on the fractional distribution of ribosomes and their membrane attachments and respective amino acid incorporation activities in vitro. He concludes that the regulation of protein synthesis by growth and developmental hormones may involve a simultaneous control of the rates at which cytoplasmic RNA and membranes are proliferated as functional units within the cell. This may have important implications for our finding (Figs. 7 and 8) that new polyribosomes appear in the cytoplasmic fraction of the homogenized uterus during early estrogen action, with different amino acid incorporation properties compared to the old ones. There is evidence that phospholipid synthesis is stimulated during early estrogen action (*81*), and this occurs approximately at the time that we find new polyribosomes appearing and accumulating in the cytoplasm (*41*).

81. G. C. Mueller, J. Gorski, Y. Aizawa, in *Mechanisms of Action of Steroid Hormones*, C. A. Villee and L. L. Engel, Eds. (Macmillan, New York, 1961), p. 181.
82. B. W. O'Malley, *Biochemistry* **6**, 2546 (1967); S. G. Korenman and B. W. O'Malley, *Biochim. Biophys. Acta* **140**, 174 (1967); B. W. O'Malley and P. O. Kohler, *Proc. Nat. Acad. Sci. U.S.* **58**, 2359 (1967); P. O. Kohler, P. M. Grimley, B. W. O'Malley, *Science* **160**, 86 (1968).
83. M. L. Vittorelli, R. A. P. Harrison, C. Lutwak-Mann, *Nature* **214**, 890 (1967).
83a. E. W. Hahn, R. B. Church, A. Gorbman, L. Wilmat, *Gen. Comp. Endocrinol.* **10**, 438 (1968); B. W. O'Malley, W. L. McGuire, P. A. Middleton, *Nature* **218**, 1249 (1968).
84. W. Gilbert and B. Müller-Hill, *Proc. Nat. Acad. Sci. U.S.* **56**, 1891 (1966).
85. M. Ptashne, *ibid.* **57**, 306 (1967).
86. J. Bonner, M. E. Dahmus, D. Fambrough, R. C. Huang, K. Marushige, D. Y. H. Tuan, *Science* **159**, 47 (1968).
87. W. Benjamin and A. Gellhorn, *Proc. Nat. Acad. Sci. U.S.* **59**, 262 (1968); A. R. Chipperfield, *Life Sci.* **6**, 2643 (1967).
88. J. A. V. Butler, in *Histones: Their Role in the Transfer of Genetic Information*, A. V. S. de Reuck and J. Knight, Eds. (Little, Brown, Boston, 1966) p. 4; L. S. Hnilica, *Progr. Nucleic Acid Res.* **6**, 25 (1967).
89. The research carried out by my colleagues and me and cited in this article was supported mostly by funds made available by NIH grants HD-00726 and CDA-1-K31-GM-9997-01, the John Simon Guggenheim Memorial Foundation (New York), and the Lalor Foundation (Wilmington, Delaware). Much of the research was in collaboration with J. R. Tata, C. C. Widnell, C.-S. Teng, and A. R. Means. I have also been fortunate in having the advice and criticism of H. S. Forrest, B. Hardesty, R. L. Airth, R. K. Selander, J. J. Biesele, S. E. Harris, D. Bloch, and J. D. Watson. I also thank F. L. Hisaw for his support and interest.

Undergraduate Achievement and Institutional "Excellence"

Traditional indices of institutional quality do not appear to contribute to student achievement.

Alexander W. Astin

Although the American system of higher education is noted for its diversity, most of its institutions pursue a common quest for quality or "excellence." Among the attributes which are generally regarded as indices of excellence are a select student body, a highly trained faculty, an institutional emphasis on scholarship, a large library, a high faculty-student ratio, and a vigorous program of research. Perhaps the most important benefit presumed to derive from these attributes concerns the intellectual development of the student. In the folklore of higher education, it is assumed that the student's learning and intellectual development will be enhanced if he attends a "high-quality" institution. The principal purpose of the research reported here was to test this assumption empirically, by means of a longitudinal study of undergraduate students attending colleges of varying degrees of "quality."

Design of the Study

Studies of the comparative effects of collegiate institutions on the student's development are difficult to design, primarily because students are not distributed randomly among institutions. On the contrary, particular types of students are attracted to particular types of institutions. Under these circumstances, observed variations among colleges in the average achievement of their students may result from differences in ability that existed prior to matriculation, as much as from the differential impact of the institutions themselves. The nonrandom character of college attendance necessitates the use of "natural experiments," in which the comparative influence of different institutions is examined only after some attempt is made to compensate for differences in the average academic ability of the entering students.

The need for controlling differential student inputs is well illustrated by the history of studies of institutional "Ph.D. productivity" (*1*). In general, this research has shown that an adequately controlled study requires the following three types of data. (i) Student output information—performance or achievement of the student; these data represent the dependent variable or variables of concern in the study; (ii) student input (control) information—characteristics of the student, at the time of college entrance, that might affect his subsequent performance on the output measures; (iii) environmental data—characteristics of the student's college that might affect his subsequent output performance.

Sample of Students

The sample of 669 students used in the analysis was drawn from a larger sample comprising the freshman classes entering a stratified national sample of 248 accredited, 4-year colleges and universities in the fall of 1961 (*2*). A subject was included in the study if he satisfied the following four conditions: (i) he was among the random samples of approximately 250 students at each college who were selected for a follow-up study conducted in 1962 (*3*); (ii) his institution was one of the 38 in our sample that administered the area tests from the Graduate Record Examinations to its seniors in 1965; (iii) he could be positively identified by name among those students from whom Graduate Record Examination scores were available; (iv) he had taken the National Merit Scholarship Qualifying Test while in high school, and his scores could be obtained from the files of the National Merit Scholarship Corporation. This last requirement was considered essential, since the student's academic ability before entrance into college was expected to be a major determinant of his subsequent performance on the Graduate Record Examination (*4*).

The author is director of research, American Council on Education, Washington, D.C., and is currently on leave as a fellow at the Center for Advanced Study in the Behavioral Sciences, Stanford, California. This article is adapted from chapter 3 of *The Educational and Vocational Development of American College Students*, to be published in the fall by the American Council on Education.

Student Output Measures

The measures of intellectual achievement used in this study were the students' scores on the area tests of the Graduate Record Examination, which are constructed and administered annually by the Educational Testing Service as part of its Institutional Testing Program. The three area tests, which require 75 minutes each to administer, cover social science, humanities, and natural science, respectively. This battery of tests was regarded as representing an appropriate and comprehensive assessment of the undergraduate student's intellectual development and achievement for several reasons. First, the test content covers three broad areas in the liberal arts which seem relevant to the educational objectives of most undergraduate institutions. Second, the scores on the area tests, unlike the traditional grade-point average, represent standard measures of achievement which permit meaningful comparisons among institutions. Finally, the conditions of participation in the Institutional Testing Program require that all seniors take the area tests; therefore, student self-selection (which occurs in the Graduate Record Examination National Program for Graduate School Selection) is not a factor.

Student Input (Control) Measures

Student input data were obtained from the test records of the National Merit Scholarship Corporation and from a brief questionnaire administered to each student during the freshmen orientation or registration period in the fall of 1961. Data from these sources were used to generate the following 103 student input measures.

1–6) Scores on the National Merit Scholarship Qualifying Test (five subtests, plus a composite score).

7) Sex (scored as a dichotomy).

8–16) High school grades (for example, A, A–, through C; scored as a continuous variable and also as eight separate dichotomous "dummy" variables).

17) Size of high school class.

18–35) Dichotomous scores on 18 nonacademic achievements (for example, won a prize in a school science contest, elected to a student office).

36) Father's educational level.

37–52) Father's occupation (for example, scientist, school teacher, lawyer; scored as 16 separate dichotomous variables).

53–58) Highest degree planned (bachelors, masters, Ph.D., LL.B., M.D., or D.D.S.; scored as a continuous variable and also as five separate dichotomous variables).

59–73) Intended field of study in college (for example, biological science, engineering, business; scored as 15 separate dichotomous variables).

74–103) Career choice (for example, accountant, chemist, journalist; scored as 30 separate dichotomous variables).

Table 1. Characteristics of the 669 students for whom input data and scores on the Graduate Record Examination area tests were available.

Characteristic	Mean or %	Standard deviation
Percentage of men	51.1	
Percentage initially majoring in		
Social sciences	13.0	
Education	11.1	
Arts and humanities	16.1	
Natural sciences	29.1	
Other fields	12.9	
Undecided	17.8	
Percentage with average high school grade of		
A– to A+	31.8	
B– to B+	53.4	
C+ or lower	14.8	
Mean score on National Merit Scholarship Qualifying Test		
English usage	20.7	4.0
Mathematics	22.7	4.9
Social science reading	23.5	4.5
Natural science reading	23.5	5.4
Word usage	23.8	4.7
Composite	22.8	3.8
Mean score on Graduate Record Examination area tests		
Social science	511.3	102.9
Humanities	516.1	91.3
Natural science	523.1	88.1

Some of the input characteristics of the 669 students are summarized in Table 1. The sample included approximately equal numbers of men and women majoring in a variety of undergraduate fields. Several items in Table 1 suggest that this group of students was generally superior: nearly one-third of them obtained average grades of A– or better in high school, and their mean scores on the subtests of the National Merit Scholarship Qualifying Test were somewhat above the mean for college students in general (approximately 20.0). Nevertheless, this group manifested considerable variation in academic potential: nearly 15 percent of them obtained grades of C+ or lower in high school, and their standard deviations on the subtests of the National Merit Scholarship Qualifying Test were comparable to those of college students in general (*5*). Their means and standard deviations on the area tests of the Graduate Record Examination (the output measures) compared favorably with the population mean of 500 and standard deviation of 100, indicating that the performance of our sample of students is reasonably representative of the overall achievement level of seniors at institutions where this particular battery of tests is administered.

Environmental Measures

Measures of institutional quality. In a factor analysis of characteristics of colleges and universities (*6*), it was found that most of the traditional indices of institutional "quality" were highly interrelated. Institutions with relatively large expenditures per student for general operating expenses, for example, also tended to have a relatively high income per student for research, endowments, capital income, and scholarship funds. Furthermore, these wealthier institutions tended to recruit highly able student bodies and to have large libraries and high faculty-student ratios. The statistical factor identified with this complex of closely intercorrelated institutional characteristics was labeled "affluence" in the earlier study, although such terms as "quality" and "prestige" might be equally appropriate. The two best indicators of institutional affluence turned out to be the average academic ability of the entering student body and the per-student expenditures for "educational and general" purposes (meaning, primarily, salaries for faculty and staff). These two measures comprised the principal indices of institutional excellence used in the study.

1) Selectivity (an estimate of the average academic ability of the entering students) (*2*).

2) Per-student expenditures for educational and general purposes (*7*).

Within the total population of 4-year institutions, the absolute degree of variation with respect to these (and related) measures of quality is considerable. The 30 most affluent institutions in the United States, for example, spend more than four times as much money per student for educational and general purposes as the 30 least affluent do. Similarly, it has been estimated that the 25 most selective institutions in the country recruit half or more of their entering students from among the top 3 percent

in academic ability. On the other hand, fully 15 percent of the institutions (nearly 200) enroll virtually no students from this select 3 percent. That our measure of selectivity conforms to commonsense notions about which are the "quality" institutions can be seen by listing the ten most selective institutions in the country: Caltech, Radcliffe, M.I.T., Swarthmore, Rice, Harvard, Stanford, Reed, Amherst, and Pomona (*8*). As might be expected, selectivity is also highly correlated ($r = .69$) with the overall quality of the institution's graduate program, as revealed in Cartter's study (*9*).

Five additional measures of affluence, which are also generally considered to be indicative of institutional quality, were used.

3) Number of books in the library.

4) Number of books in the library per student.

5) Faculty-student ratio.

6) Percentage of faculty with Ph.D. degree.

7) Total affluence (average based on measures 2–6).

Our final measure of institutional quality was included to test the assumption that the student's intellectual achievement is enhanced if he is exposed to an environment where the competition for intellectual rewards is very high. Although one would expect that the intelligence level of the student's peers (environmental measure 1, above) affects the amount of competition at an institution, we used a more direct measure that had been developed in a study of college environments (*3*).

8) Academic competitiveness (the degree of competition for grades as perceived by the student body).

In addition to the eight variables listed above, 61 other measures of institutional characteristics were included in our analysis for exploratory purposes.

9–12) Type of control (public, Protestant, Catholic, private-nonsectarian).

13–18) Type of institution (university, liberal arts, teachers, men's, women's, predominantly Negro).

19–22) Geographic region (northeast, south, north central, west-southwest).

23–26) Type of college town (large city, medium-sized city, suburb, small town).

27) Total undergraduate enrollment.

28) Percentage of men in the student body.

29–34) Curricular emphases (percentages of degrees awarded in six broad fields: realistic, scientific, social, conventional, enterprising, and artistic) (*10*).

35–69) Thirty-five measures of the college environment derived from the Inventory of College Activities, an instrument for estimating the frequency of occurrence of observable stimuli in the peer, classroom, administrative and physical environments of the institution (*3*).

Environmental variables 9 through 26 were scored as dichotomies, whereas measures 27 through 69 were scored as continuous variables. Some of the characteristics of our sample of 38 institutions are summarized in Table 2. The mean of 48.8 and standard deviation of 9.0 for selectivity were very close to the population values of 50 and 10, indicating that, in its general level and diversity of selectivity, our sample was reasonably representative of the total population of accredited 4-year institutions. The fact that 32 of our 38 institutions were liberal arts colleges (the other six were five universities and one teachers college) is reflected in the relatively small mean and standard deviation for enrollment size. This overrepresentation of liberal arts colleges is characteristic of the total group of institutions participating in the Institutional Testing Program of Educational Testing Service.

Table 2. Characteristics of the 38 institutions attended by the 669 students.

Characteristic*	Mean	Standard deviation
Selectivity	48.8	9.0
Size	45.8	7.4
Characteristics of entering classes		
Intellectualism	50.1	8.7
Estheticism	46.4	9.2
Status	52.0	9.2
Pragmatism	51.6	6.5
Masculinity	50.6	8.2

* Population ($N = 1015$) means and standard deviations on each characteristic have been set at 50 and 10, respectively (*2*).

The institutions in our sample spent a median of $1170 per student for educational and general purposes, with a range from $660 to $4280 per student. These figures, together with the data shown in Table 2, indicate that our sample of 38 institutions was reasonably diverse with respect to quality—the principal independent variable of concern in the study.

The distribution of the 669 students among the 38 institutions was fairly uniform. There were no more than 49 students from any one institution, and the median number of students per institution, which was 16, was very close to the mean number per institution of 17.6 (*11*).

Interaction Measures

Some versions of the folklore concerning institutional excellence deal with the interaction between student and institutional quality, rather than simply with the independent effects of institutional quality. More specifically, many educators assume that the positive effects of quality on achievement do not operate uniformly across all levels of student ability, and that the impact will be greatest for the most able students (that is, the greater the student's ability the more intellectual benefit he will derive from attending an institution of high quality). This assumed benefit is frequently used to justify the highly selective admissions policies of many institutions. Although many such interaction terms between specific student and environmental characteristics can be calculated, the following appear best to represent this expected interaction.

1) The product of the individual student's academic ability (as measured by his composite score on the National Merit Scholarship Qualifying Test) and the average ability of all undergraduate students at his institution (selectivity).

2) The product of the student's academic ability and the institution's per-student expenditures for educational and general puposes.

Before these terms were computed, all variances were equated in order to balance the contribution of student and of institutional quality to each term.

Testing of Hypotheses

Stated in positive terms, the general hypotheses tested in this study were as follows. (i) The academic excellence of the undergraduate institution—as defined by the level of ability of the student body, the degree of academic competitiveness in the college environment, and the level of the institution's financial resources—has a positive effect on the undergraduate student's intellectual achievement. (ii) The extent of the positive effect of institutional quality on intellectual achievement is proportional to the student's academic ability. In conventional statistical terminology,

Table 3. Correlations between measures of institutional quality and measures of student achievement, before and after control of differential student input characteristics. GRE, Graduate Record Examination.

Index of quality or excellence	Correlations with student achievement (GRE)					
	Before control of input measures			After control of input measures		
	Social science	Humanities	Natural science	Social science	Humanities	Natural science
Ability level of student body	.20†	.17†	.09*	.00	−.07	−.08*
Academic competitiveness	.11†	.15†	.05	.01	.06	−.09*
Expenditures (education and general) per student	.21†	.11†	.13†	.04	−.08*	−.05
Library size	.24†	.11†	.16†	.12†	.03	.03
Books in library per student	.10†	.02	.08*	.03	.02	−.06
Faculty-student ratio	.17†	.09*	.05	.07	.02	−.08
Percentage faculty with Ph.D.	.20†	.09*	.18†	.06	.05	.00
Total affluence	.27†	.13†	.15†	.12†	.04	−.05
Interaction between student aptitude and ability level of student body	.46†	.45†	.32†	.02	−.06	−.08*
Expenditures (education and general) per student	.52†	.47†	.39†	.05	−.07	−.06

* $P < .05$; † $P < .01$

Table 4. The prediction of undergraduate achievement in social science: summary of stepwise regression analysis. NMSQT, National Merit Scholarship Qualifying Test.

Independent variable entering equation	Sign	R	Increase in R^2	F-value*	
				To enter equation	In final equation
Student input characteristics					
Academic aptitude (NMSQT composite)	+	.564	.318	310.9	179.5
Sex (male)	+	.616	.062	66.1	33.2
Major in history or political science	+	.634	.023	25.2	15.2
English aptitude (NMSQT)	−	.644	.013	14.2	30.4
Major in economics, psychology, or sociology	+	.651	.009	10.4	14.7
Father a skilled worker	−	.656	.007	8.3	3.1
Mathematical aptitude (NMSQT)	−	.660	.005	6.1	18.5
Major in mathematics	+	.665	.006	6.9	10.2
Major in education	+	.669	.006	6.8	5.8
Career choice of politician or diplomat	+	.673	.005	6.0	6.8
Won leadership award in high school	−	.677	.006	6.9	9.7
High school grade average	+	.683	.008	9.6	14.0
Career choice of businessman	+	.686	.005	6.1	6.9
Career choice of nurse	−	.689	.004	4.3	0.4
Career choice of college professor	−	.691	.004	4.4	5.2
Father's educational level	+	.694	.004	4.5	2.0
College environmental characteristics					
Severity of administrative policy against heterosexual activity	−	.703	.013	16.1	6.4
College located in suburban area	−	.710	.010	12.6	17.8
Student employment	+	.715	.008	9.9	10.7
Predominantly Negro	−	.718	.004	5.1	5.1

* $F_{.05} = 3.88$; $F_{.01} = 6.75$; $F_{.001} = 11.11$.

Table 5. The prediction of undergraduate achievement in humanities: summary of stepwise regression analysis.

Independent variable entering equation	Sign	R	Increase in R^2	F-value*	
				To enter equation	In final equation
Student input characteristics					
Word usage aptitude (NMSQT)	+	.593	.351	361.0	122.7
English aptitude (NMSQT)	+	.624	.039	42.2	14.6
High school grade average	+	.637	.016	17.6	19.4
Natural science reading aptitude (NMSQT)	+	.642	.006	6.8	6.5
Major in business	−	.646	.006	6.8	5.0
Major in fine arts or music	+	.650	.005	6.0	6.1
Planning a Ph.D. degree	+	.653	.004	4.5	3.0
Father a college professor	+	.656	.004	4.0	5.0
College environmental characteristics					
Verbal aggressiveness in the class	−	.678	.029	35.4	38.2
Familiarity with the instructor	+	.688	.014	17.6	13.2
Nonsectarian	+	.692	.005	6.3	7.9
Expenditures (educational and general) per student	−	.695	005	5.7	9.5
Total affluence	+	.697	.004	4.7	4.7

* $F_{.05} = 3.88$; $F_{.01} = 6.75$; $F_{.001} = 11.11$.

the first hypothesis is concerned with the main effects of institutional excellence on intellectual achievement, whereas the second hypothesis is concerned with the interaction effects of institutional quality and student ability on intellectual achievement.

A primary objective of the statistical analyses of data was to adjust for differences in the characteristics of freshmen entering different institutions so that relatively unbiased tests of our two hypotheses could be performed. The statistical technique used for this purpose consisted of a three-stage, stepwise, linear regression analysis, in which the dependent variable was the student's score on one of the area tests of the Graduate Record Examinations. During each stage of the analysis, a different subset of independent variables was entered into the regression equation in a stepwise fashion until no additional variable from that subset was capable of producing a reduction in the residual sum of squares in the test exceeding $P = .05$. During the first stage in each analysis, the 103 student-input (control) variables were permitted to enter into the equation. During the second stage, the 69 college environmental variables, including the measures of institutional excellence, were permitted to enter. The final stage of the analysis permitted the two interaction terms to enter the equation. Three such three-stage analyses were performed, one for each of the area tests of the Graduate Record Examination.

At the end of the first stage in each analysis, the student's residual score on the particular area test was linearly independent of his characteristics at the time of entrance to college. Presumably, this residual variation in performance is attributable either to differential environmental experiences since entering college (including effects of the college environments) or to errors of measurement (*12*). In short, the purpose of the first stage in each analysis was to equate statistically the students entering each institution in order to minimize bias in the interpretation of relationships between institutional characteristics and student achievement.

Results

From inspection of Table 3, in which the results of the tests of our two major hypotheses are given, a positive relation between the college senior's intellectual achievement and the quality of his institution is evident. More simply, students in the higher-quality institutions tended to perform better than students in the institutions of lesser quality. However, virtually all the coefficients (first three columns, Table 3) were greatly diminished in size as a consequence of controlling differential inputs, and nearly half of the signs became negative (last three columns, Table 3). More important, only seven of these partial coefficients were statistically significant, and, of these, five were negative in sign (*13*).

These findings offer little support for either of our general hypotheses concerning the effects of institutional quality on student achievement. Significant positive relations with measures of quality were found only in the case of achievement in social science, whereas the significant partial correlations involving achievement in humanities and natural sciences were all negative. All of these coefficients, however, were trivial in size, and no single measure of institutional quality seemed to have a consistent effect—positive or negative—on achievement in even two of the three areas.

The results of the stepwise linear regression analyses are summarized in Tables 4, 5, and 6. Of the student's characteristics at the time he enters college, the most important single determinant of his level of achievement as a college senior was his academic ability as measured during high school. As might be expected, the student's mathematical aptitude was most important in predicting his subsequent level of achievement in natural science, whereas his aptitudes in word usage and in English were most important in predicting achievement in humanities. Overall academic ability (as measured by the National Merit

Table 6. The prediction of undergraduate achievement in natural science; summary of stepwise regression analysis.

Independent variable entering equation	Sign	R	Increase in R^2	F-value*	
				To enter equation	In final equation
Student input characteristics					
Mathematical aptitude (NMSQT)	+	.471	.222	190.1	18.9
Sex (male)	+	.532	.062	57.9	112.0
Natural science reading aptitude (NMSQT)	+	.578	.050	50.3	14.3
Major in physical science	+	.609	.036	38.0	34.2
Major in biological science	+	.638	.037	40.8	28.7
High school grade average	+	.648	.013	14.6	22.1
Word usage aptitude (NMSQT)	+	.656	.011	12.7	18.8
Career choice of lawyer	−	.664	.010	11.8	11.6
Major in accounting	−	.669	.007	8.7	14.9
Career choice of businessman	−	.674	.006	7.7	9.6
Major in English	−	.679	.006	7.6	3.1
Major in philosophy or religion	−	.683	.006	7.2	7.3
Career choice of biological scientist	+	.687	.005	6.3	9.2
Won award in high school debate contest	−	.690	.005	6.4	7.9
Father a farmer	+	.694	.005	5.8	4.8
Edited high school paper or magazine	+	.697	.004	4.8	5.6
Career choice of dentist	−	.699	.004	5.1	6.4
Elected to student office in high school	−	.702	.004	4.7	3.8
Major in agriculture	+	.704	.003	4.2	3.8
College environmental characteristics					
Student employment	+	.712	.011	14.9	10.2
Nonsectarian	+	.718	.008	10.4	21.3
Severity of administrative policy against drinking	+	.721	.005	6.9	9.2
Emphasis on athletics	−	.724	.003	4.3	10.1
Extroversion of the instructor	−	.726	.003	4.3	8.2
Rate of cheating in the classroom	+	.728	.003	4.5	4.5

* $F_{.05} = 3.88$; $F_{.01} = 6.75$; $F_{.001} = 11.11$.

Table 7. Environmental characteristics showing similar effects on all three measures of student achievement.

Environmental variables	Partial correlation, after control of student input variables, with achievement in		
	Social science	Humanities	Natural science
Peer environment			
Use of automobiles	.08*	.13†	.15†
Career indecision	.08*	.11†	.10†
Verbal aggressiveness in the class	−.07	−.23†	−.14†
Independence	−.02	−.08*	−.12†
Administrative environment			
Flexibility of the curriculum	.09*	.16†	.04
Severity of administrative policy against cheating	−.09	−.14†	−.11†
Severity of administrative policy against heterosexual activity	−.16†	−.10*	−.02
Realistic (technical) emphasis in the curriculum	.10*	.08*	.08*
Total enrollment	.07	.08*	.10*
Roman Catholic control	−.14†	−.12†	−.08*

* $P < .05$; † $P < .01$

Scholarship Qualifying Test composite score) was the best single predictor of undergraduate achievement in social science. Being male carries substantial positive weight in predicting achievement in both natural and social science, although sex did not enter into the prediction of achievement in humanities.

Next to academic ability and sex, the most important predictors of undergraduate achievement were the student's intended field of study and his career choice at the time he entered college. For the most part, the fields of study and career choices that carried significant weight in each analysis were appropriate to the particular area test under consideration. The student's level of achievement in natural science, for example, was relatively high in his senior year if he had initially intended to major in physical science, biological science, or agriculture, and relatively low if his initial major had been in accounting, English, or philosophy. Similarly, students tended to perform relatively well on the area test in social science if they had initially planned to major in history, political science, economics, psychology, sociology, education, or (rather surprisingly) mathematics. Students performed relatively well on the humanities test if they had planned to major in fine arts or music and relatively badly if they had planned to major in business. A similar predictive pattern was found when the student's intial career choice was considered. (There is, of course, some redundancy in career choices and fields of study.)

Since the student's initial study plans appeared to have these effects even though his initial achievement level as measured by the National Merit Scholarship Qualifying Test was controlled, it seems safe to conclude that scores on the Graduate Record Examination area tests reflect differential learning that occurred as a result of the student's particular undergraduate course of study. The only other input variable which was consistently related to performance on the area tests was the student's average grade in high school, which, not surprisingly, carried a positive weight in predicting achievement in all three areas.

The colleges' environmental characteristics that entered into the regression equation during the second stage of the analysis (after the control of student input characteristics) are listed at the bottom of Tables 4, 5, and 6. Measures of institutional excellence or quality entered into only one of the three analyses, that of achievement in the humanities. In this instance, the educational and general expenditures per student entered in with a negative weight, after which the total affluence measure entered in with a positive weight. (Until this last step in the analysis, total affluence showed no relation to achievement in humanities.) These findings once again contradict the folklore concerning institutional excellence.

The second stage in our three analyses failed to reveal any clear-cut pattern of institutional characteristics which either fosters or inhibits student achievement. However, in order to explore further the possibility that there might be certain consistent patterns which are obscured by the large number of partially redundant college variables, we examined the partial correlations between the three achievement measures and each of the 69 measures of environmental characteristics immediately after the first stage of the analysis (the control of student input variables). Several environmental characteristics which, at this stage in the analysis, had consistent partial correlations with all three achievement measures are listed in Table 7. The criteria for inclusion in this list were that the sign of the partial correlation be the same for all three measures and that at least two of the partial correlations be statistically significant ($P < .05$). Somewhat surprisingly, the peer environments of those institutions where the students' level of achievement exceeded the level predicted from their freshman input characteristics had several distinct characteristics: students tended to make frequent use of automobiles, to be undecided about their careers, and to manifest little independence or verbal aggressiveness in the classroom. Moreover, at institutions which had relatively flexible curricula (few required courses) and relatively permissive policies concerning cheating and heterosexual activity, students tended to achieve above the expected level. Students attending relatively large institutions with a fairly strong technical emphasis in the curriculum tended to perform somewhat better than expected, whereas students attending Roman Catholic institutions tended to perform below expectation.

At first glance, this pattern of environmental characteristics seems contrary to commonsense notions about the environmental influences that facilitate student achievement. One obvious explanation for the apparently negative effects that severe policies against cheating had on achievement is that students find it easier to "improve" their scores when the Graduate Record Examination is administered in an environment where cheating is tolerated.

A study involving the larger sample of 246 institutions (*14*) may help elucidate the total pattern of relationships shown in Table 7. One of the major objectives of this earlier study was to identify environmental characteristics of the college that effect the student's chances of dropping out before graduation. Two "dropout" criteria were used: completing 4 years of undergraduate study during the first 4 years after matriculation and obtaining the bachelor's degree 4 years after entering college. All the environmental characteristics shown in Table 7 except one (severity of administrative policy against heterosexual activity) showed statisti-

cally significant effects on the student's chances of dropping out. In every case, the direction of the effect was the opposite of the direction shown in Table 7. In other words, the same environmental characteristics which increase the chances of some students' dropping out seem to have a positive effect on the achievement of other students during the senior year. Perhaps those institutions with relatively high dropout rates facilitate student achievement because they encourage the less motivated and less able students to drop out before they reach the senior year. Consequently, those students who survive the four undergraduate years to take the Graduate Record Examinations have endured a more stringent screening procedure. Conversely, institutions with relatively low dropout rates may have a negative effect on student achievement in that they encourage students who might otherwise drop out because of low motivation to stay through the 4 years. These students, in turn, would tend to perform below expectation on the Graduate Record Examination.

Table 8. Relative proportions of variance in achievement attributable to student input and to college environmental variables. GRE, Graduate Record Examination.

Proportion of variance attributable to	GRE area test		
	Social science	Humanities	Natural science
Joint contribution of student input and college environment	.515	.486	.530
Student input alone	.482	.430	.496
College environment alone	.198	.106	.104
Input independent of environment	.317	.380	.426
Environment independent of input	.033	.056	.034

Importance of Student Input and Environmental Variables

Although our analyses failed to confirm the folklore concerning the presumed educational benefits of institutional quality, there was some evidence in our findings that the student's achievement is affected by institutional characteristics other than the traditional measures of quality. But these effects appear to be relatively small compared with the effects of student input characteristics. In order to test more directly the relative importance of these two classes of effects, we performed a second series of analyses similar to the ones summarized in Tables 4, 5, and 6. In these additional analyses, however, the 69 college characteristics were permitted to enter the regression equations before any of the student input measures were permitted to enter (that is, the first two stages in the earlier analyses were reversed).

The results of both sets of analyses are compared in Table 8. Each of the coefficients (R^2) in the table represents the proportion of common variance or overlap between one of the achievement measures and a particular subset of independent variables. In brief, these results show clearly that variations in achievement during the senior year in college were much more dependent upon differences in student characteristics that existed prior to matriculation than they were upon the characteristics of the colleges attended by the students. Even when the bias resulting from differential student inputs was not controlled, college characteristics accounted for only about 20 percent of the variance in social science achievement and only about 10 percent of the variance in achievement in humanities and natural science. When student input differences were controlled, the contribution of college characteristics shrank to only about 5 percent of the variance in achievement. The substantial contribution of the student input, on the other hand, was only moderately reduced if the college characteristics were first controlled (*15*).

These results tended to confirm earlier studies of differential college influence (*1*), in which variations in student performance on the Graduate Record Examination aptitude tests (*16*), in institutional Ph.D. productivity (*1*), and in other criteria were found to be primarily dependent upon variations in student inputs. It must be kept in mind, however, that our analysis accounted for only about half of the observed variation in student achievement in the senior year. A large proportion of this residual variation is undoubtedly attributable to errors in our measuring instruments, although it is also possible that we have so far failed to identify other important environmental factors. In studies under way at the American Council on Education, we are attempting to isolate these other environmental factors that may affect student achievement.

Summary

The principal purpose of this study was to determine the effects of certain traditional indices of institutional excellence on the intellectual achievement of the undergraduate student. Our analysis failed to confirm the hypothesis that the student's achievement in social science, humanities, or natural science is facilitated either by the intellectual level of his classmates or by the level of academic competitiveness or financial resources of his institution. Similarly, the evidence did not support the contention that the bright student benefits more than does the average student from exposure to these assumed indices of institutional "quality." Additional analyses indicated that differences in student achievement during the senior year were much more highly dependent upon variations in student characteristics that existed before entrance into college than upon the characteristics of the undergraduate college attended. The results of these analyses suggest that it may be wise to reexamine some of our traditional notions about institutional excellence, particularly as it relates to the intellectual development of the student.

References and Notes

1. R. H. Knapp and H. B. Goodrich, *Origins of American Scientists* (Univ. of Chicago Press, Chicago, 1952); J. L. Holland, *Science* **126**, 433 (1957); D. L. Thistlethwaite, *ibid.* **130**, 71 (1959); A. W. Astin, *ibid.* **136**, 129 (1962); *ibid.* **141**, 334 (1963); *J. Educ. Psychol.* **54**, 63 (1963).
2. A. W. Astin, *Who Goes Where to College?* (Science Research Associates, Chicago, 1965).
3. ———, *The College Environment* (American Council on Education, Washington, D.C., 1968).
4. The substantial loss of subjects (only 669 remained from an initial sample of 9877 entering students) was caused primarily by the random subsampling within colleges, by the number of dropouts and transfers, and by the requirement that National Merit Scholarship Qualifying Test scores be available. These scores were considered preferable to scores on either the Scholastic Aptitude or the American College tests, because the use of these last two tests in admissions might lead to regression artifacts if the scores are subsequently used to control differential student inputs.
5. A. W. Astin, unpublished manuscript.
6. ———, *J. Educ. Psychol.* **53**, 224 (1962); ——— and J. L. Holland, *Coll. Univ.* **37**, 113 (1962).
7. A. M. Cartter, Ed., *American Universities and Colleges* (American Council on Education, Washington, D.C., ed. **9**, 1964).
8. A. W. Astin, *Coll. Univ.* **40**, 282 (1965).
9. A. M. Cartter, *An Assessment of Quality in Graduate Education* (American Council on Education, Washington, D.C., 1966).
10. A. W. Astin and J. L. Holland, *J. Educ. Psychol.* **52**, 308 (1961).
11. There tended to be slightly more students in the more selective institutions, so that the

mean selectivity score using the student as the unit of analysis (52.5) was slightly higher than the mean selectivity score using the institution as the unit of analysis (48.8) (Table 2). Student means on other institutional characteristics, however, tended to be very close to the institutional means.

12. It is always possible, of course, that the residual scores on the Graduate Record Examination were not independent of certain potentially biasing student input characteristics that were inadvertently left out of our analysis. The principal objective in this and similar "natural experiments" is to measure and statistically control as many potentially biasing student input characteristics as possible.
13. In terms of classical test theory, our method of analysis would not produce residual scores on the dependent variable which are independent of the student's "true" input scores, as long as there are random errors in the measurement of the input variables. Such errors have the effect of flattening the slope of the observed regression of the dependent variable on the independent variables. The appropriate procedure to adjust for this source of bias is to compute the intercorrelations of the variables using the variances of the "true" input scores rather than the variances in the observed input scores. We were not able to conduct our entire analysis using these "true" variances, because of the difficulty in estimating the reliability (that is, the ratio between "true" and observed variances) of the many qualitative input variables (for example, the student's initial field of study). However, the availability of reliability estimates for our key input variables—the National Merit Scholarship Qualifying Test scores—enabled us to run two additional analyses: one using the observed variances in these scores, and the other using their estimated true variances. In both analyses the scores were first entered into regression after which we examined the partial correlations between achievement on the Graduate Record Examination and the various measures of institutional quality. Using the true rather than the observed variances altered the partial correlations only slightly, but in every instance the shifts were in the negative direction (that is, contrary to the two hypotheses).
14. A. W. Astin and R. J. Panos, *The Educational and Vocational Development of American College Students* (American Council on Education, Washington, D.C., in press).
15. Because of the relatively small numbers of students at each institution, it was not possible to compute reliable estimates of the mean residual gain (or loss) in points on the Graduate Record Examination for individual institutions. Nevertheless, it should be recognized that there may be some institutions where the absolute "value added," in terms of points on the Graduate Record Examination above or below what would be expected from the students' input characteristics, is considerable. The point to keep in mind is that the results of the current study indicate that such institutions are no more likely to be found among the highly affluent than among the least affluent institutions.
16. R. C. Nichols, *J. Educ. Psychol.* **55**, 45 (1964); A. W. Astin, unpublished manuscript.
17. This study was supported in part by grant GR-22 from the National Science Foundation to the American Council on Education. I thank G. V. Lannholm of the Educational Testing Service for his assistance in obtaining the students' scores on the area tests of the Graduate Record Examinations; C. Sell for assistance in data processing; and R. J. Panos for his help in many phases of this project.

Medical Schools: Federal Funds Increase, So Do Budget Ills

Medical schools straddle two sectors of the economy in which costs are rising giddily—higher education and health services. Many a medical school is living beyond its income and relying on emergency fund raising or timely benefactions to make up the deficit. There is even dark talk of some financially weaker schools losing accreditation.

Federal research funds have provided the biggest growth factor in medical school budgets since World War II, but it was not until 5 years ago that federal money for medical-school teaching programs became available explicitly and in significant quantities. Just how important these funds have become to the medical schools can be judged from the cries of anguish which arose when the administration's spring economy edict resulted in a drastic shortening of the list of medical schools scheduled to receive funds under a "special improvement grants" program specifically intended to help schools overcome weaknesses which give them accreditation problems.

More than 50 expectant medical schools got the bad news that their projects, most designed to strengthen faculty or improve teaching resources, could not be funded after all. About $20 million had been available originally for the program; this was finally cut to $10 million. Grants, mostly in the $200,000 to $300,000 range, went to 23 medical schools and two schools of osteopathic medicine judged to be in greatest need. The Bureau of Health Manpower, formerly under the Public Health Service but shifted to the administrative fief of the National Institutes of Health in a recent reorganization, administers the grants program and has been taking a buffeting from its disappointed medical-school clients. The program has been on the books for 3 years, but this was the first year that funds had been appropriated to finance it, and the disappointment at having the grants snatched away seems to have been sharpened by the fact that, financially, so many schools are living dangerously this year.

The bureau also administers the bigger "basic improvement grants" program which this year pumped $32 million into medical schools and other health-professions schools. Funds under this program are distributed by a formula which takes into account the number of full-time students in each school. The special grants are awarded on a competitive basis, and administrators at some schools told *Science* they apparently failed to describe their straits vividly enough and now feel that grants went to some schools whose plight was less desperate. The section that administers the grants says that an effort is being made to acquaint its clients with what is expected on the applications, and also indicates that more visits to applicant schools will be made, to gather on-the-spot information.

Direct federal support of medical-school teaching programs dates back to 1963, when the Health Professions Assistance Act became law. It had the distinction of being the solitary major legislative innovation proposed by President Kennedy in the field of education to be passed before his assassination. The act originally authorized matching grants for the construction of teaching facilities, and so far it has provided $365 million for the building, expansion, and renovation of teaching facilities for medical and dental schools and other health-professions schools.

The law was amended in 1965 to provide the improvement grants programs and also a loan program for students of medicine, dentistry, osteopathy, and optometry. Students in podiatry, pharmacy, and veterinary medicine have since been made eligible.

There was a breakthrough for federal aid to health-professions teaching programs, and the situation now is dra-