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ABSTRACT

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Abstract

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INTERACTION BETWEEN COLLEGE EFFECTS AND STUDENTS' APTITUDES

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Most people assume that a student who goes to Harvard will learn more than a student who goes to Normal State. They assume that "better" professors, libraries, and "atmosphere" will result in more knowledge of science, humanities, and social science. But is it true? The average Harvard graduate may be more knowledgeable than the average Normal State graduate; however, the average Harvard student is also more knowledgeable than the average Normal State student when he enters college as a freshman. Thus, if Harvard enrolls only very bright students, and Normal State enrolls average students, Harvard seniors will naturally seem brighter than Normal State seniors at the end of college. The point is this: before we can tell whether Harvard or Normal State (or Swarthmore or Ohio State) is more effective, we have to control for the ability of the students going to those colleges.

The idea of controlling for the ability of the students who attend various colleges seems simple and straightforward enough, but it involves many thorny statistical problems. If we do apply controls, how much of the outcome can we legitimately attribute to initial ability? How should we control for initial ability? Should we develop some score we would expect a student to get on the senior score based on his initial ability, then subtract this expected score from the actual score? Should the student or the college be the unit of analysis? Various analysis systems have been developed that offer different answers to these questions.

For example, a recent study of college effectiveness (Rock, Centra & Linn, 1970) indicated that there was a small but significant college effect on "achievement" when the school was the unit of analysis and the input was controlled. However, due to the methodological approach used only estimates of the overall effectiveness of a college across a broad range of student ability was tested. Feldman and Newcomb (1969) review more than 1,000 studies of the impact of college experience on student attitudes and achievement but almost all of them are only concerned with overall effectiveness. Astin (1970), in a much needed summarization of the methodology used in "college impact" studies, does discuss the concept of possible interaction between student aptitudes and college environment on achievement. He points out many of the pitfalls of applying standard statistical techniques to the interaction problem.

Various systems for controlling for initial ability have been used but most seem to have considerable limitations. One of the most widely used models has been the "input-output" model. This model develops a predicted output score for students from their input scores, then subtracts this predicted score from the actual scores students obtain on the final measure. The average differences between expected and actual scores are then related to characteristics of the colleges. In general, the usual statistical controls used in the input-output model are based on logic underlying prediction models rather than explanatory models. As a result the interpretation of the part and/or partial correlation inherent in the prediction models is often open to question (Linn & Werts, 1969). Also the various correlational techniques are not easily amenable to the identification of interactions or nonlinear effects. This study approaches the problem in a way that appears to overcome some of the limitations of these methods. This approach is designed to find groups of colleges that are about equally effective for students with various levels of initial performance. Then the characteristics of the identified criterion groups are compared to see which characteristics are related to the relative effectiveness of the groups. For example, if colleges in more effective groups of colleges are smaller than colleges in less effective groups, we would assume that the size of a college is related to its effectiveness. But the advantage of this method is its definition of effectiveness.

This method attempts to provide an intuitively simple approach which identifies both overall college effects and effects which interact with student ability. First, in order to come to any conclusions about the differential effects of the college we must treat the college as a sampling unit. However, the usual method of analyzing the resulting variation due to college mean output differences corrected for input ignores the within-college variation. In this study we made use of the within-college variation in estimating the interaction. Specifically, four steps were carried out: (1) all within-school regression lines were computed, i.e., Graduate Record Examination (GRE) Area tests were regressed on the College Entrance Examination Board Scholastic Aptitude Test (SAT) scores within school, (2) Ward's (1963) hierarchical clustering technique was applied to group schools on the basis of the similarity of their regression lines, (3) multiple group discriminant functions using the regression parameters as the group discriminants were computed. This provided a test of whether the newly formed groups differed with respect to their pooled regression lines, and (4) discriminant functions using college descriptive variables as the group discriminants were then computed. This method thus identified criterion clusters of colleges that differed in effectiveness by clustering on the slope, the mean SAT scores of the students, and the intercept. Therefore, one can identify and group colleges that have different effectiveness for students of different levels of initial ability. Then the simultaneous evaluation of the college descriptive variables which discriminate the clusters of colleges along with the relative slopes of their pooled within-group regression lines indicated the college characteristics which are associated with overall as well as differential effectiveness.

Data and Analysis

The data included a sample of 6,855 students from 95 colleges. The institutions in this study were largely private; only four were state colleges or universities. In general, student enrollment figures were modest; only 10 colleges had more than 2,000 undergraduates, while 50 colleges enrolled fewer than 1,000. None of the colleges approached the large enrollments typified by some state and city universities. In addition to the public colleges and universities, the established, highly selective colleges in the Northeast were also underrepresented. Approximately half of the colleges in the sample were church related, with this group divided about equally between Catholic and Protestant denominations. In sum, the sample, while not representative of all American higher education, at least included the many types of small liberal arts institutions.

Within each college a random sample of approximately 100 individuals was gathered, each of whom had SAT scores at their college entrance and the

GRE Area tests as upperclassmen. A total of 25 descriptive measures of the college were included in the analyses. These measures are listed in Table 1.

Insert Table 1 about here

Three separate taxonomies of the within-group regression lines were produced: one set was produced from the regressions of GRE Social Sciences on SAT-M; another set of groupings was produced from the regressions of GRE Humanities on SAT-v, and the last set was produced from the regressions of GRE Natural Science on SAT-M. In each case the one best predictor of any one criterion was used rather than both SAT-V and M, since in all three cases the increase in prediction was negligible. Also the stability of the college groupings based on the similarity of the within-college regression lines depends, of course, on holding to a minimum the number of parameters used to describe the regression lines. Thus the clustering of within-college regression lines was based on their similarity of intercepts, the regression weight and the mean predictor score for each college. Before clustering all three of these regression parameters were standardized.

Ward's (1963) grouping or clustering procedure as applied to the regression parameters starts with g groups and then forms g-1 groups selectively collapsing groups which maximize the between- to the within-group sum of squares, continuing until the researcher notices a large increment in the within-group sum of squares indicating the combining of two rather dissimilar groups and/or until the number of colleges within the smallest group becomes large enough to provide satisfactory future statistical estimates. The application of both of the above restraints led to five groups for the humanities criterion, three for natural science, and four groups for social science. When the grouping was completed the students from colleges within a single group were pooled and the within-group regression equation computed.

Multiple group discriminant analyses were then performed to test for differences between the groups in each area on the college descriptive measures.

Results

Figure 1 shows the pooled within-group regression lines for the humanities area, the social sciences, and the natural sciences (the number of colleges in each group are shown in Table 3). Inspection of the humanities regression plots indicates that the regression line for group 1 based on an N of 17 colleges has a considerably steeper slope than groups 3 and 4 based on sample sizes 26 and 8 colleges respectively. The regression line for group 2 which was based on 13 colleges has a slope that was similar to the slope for group 1, but a considerably different intercept. Although there appears to be some interaction between ability level and effectiveness for groups 2 and 3 the main effect associated with the group 1 colleges seems to be the overriding effect. Even of more interest here is the fact that groups 1, 2, and 5 have essentially the same input with respect to SAT-V yet their mean outputs differ by almost 100 points. There is a slight tendency for the colleges having lower input scores to also have flatter slopes, for example, group 3 and group 4 colleges.

Insert Figure 1 about here

The social science regression plots were based on four groups. Similar to the humanities area there is one group of colleges based on an N of 9 whose regression plot differs considerably from the remaining three groups. Unlike the humanities area, however, group 1 colleges differ primarily from the remaining groups of colleges only with respect to their intercept. On the basis of those plots we might suspect that group 1 colleges tend to emphasize achievement in those areas measured by the GRE Social Sciences.

The natural sciences plots show three clusters that are similar with respect to input (SAT-M) but differ with respect to slope and intercept. However, as in both the humanities and the social sciences there is one cluster of colleges that is characterized by higher achievement. As in the humanities there is also one cluster of colleges, group 2, that not only has the lowest SAT-M mean but also has the flattest slope. It would seem that within the natural sciences and humanities the relationship between input and output is lowest for the schools characterized by lower inputs.

At this point it seems reasonable to inquire whether the clusters of colleges are indeed significantly different with respect to their regression parameters. Thus discriminant functions were computed using the regression parameters associated with each college as the discriminants and their group membership as the dependent variable. In all three areas, humanities, social science, and natural science, at least two out of the three possible functions were significant ($P < .01$). In all cases the univariate F's for intercept, slope, and SAT-V or M were highly significant ($P < .01$). Thus it may be concluded that the groups were internally homogeneous with respect to the regression parameters, yet significantly different from each other.

Table 2 shows the results of the discriminant function analysis using

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Insert Table 2 about here

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college characteristics as discriminants for the five groups in the humanities area, the four groups in the social science, and the three groups in the natural science area. Although the canonical correlation for the natural science area was relatively high indicating fairly good discrimination it was not statistically significant, thus any further interpretation with respect to the size of the discriminant function coefficients was not warranted.

Table 3 presents the five highest correlations between college character-

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Insert Table 3 about here

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istics and the discriminant scores based on the first discriminant function from both humanities and social science areas. That is, the size of these correlations indicate their relative contribution to the particular function (in this case the first function) which best discriminates the groups in the humanities and social sciences. It is interesting to note that three of the five variables overlap; that is, income per student, proportion of faculty with doctorate, and Astin's (1965) measure of selectivity appear in both the humanities and the social science results.

In order to gain insight into the relative ordering of the groups with respect to the variables which have the highest correlation with the discriminant function score the group means and their associated univariate F tests were examined. Table 4 presents the group means and the univariate F's for

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Insert Table 4 about here

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those variables having the highest correlation with the first discriminant function in the humanities and the social sciences. Since the overall or multivariate F for the natural sciences was not significant, further interpretations based on the univariate F's for the natural sciences was not warranted.

Humanities

In Table 4 the patterns of the group means in the humanities area for the variables having the highest correlation with the discriminant scores reflect for the most part what one might expect from inspection of slopes in Figure 1. That is, groups 1 and 2 have for the most part the higher mean scores on the five significant college characteristics, especially selectivity, budget, and percentage of students graduating in four years. Group 1, of course, is the group of colleges whose pooled within-groups regression line in Figure 1 suggests a relatively large "main effect" with respect to achievement in the humanities. That is, the predicted humanities achievement score given for a student entering with typical or average SAT-V scores for these groups of institutions would be expected to score more than 50 points higher than similar individuals attending any of the schools in the remaining four groups. This, of course, is a simple projection on the GRE axis from the point on group 1's regression line defined by the SAT-V means in Figure 1. It is also interesting to note that with the exception of group 4 the remaining clusters of schools all have similar student inputs with respect to ability as measured by the SAT-V.

Group 4, of course, is characterized not only by considerably lower student ability input with respect to SAT-V but also has the lowest means on all five of the college characteristics. It should, however, come as no surprise that relatively low student input and low budgets seem to go hand in hand. Unfortunately these data do not allow us to infer what might be the effect on the slope and/or intercept if colleges with low ability inputs were in turn characterized by high budgets, proportion of faculty with doctorate, etc. For colleges characterized by similar and relatively higher verbal input, the humanities data do suggest that proportion of faculty with doctorate, size of budget, and selectivity are related to achievement. Selectivity is based on Astin's (1965) work and is defined as the ratio of the number of national merit scholars who apply for admission to the total number of students in the entering freshman class.

In order to examine the possibility that the high achieving schools in the humanities may have had a greater proportion of majors in the humanities area (reflecting a greater emphasis on course work in the humanities), additional data were gathered and analyzed. It was found that on the average 34% of the students in group 1 colleges major in the humanities as compared to 32% for the total sample. Although there is a tendency for group 1 colleges to have a slightly larger proportion of students in humanities, it is doubtful whether an additional 2% of humanities majors can explain all of the over 50-point average increment in achievement associated with group 1 colleges.

Social Science

In the social science area the slopes of all four clusters of colleges are quite similar yet the intercept for group 1 is considerably higher than the remaining clusters, indicating that individuals attending these colleges can be expected to achieve, on the average, 60-70 points higher than individuals of comparable SAT-M ability inputs who attended colleges in the other remaining three clusters. Although group 1 colleges appear to have this large main effect with respect to achievement in the social sciences, it is not reflected in the group means shown in Table 4. In fact, group 4's means are the highest on all five variables. Group 4 is, of course, the least effective group of colleges with respect to social science achievement according to the regression plots in Figure 1. Conversely, group 3, which is similar to group 4 with respect to its relative lack of effectiveness in the social sciences, has the lowest means on all five variables. Those inconsistencies in the pattern of group means relative to overall effectiveness in the social sciences area would lead one to conclude that additional data may be needed to explain the group's differential effectiveness. The fact that all the slopes are quite similar and the primary difference between groups lies in the intercepts suggests that differences between groups may be simply differential emphasis with respect to subject matter areas.

Therefore, data on the proportions of students in the various subject areas were tabulated. Of particular interest was the comparison between groups 1 and 4 with respect to the average proportion of students majoring in social sciences. Surprisingly enough, the proportions were quite similar--19% in group 1, the most effective group, and 17.5% in group 4, the least effective group. Further examination of the data, however, revealed that group 1 had proportionally less than half as many students in the natural sciences (13.6%) as did group 4 (26.5%); group 1 also had proportionally twice as many students in the areas of education and business (30.6%) than did group 4 (16.3%), the least effective group. Thus, it would seem that emphasis on subject content as measured by the proportion of students majoring in social science and allied areas may be the primary determinant of achievement in social science as measured by the GRE test. It would further seem that institutions which emphasize the natural science areas appear to accomplish this somewhat at the expense of the social science areas. The fact that group 4 institutions are characterized by both a high proportion of natural science majors and also the highest income per student also seems consistent with the possibility that education in the natural sciences may indeed require greater financial resources per unit of achievement than do the social sciences. In short, those schools that have limited income may have little choice but to place greater emphasis on the social science or related areas.

Natural Sciences

Since the canonical correlation was not significant, post hoc univariate F tests were not carried out. However, as in the humanities and social science areas, additional data were collected and analyzed with respect to proportion of majors in natural science. It was found that group 1, the most effective group of institutions in the natural sciences, had a slightly higher proportion of science majors (28%) than the average for the total sample (25%). Group 1 also had a lower proportion of majors in the humanities (28%) than the total sample average of 32%.

Discussion

These results suggest a tentative and complicated answer to our original question: Do students who attend one kind of college learn more than those who attend another kind of college? The answer seems to be "yes, but...." First, even the significant differences between the colleges were generally small. A more heterogeneous sample may have resulted in larger differences. But even assuming sizable differences, it appears that the effective colleges were good at different things. That is, when we compared the most effective group of colleges in each area, there was little overlap in the colleges composing the groups. There was not one college that appeared in both the most effective group in humanities and the most effective group in social science. Only one college was in the most effective groups in humanities and natural science. In general, then, there did not seem to be any group of colleges that was among the best in every area.

One possible explanation for the lack of significant results for the natural sciences items may stem from the content of the GRE area tests. Most of the items in the Natural Science area either require knowledge that could only be obtained in courses in science, or depend on mathematical reasoning that would presumably be present in students before college. In contrast, a sizable proportion of the items in the humanities and social science tests seem to require knowledge that could be learned outside the classroom, for example, that impressionism is a school of art, while existentialism is a school of philosophy, or that members of the security council at the United Nations can exercise a veto. It is thus possible that knowledge of the humanities and social sciences may be related to general features of the environment, while knowledge of the natural sciences depends more on specific course work. This brings up the matter of distributional or course requirements. It is quite possible that the more effective colleges in the sciences require more course work in the natural sciences regardless of the student's major field of study. If these data were available, it would be interesting to compare performances of colleges characterized by distributional requirements with those with more lax requirements.

The humanities results suggest that students who go to selective colleges tend to achieve more than students who go to less selective colleges. From the data, it is hard to say whether this is due to the stimulating effect of other knowledgeable students or to some other characteristic of the colleges.

Conclusions

In comparing the most effective groups of colleges in each achievement area, it was found there was little overlap in the colleges composing the groups. Thus, in general, there was no one group of colleges which was "best" in every area. There was also a tendency for the less selective colleges in the humanities and natural science areas to be characterized by smaller relationships between their input and output.

Finally, these results suggest some of the practical possibilities of college impact research. The concern for symmetry in the information provided to students and to institutions creates a need for a better understanding of the differential effects of colleges. Recently a study group commissioned by the College Entrance Examination Board made public their recommendations which included providing evaluative information about colleges to students, i.e., having colleges take "tests." The purpose of such a college evaluation procedure would be to provide students with a more accurate and detailed basis for choosing a college. Hopefully, the student could be presented with data which would indicate types or classes of colleges which would be particularly successful with his unique pattern of abilities and interests. Experience with the methodology used in this study suggests that certain colleges may be identified that are effective with students characterized by differing ability levels. That is, although a college may not demonstrate above average effects on achievement overall, it may yet show above average effects for low ability people or vice versa when considered separately. Thus, eventually we may have a data bank of information that could be used to guide and place students. The same information might be used by colleges for planning for the most effective use of their resources and for the allocation of their efforts.

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Table 1

College Descriptive Measures

Used in Analyses

Measures Derived from Office of Education Records	Measures from Astin (1965)
Number of Books in Library (Decile Ranking)	Intellectualism
Books per Student (Decile Ranking)	Estheticism
College Income per Student (Decile Ranking)	Status
Number of Faculty per Student (Decile Ranking)	Pragmatism
	Masculinity
Proportion of Faculty with Doctorate (Decile Ranking)	Estimated Selectivity
Full Time Equivalent of Undergraduate Enrollment (Decile Ranking)	Size
College Expenditures per Student	Realistic Orientation
Type of College Control	Scientific Orientation
Percentage of Students Graduating in Four Years	Social Orientation
	Conventional Orientation
Percentage of Graduates Continuing to Graduate or Professional Schools	Enterprising Orientation
Total Budget	Artistic Orientation
Percentage Freshman Male	

Table 2

Discriminant Function Analysis Using College Characteristics as the Discriminants

Humanities

	Canonical R	Multivariate F	Degrees of Freedom	P
First Function	.864	1.428	100, 149	.024
Second Function	.668	.843	72, 113	.668

Social Sciences

	Canonical R	Multivariate F	Degrees of Freedom	P
First Function	.778	1.397	75, 144	.053
Second Function	.689	1.057	48, 77	.408

Natural Sciences

	Canonical R	Multivariate F	Degrees of Freedom	P
First Function	.732	1.273	50, 78	.167
Second Function	.590	.877	24, 40	.627

Table 3

Correlations between the First Discriminant Function Score
and Selected College Characteristics[a]

GRE AREAS[b]

Humanities		Social Sciences	
Income/Student...	14	Income/Student...	20
Proportion of Faculty with Doctorate.	13	Proportion of Faculty with Doctorate.	26
Selectivity......	19	Selectivity......	19
% Graduating in 4 years........	15	Books............	18
Budget...	13	% Going to Graduate School.........	20

[a]The five largest correlations with each function were selected.

[b]Correlations for the Natural Sciences are not presented here since the Canonical R was not significant.

Table 4

Group Means and Univariate F's for Selected College Characteristics

Humanities

College Characteristics	Group 1 N = 17	Group 2 N = 13	Group 3 N = 26	Group 4 N = 8	Group 5 N = 31	F	P
Income/Student	6.06	5.69	6.15	5.00	5.75	.35	.84
Proportion of Faculty with Doctorate	6.47	5.69	5.73	4.50	5.34	.97	.43
% Graduating in four years	56.47	60.22	47.89	44.00	55.59	2.77	.00
Selectivity	550.57	523.62	484.58	386.25	514.71	5.83	.00
Budget	523.64	493.62	494.68	442.68	484.28	1.13	.34

Social Science

	G_1 N = 9	G_2 N = 42	G_3 N = 33	G_4 N = 11	F	P
Books	5.56	5.02	4.03	6.80	4.27	.01
Income/Student	5.85	5.98	5.36	6.70	.81	.49
Proportion of Faculty with Doctorate	5.88	6.05	4.72	6.70	2.52	.06
Selectivity	476.00	539.78	434.28	586.10	16.31	.00
% Going to Graduate School	37.00	27.89	26.64	45.56	3.10	.03

Fig. 1
GROUP REGRESSION LINES BASED ON POOLED WITHIN SCHOOL REGRESSION LINES