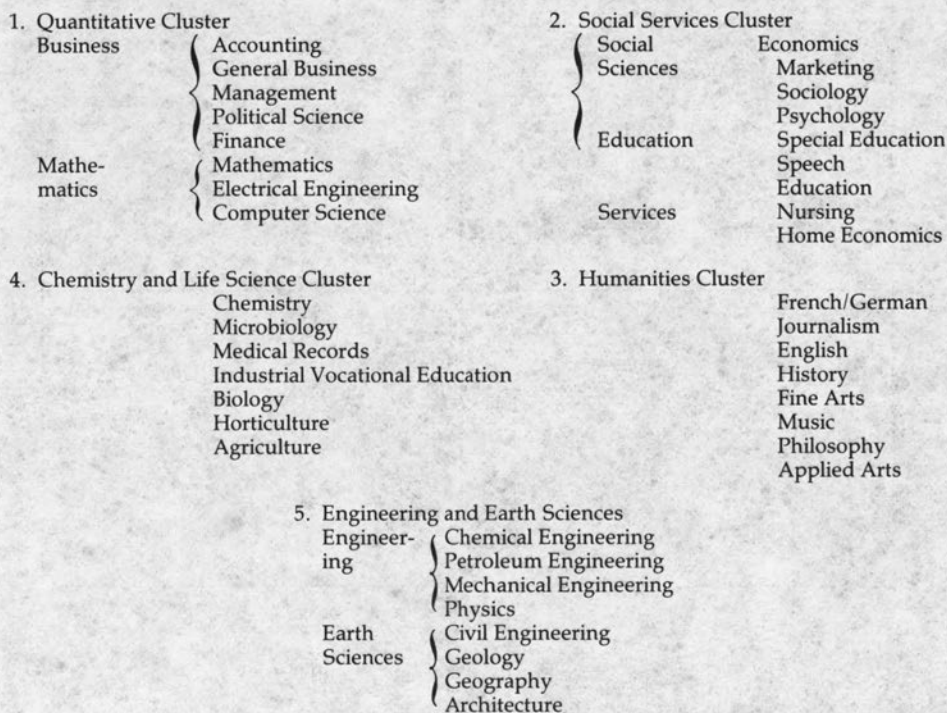


FIGURE 6  
Clusters of Academic Departments Derived from a Cluster  
Analysis of the Three-Dimensional Coordinates of  
Undergraduate Circulation

no substantial correlations between Biglan's *pure/applied* nor the earlier USL *pure/applied* and any of the several dimensions in this study—the highest (0.44) is with Dimension I of the four-dimensional solution. There are also no substantial correlations with Biglan's *life/nonlife* variable.

Since both the earlier USL and Biglan surveys were based on perceptions of faculty, neither are empirically based on solid behavioral data, though some significant correlations with behavioral variables have been found. One attempt to validate Biglan's dimensions, by Muffo and Langston, found significant differences in faculty salaries according to *hard/soft*, *pure/applied*, and *life/nonlife* categories.<sup>17</sup> Biglan himself found significant correlations between his dimensions and scholarly output.<sup>18</sup> This author found low but significant correlations between the *hard/soft*

variable from the earlier USL survey and circulation, and between the *pure/applied* variable and student enrollment. No significant correlations were found between *life/nonlife* and other variables in either the Biglan or USL studies.

David A. Kolb, examining data from a learning style inventory associated with the undergraduate majors of 800 managers, found strong similarities between Biglan's *hard/soft* and *pure/applied* dimensions and what he called *abstract/concrete* and *reflective/active* dimensions, respectively.<sup>19</sup> He further supported this association in an examination of extensive data from a 1969 Carnegie Commission of Higher Education study.

The literature of vocational interest also contains studies on the similarities of occupations. Robinson and others, for example, using smallest space analysis, a

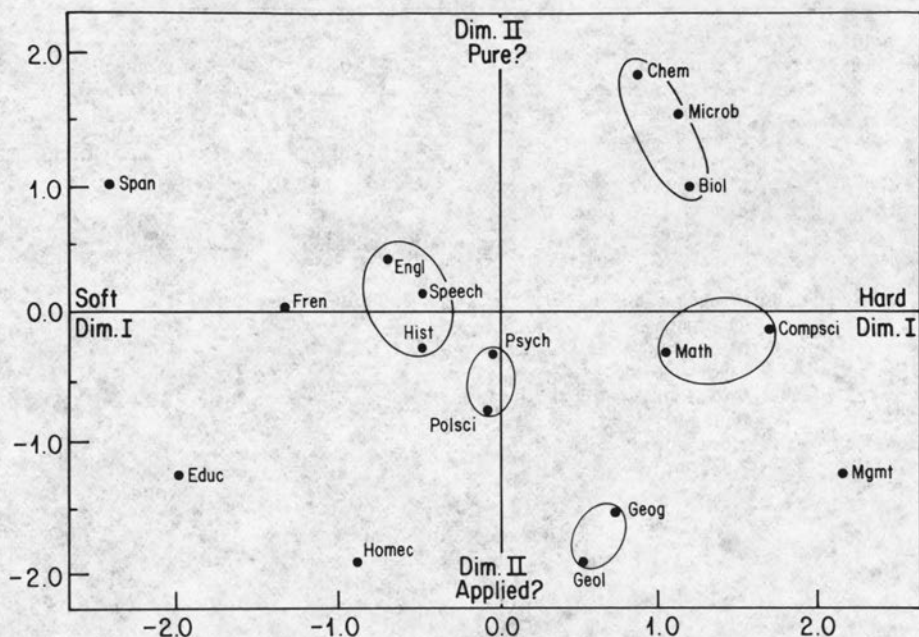


FIGURE 7  
Two-Dimensional Map of Circulation by Graduate Majors

technique related to multidimensional scaling, found two strong dimensions in several inventories of occupational similarity, the strongest of which was *object oriented* versus *people oriented* occupations. The other was *doer* versus *thinker* occupations, which included *commercial/business* versus *scientific* components, possibly in a third dimension. They contended, however, that two dimensions were sufficient to explain the bulk of variance.<sup>20</sup>

The dimensions derived in this study, being empirically based, deserve to be interpreted or explained for what they are—not whether they are something else. One of these dimensions, on the basis of correlations discussed above, could be called *hard/soft*, but only if whatever it is that is “hard” or “soft” is measured with behavioral data, as it is in this study. The other two dimensions, though firmly implanted in the data, require further analysis.

Any number of hypotheses could be generated to explain the dimensions, whether they are founded in the literature of learning theory, vocational interest, in-

formation science, sociology of science, or library science, but the most immediate explanations in the context of this study would be found in the curriculum—in terms of undergraduate course requirements, and in highly focused majors and electives for graduate students.

Whether or not these dimensions are identified or otherwise explained, and even if they are no more descriptively identified as Dimensions I, II, or III, they should be useful in many ways—particularly if they agree with dimensions found in similar data from other institutions or in a larger database.

#### IMPLICATIONS FOR COLLECTION DEVELOPMENT AND STORAGE

##### *Area Bibliographers*

Ideally, each academic department should have a librarian, expert in that department's subject matter, who would be responsible for collection development. Unfortunately, no library has enough li-

TABLE 3  
CORRELATIONS\* BETWEEN BIGLAN'S DIMENSIONS  
USL CIRCULATION AND USL FACULTY SURVEY DIMENSIONS

		H/S	Biglan's Dimensions		USL Faculty Survey	
			P/A	L/NL	H/S	P/A
USL Faculty Survey	H/S	-0.78	‡	‡		
	P/A	‡	0.78	‡		
	L/NL	‡	‡	0.86		
USL Undergrad Circulation	2 I	0.45	-0.17	-0.09	-0.24	0.17
	II	0.66	0.14	0.53	-0.61	-0.23
	3 I	0.60	0.08	-0.26	0.39	-0.21
	II	-0.16	-0.04	0.57	0.03	-0.07
	III	0.64	-0.02	0.53	-0.72	0.12
	4 I				0.32	0.44
	II		not obtained		-0.09	0.04
	III				0.62	0.06
	IV				0.44	-0.17
USL Grad Circulation†	I	0.74	-0.08	-0.06		not obtained
	II	0.40	0.31	0.10		

\*Pearson product moment correlations, except as noted,  $N = 20$ .

†Spearman rank order correlations,  $N = 11$ .

‡Not obtained.

barians for such one-to-one assignments. On the other hand, assignment of librarians to areas such as Asian studies, Slavic studies, and the like, may be equally problematic, because they may cover a broad range of unrelated subjects for which the bibliographer may be not as familiar. Furthermore, these "areas" may not correspond at all with real use patterns of the collection. An alternative to these two approaches would be to assign bibliographers to departmental clusters based on circulation, such as those found in this study. Then, every cluster or subcluster could be covered to a hierarchical depth according to the number of bibliographers available. Thus, the "quantitative" cluster could be treated as one cluster with one bibliographer, or as two at the next level deeper with two bibliographers.

#### Allocation

A major concern of collection development librarians is that allocation to departments may result in too small a budget for some departments and too large a budget for others. Faculty also voice this concern if they feel their allotment does not permit them to request books outside of their own narrowly defined areas. Knowledge of clusters would permit more flexible allocation. Each cluster would receive an al-

location with further allocation to sub-clusters if desired. The denser the cluster—i.e., the more similar each department in the cluster and the further away the cluster is from others, the less critical the suballocation, since whatever books were purchased on a subject within the cluster would have a higher probability of being used by students majoring in any subject within the cluster. But departments that are not obviously part of a cluster should receive an allocation independent of others, because their purchases are less likely to be used by others. If a department is equidistant from all others—i.e., in the center, such as English and history in this study—then the books they purchase have a high probability of being used by students in many departments. Indeed the data show this to be so, and thus they should also receive larger allocations.

#### Organization of Materials

Storage of the collection according to circulation clusters would be a logical alternative to the existing practice of storage in departmental, branch, or divisional libraries based on campus geography or on the traditional divisions of humanities, science/technology, and social sciences. Books on education and physics may be

housed together for no better reason than that the education and physics departments happen to be in the same building. On the other hand, students in the social sciences are as likely to find many of their books in the humanities division as they are in the social sciences division. Psychology books are stored with philosophy books only because their classification numbers are adjacent in the classification scheme. The divisional arrangement has never been shown to be more effective than single sequence collections, and some libraries have abandoned efforts to maintain them. On the other extreme, separate libraries for every department might be considered ideal by faculty, but are far too costly and inefficient. If a library is forced to break up its collection and if it can afford to do so, then storage of collections according to circulation clusters such as those found in this study would make sense and is worth considering. Such "cluster collections" may be more practical, convenient, and satisfying to faculty and students who complain that "my books are scattered all over the library, and all over the campus, and why can't you librarians bring them together all in one place?" Surely this is a compromiseable problem.

### *Online Retrieval*

Circulation dimensions found in this study could be used to augment retrieval in an online catalog. Traditional author, title, subject heading, and call number retrieval is limited in that they are undimensional. Each are capable of describing only one thing about a book. They can not describe other characteristics. To be sure, Boolean logic allows combinations and exclusions of authors, headings, and so on, but still the approach is limited to these traditional tags.

Assuming that the circulation dimensions were valid and generalizable, their Cartesian coordinates could be used as another way to describe books in the collection. This could be done in the cataloging process by assigning coordinates to each book in much the same manner as classification numbers are assigned. A book in

computer science might have, say, coordinates of 0.4 and -1.5 for Dimensions I and II, respectively. If it were understood that these dimensions were *pure/applied* and *hard/soft*, then these coordinates would retrieve a "hard" and somewhat "applied" book. In the paper cited above, the author suggested that these dimensions could be used to identify books desired through approval plans, but the question of how books could be assigned coordinates and who would do so is problematic.<sup>21</sup> Also, individual books would not necessarily have the same coordinates as their general subject. That is, one computer science book may be "hard" and "pure" while another may be "soft" and "applied." This would seem to require that further multidimensional analysis be done on each cluster to determine more refined coordinates for each subject within a cluster.

### CONCLUSION

Multidimensional mapping and cluster analysis of circulation provides the ability to sort out the complex overlapping interdisciplinary and cross-disciplinary relationships among the academic departments served by the library. The insights gained offer the librarian several new ways in which to enhance library service, and to treat academic departments with more flexibility. The discovered dimensions may provide new theoretical perspective on those relationships. Applications would include assignments in area bibliography, allocation to clusters of departments, organization and storage of the collection, and perhaps in online retrieval.

### FURTHER RESEARCH

Clusters and dimensions could be improved by separating data for freshmen and sophomores, who have not yet concentrated on their major, from juniors and seniors. The distinction between "use by" and "use of" should be further explored and separately submitted to MDS and cluster analysis. The dimensions need to be explained by hypothesizing correlations with other likely variables. An at-



tempt should be made to verify and, if possible, generalize the clusters and dimensions discussed here by examining

circulation or other data at other institutions and particularly in a large online utility serving many institutions.

## REFERENCES

1. Donald T. Campbell, "Ethnocentrism of Disciplines and the Fish-Scale Model of Omniscience," in Muzaffer Sherif and Carolyn W. Sherif, eds., *Interdisciplinary Relationships in the Social Sciences* (Chicago: Aldine, 1969), p.328-48.
2. William E. McGrath, Donald J. Simon, and Evelyn Bullard, "Ethnocentricity and Cross-Disciplinary Circulation," *College & Research Libraries* 40:511-18 (Nov. 1979).
3. Henry G. Small and Belver C. Griffith, "The Structure of Scientific Literature, I: Identifying and Graphing Specialties," *Science Studies* 4:17-40 (1974).
4. W. S. Torgerson, *Theory and Method of Scaling* (New York: Wiley, 1958).
5. Joseph Kruskal and Myron Wish, *Multidimensional Scaling* (Beverly Hills, Calif.: Sage Publications, 1978).
6. Roger N. Shepard, A. K. Romney, and S. Nerlove, eds., *Multidimensional Scaling: Theory and Applications in the Behavioral Sciences* (New York: Seminar Press, 1972). 2v.
7. Susan S. Schiffman, M. Lance Reynolds, and Forrest W. Young, *Introduction to Multidimensional Scaling: Theory, Methods, and Applications* (New York: Academic Pr., 1981).
8. Roger N. Shepard, "Multidimensional Scaling, Tree-fitting, and Clustering," *Science* 210:290-398 (Oct. 1980).
9. Anthony Biglan, "The Characteristics of Subject Matter in Different Academic Areas," *Journal of Applied Psychology* 57:195-203.
10. McGrath and others, "Ethnocentricity."
11. Forrest W. Young and Rostyslaw Lewycky, *ALSCAL-4 User's Guide; for Users of ALSCAL-4: A Non-metric Multidimensional Scaling and Unfolding Program with Several Individual Differences Options* (Carrboro, N.C.: Data Analysis and Theory Associates, 1979).
12. W. J. Dixon and M. B. Brown, eds., *BMPD-7, Biomedical Computer Programs, P-Series* (Berkeley, Calif.: Univ. of California Pr., 1979).
13. William E. McGrath, "The Circulation Uncertainty Principle and the Cosmology of Collection Development," in Peter Spyers-Duran and Thomas Mann, Jr., eds., *Shaping Library Collections for the Eighties, Fourth International Conference on Approval Plans and Collection Development*, Milwaukee, Wisc., 1980 (Phoenix: Oryx Press, 1980).
14. Ann Allan, "A Method for Determining Interdisciplinary Activities within a University," *Library Research* 2:83-94 (Spring 1980-81).
15. McGrath and others, "Ethnocentricity."
16. William E. McGrath, *Relationships between Subject Characteristics and Use of Books in a University Library* (Unpublished dissertation, Syracuse Univ., 1975).
17. John A. Muffo and Ira W. Langston IV, "Biglan's Dimensions: Are the Perceptions Empirically Based?" *Research in Higher Education* 15:141-59 (1981).
18. Anthony Biglan, "Relationships between Subject Matter Characteristics and the Structure and Output of University Departments," *Journal of Applied Psychology* 57:204-13 (1973).
19. David A. Kolb, "Learning Styles and Disciplinary Differences," in Arthur W. Chickering and Associates, *The Modern American College* (San Francisco: Jossey-Bass, 1981).
20. John P. Robinson, Robert Athanasiou, and Kendra B. Head, *Measures of Occupational Attitudes and Occupational Characteristics* (Appendix A to *Measures of Political Attitudes*) (n.p., Survey Research Center, Institute for Social Research, Feb. 1969).
21. McGrath, "Circulation Uncertainty Principle."