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Disciplinary Categories, Majors, and Undergraduate Academic Experiences: Rethinking Bok's "Underachieving Colleges" Thesis

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Abstract Using data from the 2008 University of California Undergraduate Experience Survey, we show that study time and academic conscientiousness were lower among students in humanities and social science majors than among students in science and engineering majors. Analytical and critical thinking experiences were no more evident among humanities and social sciences majors than among science and engineering majors. All three academically beneficial experiences were, however, strongly related to participation in class and interaction with instructors, and participation was more common among humanities and social sciences students than among science and engineering students. Bok's (*Our underachieving colleges: A candid look at how much students learn and why they should be learning more*. Princeton and Oxford: Princeton University Press, 2006) influential discussion of "underachievement' in undergraduate education focused on institutional performance. Our findings indicate that future discussions should take into account differences among disciplinary categories and majors as well.

Keywords Academic disciplines · Educational experiences · Research universities

Post-war higher education advocates spoke of "talent waste" (Wolfle 1954), because many young people who might have profited from higher education were denied access for lack of financial support or places in the system. Today, the term "talent waste" has a second meaning. Although issues of access have not been solved, most students who complete high school degrees do go on for post-secondary work (Bound et al. 2009). However, relatively few spend their time in college focusing on their studies or developing their core academic skills. Instead, social life dominates the time of most college students. For this reason, talent waste is now also a product of a higher education system that demands relatively little of most of its undergraduate students.

The amount of time students spend on their studies in and out of class has fallen by about 15 hours a week since the early 1960s, controlling for socio-demographic and

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institutional affiliations, and the average now registers at a little over 25 hours per week (Babcock and Marks 2010). Only one-third of University of California students say they complete as much as 80% of the required reading for their courses (Brint et al. 2010). By contrast, the average college student spends 40 or more hours per week on social and recreational activities (Babcock and Marks 2010; Brint and Cantwell 2010).

National assessments of student learning have demonstrated that these low levels of investment in learning lead to limited results. In a recent study of students' academic skill development at 24 U.S. four-year colleges and universities, 36% of participating students showed no statistically significant gains on the College Learning Assessment between their freshman and senior years (Arum and Roksa 2011). Although the wage advantage of college over high school education remains high, and has been growing over time (Goldin and Katz 2008), given the limited engagement of college students with their studies, actual human capital development may be exaggerated by the frequent assumption among economists that it is closely associated with the college wage premium.

Former Harvard President Derek Bok (2006) has used the term "under-achievement" to characterize the performance of American colleges and universities in undergraduate education. We accept the term "underachievement" as frequently apt, but we question the use of the term as a blanket characterization of all undergraduate majors in U.S. colleges and universities. As we will show, hours of study and conscientious study behaviors vary greatly among undergraduates depending on their disciplinary category and major. Analytical and critical thinking experiences also vary by major, albeit in a less pronounced way. Participation in class and interaction with professors is strongly associated with each of these academically beneficial experiences, and it too varies by disciplinary category and major.

Research universities are a strategic site for studying undergraduate academic outcomes because of long-standing concerns about the quality of the undergraduate academic experience found in these institutions (see, e.g., Barzun 1945; Boyer Commission 1998), including occasionally frank admissions by university administrators that undergraduate education is a low priority for research university faculty and administrators (see, e.g., Kerr 1962, pp. 64–65; Cole 2009, p. 4). These concerns are supported by empirical studies that cast doubt on the quality of the undergraduate experience in research universities (Hu and Kuh 2001; Kuh 2003a).

Using data drawn from a large sample of University of California upper-division students surveyed in 2008, we examine disciplinary category and major differences on three academic behavior and experience measures—(1) study time, (2) academic conscientiousness, and (3) analytical and critical thinking. This study provides the first systematic comparison of disciplinary categories and majors on these important measures of the student academic experience. Our analyses confirm the great importance of participation (measured as frequency of classroom participation and interaction with professors) as a correlate of academically beneficial experiences (see Kuh 2003a). At the same time, we establish that disciplinary category and major differences remain significant, even after participation is statistically controlled. We also show that the academic achievements and socio-demographic backgrounds of students in different fields do not account for much of the variation in the three academic experience measures.

Previous Literature

As practiced by disciplinary experts, all disciplines involve highly sophisticated intellectual understandings. These understandings differ between the disciplines, with some disciplines requiring more sophistication in quantitative skills and other disciplines requiring more sophistication in interpretive skills. Our focus is not on the skills of experts, but rather on the academic experiences of novices who are just beginning to learn the subject matter of their disciplines and how experts think in relation to this subject matter.

The disciplinary classification scheme we adopt in this paper emphasizes differences between "high paradigm" and "low paradigm" fields (Biglan 1973a, b; Braxton and Hargens 1996; Braxton et al. 1998).[1] The distinction refers to the level of consensus among scholars about the accepted findings, theories, methods, and principles of analysis in the field. The natural sciences and engineering are primary examples of high-paradigm (or "hard") fields in which knowledge is cumulative and students are expected to master an established set of conceptual frameworks, principles, and methods. The non-quantitative social sciences, the humanities, and the arts are primary examples of low-paradigm (or "soft") fields in which a much larger proportion of the knowledge corpus is subject to reinterpretation based on the development of new forms of criticism and new analytical perspectives.

Scholars have established that differences in epistemological assumptions and educational goals lead to differences in students' learning experiences in the hard and soft disciplines. Donald (1983) found that hard fields had tightly structured course content with highly related concepts and principles, while soft fields were more often characterized by open course structures and looser organization. Braxton (1995) found that hard disciplines placed greater importance on student career preparation and emphasized learning facts, principles, and concepts. Soft disciplines, by contrast, placed greater importance on broad general knowledge, on student character development, and on developing students' critical thinking skills. Similarly, Hativa (1997) found that soft fields placed greater importance on creativity of thinking and oral and written expression, while hard fields placed greater emphasis on ability to apply methods and principles. Assessments of student learning reflect these differing curricular emphases. In their assessments, hard disciplines require memorization and application of course materials, while soft disciplines are more likely to favor exam prompts requiring analysis and synthesis of course content (Braxton 1995; Smart and Ethington 1995).[2]

Scholarly doubts about the quality of the undergraduate experience in humanities and social sciences disciplines stems from important characteristics of learning environments in science and engineering fields that are not shared by the humanities and social science disciplines. First, the science and engineering disciplines are selective; not all who wish to study these fields are allowed to do so. Nationally, failure rates in gateway mathematics and science courses have ranged in recent decades from 30 to 50% (Gainen 1995; Tall

[1] The best known disciplinary typology, sometimes known as the Biglan-Becher typology (Neumann 2001), is a four-fold classification, dividing fields on one axis by their emphasis on paradigmatic development (the "hard-soft" axis) and, on a second, by their focus on basic or applied subject matter (the "pure-applied" axis) (Biglan 1973a, b; Becher 1989). The "pure-applied" axis is less important for our purposes. Most undergraduate education in the University of California, as well as in other leading research universities, focuses on "pure" subjects. Some important fields in research universities, such as business (a "hard-applied" field) and education (a "soft-applied" field), are offered at only a small number of UC campuses and are therefore not included in these analyses. We do not consider the third dimension of the original Biglan scheme ("life-non-life") except in so far as it is incorporated into our disciplinary categories (as life sciences) and major categories (as biology, cell and molecular biology, and environmental science).

[2] Recent studies confirming differences in teaching styles and academic goals by level of paradigmatic development include Braxton and Hargens (1996), Braxton et al. (1998), Becher (1994), Hativa (1997), Lattuca and Stark (1994), Smart and Umbach (2007), Smart et al. (2000), and Umbach (2007b). For an overview, see Neumann (2001).

1997). These disciplines not only require demonstrated mastery of complex concepts and quantitatively challenging course materials, but grading is also more stringent than in the social sciences and humanities (Gainen 1995; Johnson 2003). Moreover, these disciplines are more closely linked than other fields to high-wage labor market opportunities (Arcidiacono 2003). Previous studies have suggested that these four factors—selection pressures, curricular rigor, stringent grading, and labor market rewards—combine to promote greater effort and conscientiousness on the part of undergraduate students studying "hard" disciplines (Arcidiacono 2003; Brint and Cantwell 2010; Johnson 2003).

Historically, proponents of the humanities and social sciences have often claimed that these disciplines offer an important compensating advantage: greater opportunities for analytical and critical thinking experiences. Ideal representations of liberal arts education emphasize that professors should seek to expose students to multiple conceptual schemes, competing interpretations, rigorous investigation of the quality of evidence and arguments, and a more pronounced critical approach to materials. These are the types of cognitive experiences that liberal arts proponents have long hoped colleges and universities would provide for students (see, e.g. Bloom 1956; Shulman 1997).

Recently, however, some scholars have raised doubts about the quality of experience of students in the humanities and social sciences, even in this area of assumed strength. These doubts stem from concerns about the effects of low academic standards on the quality of classroom experiences (Babcock and Marks 2010, Johnson 2003), the effects of the dominance of time spent on social and recreational activities as an influence on students' commitment and learning (Arum and Roksa 2011; Brint and Cantwell 2010), and even the possibly stultifying effects of socio-political orthodoxy in some humanities and social science fields (Rothman et al. 2005; Wood 2003; cf. Gross and Simmons 2007).

Within the context of the University of California system, our research suggests that recent doubts about educational experiences in the humanities and social sciences have some validity. Zero-order differences among the disciplinary categories were marginal on the analytical and critical thinking scale. When academic achievement and socio-demographic background variables were controlled, physical and life science students scored as high as humanities and social science students on the scale. When frequency of participation was controlled as well, science and engineering students scored marginally higher than humanities and social science students (cf. Pascarella and Terenzini 2005, pp. 174–176, 604–608). Students majoring in one discipline, economics, stood out as scoring low on this scale, but students in no majors clearly distinguished themselves as scoring high.

Data and Methods

Study Population

The study is based on responses of upper-division students to the University of California Undergraduate Experiences Survey (UCUES) fielded in spring 2008. UCUES is administered biannually at each of the nine University of California undergraduate campuses as a census of all students. Because of the small number of respondents from UC Merced, this campus was excluded from the study. The UC system is the largest system of publicly supported research universities in the country. In 2008, UCUES response rates on the campuses in our study varied from a low of 31 to a high of 50%. Previous studies indicate that respondents have higher grade point averages than non-respondents, but that parameter estimates are unbiased due to the large size of the sample (Chatman 2006).

Students must graduate in the top 12.5% of high school students statewide to be eligible for admission into the University of California. The sample, therefore, constitutes a relatively high-achieving group of students (Douglass 2007). Nonetheless, high levels of variability exist within the population—in student grades, student behaviors conducive to academic success, and student background and experience characteristics related to academic achievement. While mean scores on variables undoubtedly differ between UC undergraduates and the population of all college students, we expect the form of key relationships observed for UC students to generalize to the population of students attending relatively selective research universities.

UCUES has been operating for 9 years as a web-based census. Incentives are provided to students for participation in the survey. All participating students complete a set of core items and, in addition, one of five randomly-assigned modules. Data on student backgrounds, high school records, SAT scores, and UC GPA are appended to the data file by UC staff.

Because we are interested in disciplinary categories and majors, we included only upper-division students in the study population. Upper-division transfer students do not have UC GPAs that date from freshman year, and we therefore also excluded transfer students from the study population. The census approach adopted in UCUES yields a large sample (more than 17,500 respondents for analyses of disciplinary categories and more than 16,000 respondents for analyses of majors) in spite of these exclusions. Sizable numbers of respondents were located across each of the eight UC campuses, six disciplinary categories, and 18 majors we studied.

Dependent Variables

We focus on three dependent variables. We computed *study time* from the sum of time spent in class attending lectures, sections, and labs and time spent studying or preparing for class each week. For the UCUES upper-division sample as a whole, this variable had a mean of 27.8 hours and a standard deviation of 11.7 hours. We computed *academic conscientiousness* as a factor-weighted scale composed of five items measuring the frequency with which students reported efforts to improve their academic performance through behaviors that contribute to subject matter mastery: by raising their standards, revising their papers, seeking help to understand course materials, working with fellow students on course materials, and explaining course materials to others. The scale had an alpha reliability of .72 and, when standardized, ranged from −2.76 to 2.49. Both grades and post-graduate aspirations have been strongly related to high scores on the academic conscientiousness scale (Brint and Cantwell 2010). We computed a*nalytical and critical thinking* as a factor-weighted scale consisting of nine items measuring the frequency with which students reported having experiences that contribute to cognitive development: by recalling and using facts, explaining and solving problems, analyzing course materials, evaluating and assessing methods, incorporating ideas from class in assignments, and reconsidering their own opinions based on class materials. The analytical and critical thinking scale had an alpha reliability of .87 and ranged, when standardized, from −4.13 to 1.60. The frequency measures for items on the two scales ranged from 1 (never) to 6 (very often).

This study is based on students' self-reported academic behaviors and experiences, not on measured learning outcomes. At the same time, more frequent and conscientious study behaviors and more frequent analytical and critical thinking experiences are undoubtedly conducive to learning for most students (Arum and Roksa 2011). Indeed, for less prepared and less able students, they may be a precondition for learning.

Because our data consist of students' self reports, they are potentially susceptible to social response bias. If students tend to inflate their reports of time spent on study or the frequency of academically beneficial experiences, the results reported in this study will present a more positive picture of the undergraduate academic experience than is warranted. Psychometric studies have shown that student self-reports of study behaviors and experiences during the college years are valid and reliable, when survey items are clearly worded and represent activities with which student have had recent experiences. Under these conditions, student responses accurately represent the frequency of their behaviors and experiences (Kuh 2003b; Ouimet et al. 2004; Pace 1985, 1995). UCUES survey items meet these requirements. It is possible that some types of students tend to overstate or understate the frequency of academically beneficial experiences. To the extent that systematic biases are found in the data, parameter estimates for particular categories of students will be unreliable. The existing literature, which focuses on racial-ethnic differences (Bowman 2008; Brint et al. 2010) suggests that the major findings of this study are unaffected by such biases.[3]

Selection bias represents another potential limitation of the UCUES survey data. Students may select themselves into research universities for reasons that are not measured but nevertheless affect the results of this study. Students may also select themselves into certain majors that potentially play to their strengths. We control for a variety of student characteristics, including their socio-demographic backgrounds and academic achievements. Even so, we cannot rule out the possibility that unmeasured student characteristics, such as motivation to study a major, influence our results.

Independent Variables

We compared students in six broad disciplinary categories: (1) engineering, (2) physical sciences, (3) life sciences, (4) social sciences, (5) humanities, and (6) arts. Because engineering is an applied rather than a pure field, we treated engineering students separately from physical sciences students. Physical sciences consist of students majoring in chemistry, geology and earth sciences, mathematics, physics, and statistics. Life sciences consist of biology, biochemistry, cell and molecular biology, environmental science, and related disciplines. Social sciences consist of anthropology, area studies, economics, political science, psychology, sociology, and related fields. Humanities consist of art history, American studies, classics, English, media and cultural studies/communications, foreign languages and literatures, history, philosophy, and related fields. The arts consist of creative writing, dance, drama, film, music, and studio arts. In our analyses of disciplinary categories, we used social sciences as our reference category, because the social sciences are often characterized as lying between the natural sciences and humanities in the extent of their reliance on quantitative methods and in their more positivistic epistemological orientations.

Similarities among disciplinary categories may mask substantial differences between the majors that make up these categories. Moreover, majors are a primary source of identity and interest among university students (Chatman 2007). We therefore also

[3] Thus far, studies have focused on over and under-estimates by students in different racial-ethnic groups. These studies suggest that Asian students may underestimate the frequency of academically beneficial experiences, as well as their levels of academic proficiency, while students from other racial-ethnic groups may over-estimate their levels of academic proficiency (Bowman 2008; Brint et al. 2010). Racial-ethnic differences do not figure prominently in the findings of this research, however.

compared students in 18 high enrollment majors. In the sciences and engineering category, we examined the following eight majors: (1) biology, (2) cell and molecular biology (including biochemistry), (3) chemistry, (4) computer science, (5) engineering, (6) environmental science, (7) mathematics and statistics, and (8) physics. Several other science majors, such as neuroscience and earth science, were too small or not widely represented enough across all UC campuses to be included. In the humanities, arts, and social sciences group, we examined the following 10 majors: (1) anthropology (2) arts, (3) English, (4) economics, (5) foreign languages and literatures, (6) history, (7) philosophy, (8) political science, (9) psychology, and (10) sociology. Again, several humanities and social science majors, such as religious studies and media and cultural studies, were too small or not widely represented enough on UC campuses to be included.[4]

We used economics majors as our reference category in analyses of study time and academic conscientiousness. Economics emphasizes quantitative methods to a greater degree than other social science and humanities majors. It is, in this respect, the most "science-like" of the humanities and social science majors and a natural midpoint between "soft" and "hard" majors on behaviors and experiences that distinguish the two categories. We used sociology majors as the reference category in our analyses of analytical and critical thinking experiences. Economics students score lower on this measure than students in any other major and therefore do not help us to distinguish high and low scoring majors. We used sociology students because they score in the middle of humanities and social sciences category and therefore provide a meaningful reference point between high and low scoring majors.

We used academic achievement and socio-demographic controls to isolate the net influence of disciplinary categories and majors on our dependent variables. We introduced the following academic achievement control variables: UC cumulative grade point average (UC GPA) and Scholastic Assessment Test (SAT) math and verbal scores. We introduced the following socio-demographic control variables: gender, race-ethnicity (measured in six nominal categories), self-identified social class (measured as an ordinal scale with five categories), and immigrant generation (measured in three nominal categories).[5] We also introduced hours of paid employment per week as a control variable. Most recent studies find that long hours of paid employment, whether on or off campus, are correlated with weaker academic commitment and lower grades among undergraduate students (see, e.g., Brint and Cantwell 2010; DeSimone 2008; Pike et al. 2009). We measured this variable as the midpoint of eight categories ranging from "0" to "more than 30."

A large body of literature has established that higher levels of classroom participation and interaction with professors are associated with more conscientious and effective study behaviors (for an overview, see Kuh 2003a). In our final set of analyses, we therefore introduced students' frequency of classroom participation and interaction with instructors as a control variable. We measured *participation frequency* as a factor-weighted scale consisting of seven items measuring the frequency during the last year that students report communicating with faculty either face-to-face or electronically, contributing to class discussion, asking "insightful" questions, and finding courses interesting enough to do

[4] Our categorizations of disciplinary categories and majors are available by request.

[5] Some UC campuses have the reputation as more demanding academic environments than others. However, in unreported results we found that campus showed minimal effects net of covariates in our model. One campus did stand out for higher average levels of study time, but inclusion of campus covariates did not improve model fit on any of the three dependent variables.

more work than required. The scale had an alpha reliability of .89 and ranged, when standardized, from −2.10 to 2.60.

Details concerning the independent and dependent variables included in these analyses are reported in Table 1.

Method of Analysis

We analyzed the data using ordinary least square regression with a specification of standard errors based on intra-group correlations, in this case by campus, to account for the possibility of artificially small standard errors in a nested data structure like UCUES (Thomas and Heck 2001).[6] We conducted separate regressions on disciplinary categories and majors for each of the three dependent variables. In Model 1, we examined only disciplinary categories or majors as predictors of academic experience outcomes. In Model 2, we introduced the battery of academic achievement, socio-demographic background, and paid employment variables to determine the extent to which disciplinary category and major differences were an artifact of the composition of students pursuing degrees in the different fields. In Model 3, we introduced the participation frequency scale as a final control. We used a constant N based on students with scores on all variables in Model 3 as the sample base in each of the analyses.[7] In tables we report standardized regression coefficients. Because of the large sample populations in the UCUES data, we focus on effect sizes above .10 and variables with p values less than .001.

Results

We report results in three sections corresponding to the three dependent variables. In each section, we first report results for disciplinary categories. We then report results for majors, showing how the latter results can be used to make finer distinctions among disciplinary categories. We focus on disciplinary categories and majors and discuss only the most noteworthy effects for control variables.

Study Time

Disciplinary Categories

Mean scores on study hours per week, in and out of class, ranged from 24.4 in humanities to 32.0 in engineering. The profile of social science students closely resembled that of

[6] In ordinary least squares regression, it is possible that standard errors may be artificially small due to the nested structure of the data (individual students nested in disciplines and majors nested in campuses). To account for this possibility, we used intra-group correlations, in this case by campus, when specifying standard errors. When compared to ordinary least squares regressions, coefficients in the models were unaffected by this specification.

[7] We used list-wise deletion of missing data. We lost 15.7% of freshmen entry upper division students through list-wise deletion. The distribution of cases by disciplinary category and major for students included in the study reflect the distribution of cases across the University of California, including students excluded from the study. The means and standard deviations of variables contributing to the factor scores of our dependent variables, as well as those for the variables in the participation frequency scale, were not significantly different from those reported in Table 1. We are consequently confident that our estimates accurately represent freshmen entry upper-division UC students.

Table 1 Descriptive statistics of dependent and independent variables

	N	Mean	Std Dev.	Min.	Max.	Loading
Dependent variables						
Study time (sum of 2-items)	20,910	27.78	11.69	0.00	66.44	
Time allocation: attend classes, sections, or labs (coded to the midpoint)	21,014	15.16	5.95	0.00	32.68	
Time allocation: study and other academic activities outside of class (coded to the midpoint)	20,919	12.63	8.07	0.00	33.76	
Academic conscientiousness	20,445	0.00	1.00	−2.76	2.49	$\alpha = .72$
In this academic year: raised standard for acceptable effort due to high standards of a faculty member	20,714	3.71	1.29	1 (Never)	6 (Very often)	.42
In this academic year: extensively revised a paper at least once before submitting to be graded	20,792	3.75	1.50	1	6	.49
In this academic year: sought academic help from instructor or tutor	20,724	3.33	1.42	1	6	.58
In this academic year: worked with group of students outside of class	20,800	3.63	1.40	1	6	.70
In this academic year: helped classmate understand material better	20,816	3.73	1.32	1	6	.72
Analytical/critical thinking	20,047	0.00	1.00	−4.13	1.60	$\alpha = .87$
Frequency of course requirements: recall facts, terms, concepts	20,706	5.12	1.05	1 (Never)	6 (Very often)	.44
Frequency of course requirements: explain and solve problems	20,625	4.99	1.14	1	6	.56
Frequency of course requirements: analyze	20,611	4.55	1.32	1	6	.72
Frequency of course requirements: evaluate methods and conclusions	20,608	4.51	1.33	1	6	.77
Frequency of course requirements: generate new ideas or products	20,625	4.20	1.43	1	6	.68
Frequency of course requirements: use facts and examples to support viewpoint	20,643	4.95	1.14	1	6	.65
Frequency of course requirements: incorporate ideas from different courses	20,586	4.55	1.23	1	6	.68
Frequency of course requirements: examine and assess other methods and conclusions	20,585	4.18	1.37	1	6	.75

Table 1 continued

	N	Mean	Std Dev.	Min.	Max.	Loading
Frequency of course requirements: reconsider own position after assessing other arguments	20,608	4.11	1.31	1	6	.68
Independent variables: continuous						
Participation frequency	20,847	0.00	1.00	−2.10	2.60	α = .89
In this academic year: communicated with a faculty member by email or in person	20,729	3.92	1.36	1 (Never)	6 (Very often)	.62
In this academic year: talked with the instructor outside of class about course material	20,733	2.96	1.48	1	6	.70
In this academic year: interacted with faculty during lecture class sessions	20,696	3.01	1.47	1	6	.78
In this academic year: contributed to a class discussion	20,803	3.74	1.38	1	6	.83
In this academic year: brought up ideas or concepts from different courses during class discussions	20,742	3.18	1.45	1	6	.83
In this academic year: asked an insightful question in class	20,727	3.13	1.40	1	6	.85
In this academic year: found a course so interesting that you did more work than was required	20,693	2.92	1.37	1	6	.61
Time allocation: paid employment total (coded to midpoint)	20,792	9.36	9.10	0.00	33.60	
UC GPA (Spring 2008)	20,378	3.23	.45	0.00	4.00	
SAT Math	21,045	640.18	88.34	270	800	
SAT Verbal	21,045	608.20	91.66	210	800	
Social Class	20,561	2.94	.98	1 (Low income/ poor)	5 (Wealthy)	

	N	Percent
Independent variables: categorical		
Sociodemographics		
Female	18,023	57.4
Male	13,391	42.6
African American	754	2.4
Hispanic	4,148	13.2
Asian American	11,499	36.5
White	11,649	37.0
Other (includes multi-racial and unknown)	2,655	8.4
International students	766	2.4
Student immigrant	7,026	23.0
Parent(s) immigrant(s)	11,333	37.0
Student & parent(s) U.S. born	12,246	40.0

Table 1 continued

	N	Percent	Sample N	Percent
Disciplines				
Physical sciences	4,902	6.0	1,118	6.3
Life sciences	18,255	22.5	4,608	25.8
Engineering	10,603	13.1	2,799	15.7
Social sciences	31,311	38.6	6,198	34.7
Humanities	11,412	14.1	2,251	12.6
Arts	4,557	5.6	871	4.9
	N	Percent	*N*	Percent
Departments				
Anthropology	1,678	2.3	269	1.7
Economics	6,981	9.5	1,285	8.0
Psychology	7,599	10.4	1,630	10.1
Political science	4,625	6.3	975	6.0
Sociology	5,057	6.9	922	5.7
English	3,759	5.1	766	4.7
Foreign language & literatures	2,111	2.9	514	3.2
Philosophy	1,014	1.4	118	0.7
History	3,879	5.3	712	4.4
Arts	4,557	6.2	871	5.4
Biology	10,914	14.9	2,700	16.7
Cell/molecular biology	4,433	6.0	1,146	7.1
Chemistry	1,694	2.3	407	2.5
Environmental science and ecology	2,054	2.8	550	3.4
Computer science	2,299	3.1	548	3.4
Engineering	8,011	10.9	2,156	13.3
Math/statistics	1,776	2.4	365	2.3
Physics	892	1.2	228	1.4

humanities students.[8] In bivariate regressions, students in each of the three science and engineering categories scored higher on study time than either humanities or social science students.

The introduction of academic achievement and socio-demographic background variables improved model fit. Net of covariates, students majoring in the sciences and engineering continued to report longer study hours compared to humanities and social science students. Not surprisingly, UC grades were another predictor of study time. By contrast, students scoring high on the SAT verbal studied less on average, net of covariates, perhaps indicating that these students can learn material faster than others or can rely on their test-taking abilities as a substitute for longer hours of study.

[8] Because of our clustering of standard errors, the standardized regression coefficient for humanities students was marginally higher than that of social science students.

The introduction of participation frequency further improved model fit. Participation frequency showed a net effect on study time similar in size to UC GPA. Disciplinary differences remained largely unaffected, however (see Table 2).

Majors

Humanities and social science majors showed little differentiation in the major-specific regressions of Model 1. All science and engineering majors reported longer hours of study than humanities and social science majors. However, students in the science and engineering majors also varied among themselves; biology, chemistry, and engineering majors reported longer study hours than other science majors.

The introduction of controls for academic achievement and socio-demographic background did not greatly improve model fit or substantially alter the zero-order relationships reported in Model 1. Students in science majors that stood out in Model 1 for their longer hours of study continued to stand out in Model 2. UC GPA continued to be associated with longer hours of study each week, and SAT verbal scores continued to be associated with fewer hours of study.

Once again the introduction of the participation frequency scale in Model 3 improved model fit. However, differences among majors in the sciences and engineering persisted. UC GPA and SAT verbal scores also continued to show sizable and highly significant net effects on study time, in a positive direction for UC GPA and in a negative direction for SAT verbal scores (see Table 3).

Academic Conscientiousness

Disciplinary Categories

Disciplinary categories explained very little variation on the academic conscientiousness scale. Life science and engineering students scored marginally higher than social science students on academic conscientiousness and humanities students scored marginally lower.

The introduction of academic achievement and socio-demographic background control variables in Model 2 improved model fit. The introduction of these controls accentuated disciplinary differences, with life science and engineering students showing higher net scores on conscientiousness. As with study time, UC GPA showed a sizable and highly significant net positive association with conscientiousness, while SAT verbal showed a sizable and highly significant net negative association. In these regressions, SAT math also showed a sizable and highly significant net negative association.

R^2 improved dramatically with the introduction of participation frequency in Model 3—from seven to 28% of the variance explained. Participation frequency proved to be a much stronger predictor of conscientiousness than any other variable in the analysis, including disciplinary categories. At the same time, disciplinary categories remained highly differentiated from one another. At similar levels of participation humanities and arts students reported fewer net conscientious behaviors than life science and engineering students. Effect sizes for UC GPA and SAT math were attenuated in Model 3, but effect sizes for SAT verbal continued to be sizable and highly significant, indicating that at similar levels of participation students with high SAT verbal scores were less conscientious about their studies.

Table 2 OLS regressions on academic outcomes: disciplinary categories

	Time on academics			Academic conscientiousness			Analytical/critical thinking		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
N	17,845	17,845	17,845	17,845	17,845	17,845	17,845	17,845	17,845
R^2	.07	.10	.13	.01	.07	.28	.00	.02	.16
Disciplines									
Social sciences	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Physical sciences	.11***	.13***	.13***	.01	.05**	.05**	−.01	.02*	.02*
Life sciences	.21***	.22***	.23***	.06**	.10***	.12***	.01	.04*	.06**
Engineering	.24***	.27***	.28***	.07**	.15***	.18***	−.05***	.01	.04**
Humanities	.02	.02*	.00	−.03**	−.02*	−.07***	.03**	.02*	−.02
Arts	.09***	.09***	.07***	.00	−.01	−.05***	−.02	−.02*	−.06***
Background									
UC GPA		.15***	.12***		.15***	.07***		.05***	−.01
SAT math		−.07*	−.04		−.11***	−.04**		−.11***	−.05**
SAT verbal		−.09***	−.10***		−.17***	−.19***		−.01	−.02**
Male		−.01	−.03*		−.04**	−.09***		−.05*	−.07***
White		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.
African American		.00	.00		.01	.00		.02	−.01
Hispanic		−.01	.00		−.01	.02		.06	.03**
Asian American		.02	.05***		−.03*	.05**		−.04	.04*
International		.01	.01		−.01	.00		−.10	−.01
Other		.02*	.02*		−.01	.00		.00	.00
Social Class		−.01	−.02*		.07***	.04**		.02	−.01
Student and parent(s) U.S. born		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.
Student immigrant		.04*	.02		.06**	.02		.05	−.01

Table 2 continued

	Time on academics			Academic conscientiousness			Analytical/critical thinking		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
Parent(s) immigrant(s)		.02	.01		.05**	.03*		.04*	.00
Activities									
Paid employment		−.01	−.03*		.03*	−.02		.06***	.02
Participation frequency			.21***			.50***			.40***

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 3 OLS regressions on academic outcomes: majors

	Time on academics			Academic conscientiousness			Analytical/critical thinking		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
N	16,162	16,162	16,162	16,162	16,162	16,162	16,162	16,162	16,162
R^2	.08	.10	.14	.01	.07	.29	.02	.03	.17
Majors									
Economics	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	−.09***	−.06**	−.03
Anthropology	.00	.00	−.01	−.01	−.02	−.05***	.01	.01	.00
Psychology	.01	.00	−.01	−.01	−.04*	−.06**	−.01	.00	.02
Political science	.01	.01	−.02	−.01	−.02	−.07***	.04*	.05*	.03
Sociology	−.01	−.02	−.03*	−.02*	−.05***	−.08***	Ref.	Ref.	Ref.
English	.02	.02	−.01	−.03*	−.03*	−.10***	−.01	.00	−.03*
Foreign language & lit	.03*	.02	.01	−.02	−.03	−.07***	−.02	−.01	−.03*
Philosophy	.00	.00	−.01	−.02	−.01	−.03**	.03**	.04***	.03**
History	.01	.00	−.02*	−.03	−.04**	−.09***	.03**	.04***	.02*
Arts	.10***	.09***	.06***	−.01	−.03	−.11***	−.03*	−.02	−.06**
Biology	.19***	.19***	.18***	.05	.05	.03	.00	.04	.06*
Cell/molecular biology	.17**	.17***	.16***	.03	.04	.02	−.01	.02	.04
Chemistry	.11***	.10***	.11***	.01	.01	.00	−.01	.01	.02*
Environ science & ecology	.05***	.06***	.05**	.01	.01	−.02	.01	.02	.02
Computer science	.09**	.10**	.10**	.00	.02	.02	−.05***	−.02	.00
Engineering	.25***	.27***	.27***	.07***	.12***	.12***	−.06*	.01	.04
Mathematics/statistics	.04***	.04***	.04***	.00	.00	−.01	−.02	.00	.01
Physics	.06***	.07***	.06***	.00	.02	.01	.00	.01	.02
Background									

Table 3 continued

	Time on academics			Academic conscientiousness			Analytical/critical thinking		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
UC GPA		.15***	.12***		.15***	.07***		.04**	−.01
SAT math		−.07*	−.05		−.12***	−.06***		−.09***	−.04*
SAT verbal		−.09***	−.09***		−.17***	−.18***		−.02	−.03**
Male		.00	−.02		−.04**	−.09***		−.04***	−.08***
White		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.
African American		.00	.00		.02	.01		.00	−.01
Hispanic		−.01	.00		−.01	.02		.01	.03**
Asian American		.01	.04**		−.04*	.04*		−.03	.04*
International		.01	.01		−.01*	−.01		−.01*	−.01
Other		.01	.02		−.01	.00		−.01	.00
Social class		−.01	−.02		.07***	.03*		.02	.00
Student and parent(s) U.S. born		Ref.	Ref.		Ref.	Ref.		Ref.	Ref.
Student immigrant		.04**	.02		.06**	.02		.01	−.01
Parent(s) immigrant(s)		.02	.01		.05**	.03*		.01	−.01
Activities									
Paid employment		−.01	−.03*		.03*	−.02		.05***	.02
Participation frequency			.21***			.51***			.40***

* $p < .05$, ** $p < .01$, *** $p < .001$

Majors

Major differences explained little of the variance in the academic conscientiousness scale. Majors were also weakly differentiated on this scale.

As in the regressions on disciplinary categories, model fit improved with the introduction of academic achievement and socio-demographic background controls. Net of covariates, engineering students showed higher scores on conscientiousness. Again, UC GPA and SAT scores showed sizable and highly significant effects.

The introduction of participation frequency again improved model fit considerably; R^2 increased from seven to 29%. At similar levels of participation, students majoring in several of the humanities and social science disciplines reported lower levels of conscientiousness than economics majors, while engineering students continued to report higher levels of conscientiousness. As in the regressions on disciplinary categories, the effects of UC GPA and SAT math scores were attenuated in Model 3, while the effects of SAT verbal scores persisted.

Analytical and Critical Thinking

Disciplinary Categories

Disciplinary differences explained very little variance in the analytical and critical thinking scale, and differences among disciplinary categories were marginal.

The introduction of academic achievement and socio-demographic background variables did not greatly improve model fit. Disciplinary categories remained weakly differentiated. Math SAT scores were the only variable to show sizable and highly significant net effects; they were associated with fewer reported experiences of analytical and critical thinking.

The introduction of participation frequency improved model fit considerably—R^2 increased from two to 16%. Disciplinary categories continued to show only marginal differences from one another. The introduction of participation frequency led to attenuation of the math SAT effects and to little change in other coefficients. While participation frequency was strongly associated with high scores on the analytical and critical thinking scale, no other variables in the model showed sizable effects.

Majors

Majors showed slightly more differentiation than disciplinary categories, but continued to explain very little variance. Relative to sociology students, economics majors scored significantly lower on the scale. As a group, science and engineering majors scored no lower than humanities and social science majors and higher than economics students.

The introduction of academic achievement and socio-demographic background variables improved model fit only marginally. The introduction of these variables attenuated the effect of economics and computer science, suggesting that zero-order relations may be largely a function of the higher math SAT scores found in these majors. High SAT math scores showed sizable net negative effects on the analytical and critical thinking scale.

The introduction of the participation frequency scale again improved model fit considerably—R^2 increased from three to 17%. Participation frequency showed sizable and highly significant effects net of covariates, while majors continued to show little differentiation from one another. The introduction of the participation scale led to attenuation of the negative effect of SAT math scores.

Discussion

The paper makes two key contributions to the study of the undergraduate academic experience in U.S. research universities. First, the findings challenge the notion that, while humanities and social science majors require less study, they offer the compensating advantage of fostering more frequent opportunities for analytical and critical thinking experiences. Instead, we found weak zero-order differences between disciplinary categories and majors. Nor did better controlled models lead to high levels of differentiation among disciplinary categories or majors on the analytical and critical thinking scale. Second, the findings demonstrate that, in areas related to work effort and conscientious behaviors, disciplinary categories and majors do matter. Students in science and engineering fields studied longer hours than students in the humanities and social sciences. Biology, chemistry, and engineering majors stood out, in particular, for their longer hours of study. Engineering majors stood out, in addition, on the academic conscientiousness scale.

Bok (2006) used the term "under-achievement" to characterize the performance of colleges and universities in undergraduate education. Based on 2008 data from the University of California, we accept Bok's term as frequently apt. However, our findings suggest that Bok's emphasis on institutional performance is at least partly misdirected. Universities are made up of a variety of majors, and student learning is strongly keyed to the content knowledge of majors. Many students also see their majors as closely connected to their identities and interests (Chatman 2007). In the University of California not all disciplinary categories and majors were under-achieving in every important dimension of the undergraduate education. Future discussions of underachievement in undergraduate education should therefore be framed to include variation among disciplinary categories and majors.

At the same time, the institutional level of analysis remains relevant where institution-wide problems exist. A recent study based on the Collegiate Learning Assessment showed that more than one-third of college students nationwide made no significant gains in analytical and critical thinking skills over the course of 4 years in college (Arum and Roksa 2011). In the University of California, we found that no disciplines stood out for promoting analytical and critical thinking experiences. These data suggest that institution-wide problems may exist in the effectiveness with which majors help students to develop their analytical and critical thinking skills. If future studies confirm these findings, Bok's focus on the institutional level would be appropriate in relation to this important area of educational purpose.

In the remainder of our discussion, we will consider what our data suggest about the causes of under-achievement in undergraduate education. We will also discuss the prospects and means for improving the academic experience of undergraduate students.

Causes of Under-Achievement

Our findings suggest that a large source of under-achievement in undergraduate education stems from the failure of instructors to maximize classroom participation.[9] In our analyses participation frequency was the most important influence on the academic conscientiousness scale, net of covariates, as well as on the analytical and critical thinking scale. It was also an important influence on study time (see also Braxton et al. 1998; Brint et al. 2008; Kuh 2003a; Umbach and Wawrzynski 2005). Of course, we cannot establish causality based on cross-sectional data. Nevertheless it seems clear that instructors in research universities should work to provide ample opportunities for students to participate in their classes and to interact with them outside of class.

Overall, humanities and social science majors do a better job of encouraging classroom participation and interaction than disciplines in the sciences or engineering. Students in particular majors—notably, political science, history, English, and arts—were more likely to report that they participated actively in their classes than most science and engineering students (see Table 4). In this respect, instructors in the sciences and engineering have much to learn from their colleagues in humanities and social sciences.

Our findings suggest that undemanding learning environments may be another important cause of under-achievement in undergraduate education. In our analyses science and engineering students scored significantly higher on study time and academic conscientiousness than humanities and social science students, in spite of their low average levels of participation frequency. These findings lead us to believe that learning environments in humanities and social science classrooms are less demanding overall than those in science and engineering classrooms (see also Brint et al. 2008; Johnson 2003). We define undemanding learning environments as those in which performance expectations are low and requirements are unchallenging. In so far as demanding learning environments are associated with higher levels of performance, instructors in humanities and social sciences have much to learn from their colleagues in science and engineering.

Prospects and Means for Improvement

Although we are skeptical that any major constituency within research universities has a strong interest in bringing about the changes that would be required for a major improvement in undergraduate education (see also Arum and Roksa 2011),[10] we do think it

[9] Under-achievement in social science and humanities education has sometimes been attributed to large class sizes or an over-reliance on lecturers (see, e.g., Nelson and Watt 1999, pp. 84–98), but these arguments appear to lack face validity, given the similar conditions found in the life sciences in many research universities. Nor have empirical studies provided support for these factors as primary influences on students' academic outcomes. (On class size, see Martins and Walker 2006; Pinto et al. 2008; on lecturers, see Bettinger and Long 2004; Umbach 2007a) While larger class sizes and over-reliance on lecturers may not be beneficial in the long run for undergraduate education in the research university, it appears that effective learning environments can be constructed even where class sizes are large and lecturers teach many courses.

[10] Arum and Roksa (2011) argue that the primary source of institutional underachievement has been an implicit treaty among students, faculty, and administrators to limit work demands. In their view, student culture fails to place a premium on learning, as compared to enjoyment of the college experience, and the social side of college life consequently takes priority over academics for all but a minority of high achievers. Faculty members, for their part, are often more interested in research and their own socio-professional involvements than in offering challenging, high-participation classes to undergraduates. Student evaluations that reward instructors for low expectations and high grades help to reinforce this pattern (Babcock 2010). Moreover, pressures to achieve high ratings on student evaluations may be particularly strong for temporary instructors whose extensions often depend on maintaining high teaching evaluations. Administrators are responsible for the economic and political well-being of their institutions, and many must, by the nature of their jobs, be at least as concerned with meeting enrollment targets as they are with the quality of the undergraduate educational experience. This implicit treaty, Arum and Roksa argue, has had the consequence of limiting students' cognitive development during the college years.

Table 4 OLS regressions on participation frequency

	Disciplines		Departments	
	Model 1	Model 2	Model 1	Model 2
N	17,845	17,845	16,162	16,162
R^2	.05	.11	.07	.13
Disciplines				
Social sciences	Ref.	Ref.		
Physical sciences	−.03	−.01		
Life sciences	−.08***	−.05*		
Engineering	−.10***	−.08***		
Humanities	.12***	.09***		
Arts	.10***	.09***		
Departments				
Economics			Ref.	Ref.
Anthropology			.07***	.06***
Psychology			.04**	.04*
Political science			.14***	.11***
Sociology			.07***	.07***
English			.16***	.14***
Foreign language & literatures			.10***	.09***
Philosophy			.05***	.05***
History			.12***	.10***
Arts			.17***	.15***
Biology			.02	.03
Cell/molecular biology			.02	.03
Chemistry			.00	.01
Environ science & ecology			.06***	.05***
Computer science			.00	.00
Engineering			−.01	.00
Mathematics/statistics			.03	.03*
Physics			.04	.02**
Background characteristics				
UC GPA		.14***		.14***
SAT math		−.13***		−.11***
SAT verbal		.03		.02
Male		.09***		.10***
White		Ref.		Ref.
African American		.02		.02
Hispanic		−.05**		−.06***
Asian American		−.17***		−.17***
International		−.02*		−.02
Other		−.02		−.02
Social class		.05***		.06***
Student and parent(s) U.S. born		Ref.		Ref.
Student immigrant		.06***		.07***
Parent(s) immigrant(s)		.03*		.03**

likely that some individual institutions and many individual professors will be interested in improving academic experiences for their students, if information about the troubled state of undergraduate education in research universities becomes more widely known. Accordingly, we offer the following suggestions for improvement as contributions to an ongoing discussion.[11]

Our findings suggest that institutions can begin the process of improvement by emphasizing techniques for increasing students' classroom participation. Even in larger lecture classes, professors can engage students with a steady stream of questions and ask them to perform what they are learning through presentations of key concepts or background reports, debates about issues raised by course materials, presentations of group research projects, and in-class problem solving. Some evidence exists that increasing numbers of faculty members are already using these techniques for stimulating participation (see DeAngelo et al. 2007). It will be more difficult to encourage research university faculty members to interact with undergraduate students, but institutions can help instructors to do so by providing awards for mentoring undergraduate students, and by providing more ample opportunities and encouragement for undergraduate research.

The creation of more demanding learning environments is a particular issue in the humanities and social sciences and one that will be difficult to develop, given professors' realistic concerns about the effects of higher standards on their teaching evaluations and their time for research. In research universities, professors in the humanities and social sciences also teach more than those in the sciences and engineering (Schuster and Finkelstein 2006, p. 89), and it would be understandable if they resisted calls to increase graded work requirements for this reason alone. Nevertheless, a goal worthy of discussion would be to increase students' average study time in the humanities and social sciences by a few hours per week. In the University of California, a change of five hours per week would lead to increases in average weekly study time (including time in class) from approximately 25 to approximately 30 hours per week, as well as the reduction of students' mean hours spent on social and recreational activities to just under 40 hours per week.

This goal could be achieved through a variety of means. Some classes may not be sufficiently challenging and would require augmentation of assignments; others may appear to be sufficiently challenging on paper, but do not in practice require students to do the assigned work in order to pass. Regular short-answer homework assignments and unannounced quizzes on the day's reading can help to improve students' motivation to complete assignments (Ballard and Johnson 2004; Chung and Chow 2006; Geist and Soehren 1997). Another change worthy of consideration would be the introduction of stricter standards for grading, including movement back toward a bell-shaped grading curve in courses where grade inflation has become pronounced.[12]

[11] Among the key documents in the recent U.S. discussion of the reform of undergraduate teaching and learning are the following: American Association of Colleges & Universities (2002, 2004), Bok (2006), Boyer Commission on Educating Undergraduates in Research Universities (1998), Chickering and Gamson (1987), Ewell (2001), Ewell and Miller (2005), National Governors Association (1986), National Institute of Education Study Group (1984), and the essays collected in Shulman (2004).

[12] Such a reform would require instructors to show clearly the types of work that yield grades at different points on the curve. It would also require that institutions provide ways to protect instructors from negative performance appraisals simply because they maintain high grading standards (Babcock 2010). Because many students see themselves as entitled to high grades for self-perceived effort (Greenberger et al. 2008), it will be important for professors to communicate clearly that self-perceived effort is not in itself sufficient to yield a high grade (Benton 2006).

Educators can also study the practices of high-performing disciplines and majors in order to adapt practices that lead to academically beneficial experiences for use in their own fields. Our findings suggest that educators can look to biology, chemistry, and engineering for ways to create higher levels of student work effort. Some part of the intensity characteristic of these majors stems from the demands they make on students to master relatively complex concepts and applications. Another part of the intensity characteristic of these disciplines likely stems from the labs and projects that require public performances of understanding and "hands-on" applications of knowledge (see Shulman 1997). The arts too emphasize public accountability through peer-led critiques and preparation for public performances and exhibitions. Not surprisingly, students in the arts also reported longer hours of study.

Educators will, however, need to look to the practices of particular instructors, rather than to the practices of disciplines, for guidance about how to enhance students' analytical and critical thinking experiences. Our findings suggest that no disciplines in the University of California stand out in this area, and none (with the exception of economics) perform significantly below the norm. Analytical and critical thinking skills are developed when students attempt to solve complex, incompletely structured problems. They are also developed through close inspection and comparison of texts, methods, and research results. These skills can be developed by instructors who require students to break down complex arguments into their analytical components. They can be developed also by requiring students to apply principles, concepts, or ideas to new problems or phenomena. Instructors can also require students to compare divergent methods of analysis or to explain conflicting findings in the literature. They can encourage students to think often about what does and does not make for convincing evidence in support of a thesis (see King and Kitchener 1994).

In sum, undergraduate education in research universities can begin to shed its reputation for under-achievement if instructors make the effort to offer ample opportunities for participation, including public performances of understanding and application of knowledge; and if they create meaningful and challenging assignments requiring serious individual effort. Some disciplines do better than others in promoting participation, while others do well in creating demanding learning environments. These disciplines can serve as models. Efforts to improve the analytical and critical thinking skills of undergraduate students would be equally desirable, but for improvement to occur in this area educators will need to study the practices of exemplary instructors rather than exemplary disciplines, because no disciplines appear to stand out in this domain.

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