BETWEEN-COLLEGE EFFECTS ON
STUDENTS RECONSIDERED

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Pascarella and Terenzini (1991, 2005) leave no doubt that students' experiences while enrolled are salient influences on a wide array of college outcomes. Those influences include students' curricular experiences (e.g., course-taking patterns and major field), classroom experiences (e.g., the quality of instruction and pedagogies encountered), and out-of-class experiences (e.g., faculty interactions, residence, employment, co-curricular involvement). Pascarella and Terenzini's reviews, however, also indicate that most studies of college effects adopt a narrow conceptual focus, concentrating on only a handful of factors. The results, they say, is a body of conceptually underspecified evidence "presenting only a partial picture of the forces at work" shaping student learning and change (2005, p. 630).

Efforts to move beyond student experiences in studying college impacts, moreover, have concentrated on a limited number of institutional characteristics as explanatory factors, what Pascarella and Terenzini call "between-college effects. These studies examine the extent to which outcomes are attributable, net of other factors, to differences in the kinds of institutions students attend. Most of these studies rely primarily on readily-available structural features (e.g., control, mission, size, admissions selectivity). These scholars and others (e.g., Astin, 1993; Dey, et al., 1997) report that such measures are consistently poor predictors of virtually *any* student outcome once students' precollege characteristics are controlled. The sole exception to this conclusion is the economic benefits (e.g., salary, occupational status) students derive. Pascarella and Terenzini conclude that between-college effects tend to be small (or non-significant) because the variance between institutions typically is less than that within. Pascarella and Terenzini suggest that the conventional descriptors are too remote from the student experience to have much impact on outcomes and are, consequently, largely unrelated to gains in student learning or changes in psychosocial or value and attitudinal areas. Persistent use of these conventional

institutional descriptors constitutes a serious weakness in how researchers think about college effects on student learning, in how they design their studies, and in their ability to explain more fully "the effects of college" on students. The limited ability to differentiate meaningfully among kinds of institutions is a non-trivial limitation on studies' relevance to theory, practice, and public policy in higher education.

Terenzini and Reason (2005) suggest that most between-college impact studies have ignored *internal* organizational features of institutions as possible, probably indirect, influences on learning. A small number of studies explore the influences of various financial contexts and expenditure patterns on such outcomes as persistence and degree completion (Bailey, Calcagno, Jenkins, Leinbach, & Kienzi, 2006; Gansemer-Topf & Schuh, 2006; Titus, 2004, 2006), or on student engagement (Pike, Smart, Kuh, & Hayek, 2006; Porter, 2006). The Pike et al. and Porter studies are noteworthy for their examination of financial and institutional characteristics on student engagement, rather than on outcomes. Both of these studies (and, indeed, most studies of college effects) view student engagement as a set of direct influences on students' subsequent learning outcomes. Pike, et al. and Porter, however, also conceive students' experiences as factors that mediate the indirect effects of institutional characteristics. Where Pike et al. examine the effects of expenditure patterns on student levels of engagement, Porter analyzes the effects of other institutional features such as "institutional density," curricular differentiation, and research emphasis, as well as expenditures per student, location, and selectivity. In all these studies, however, conventional institutional descriptors, such as control, size, curricular mission, and selectivity are confounded with more internal, operational influences, such as organizational structures; levels of collaboration within and between vice-presidential divisions; support for faculty development, and hiring and promotion and tenure criteria and policies.

Other scholars have taken a more aggregated, view of "internal" organizational features, what Berger and Milem (2000) call "organizational behavior dimensions" (p. 310). These factors identify features of an institution's operational functioning, climate, or culture that can be clustered to characterize internal organizational environments. Berger and Milem identify five such environments: bureaucratic, collegial, political, symbolic, and systemic. These "organizational effects" studies suggest that organizational environments and cultures may be more influential forces than the more commonly used structural characteristics in explaining student outcomes, most often persistence but occasionally a range of "effectiveness" measures (e.g., Astin & Scherrei, 1980; Berger, 2000; 2001-2002, 2002; Braxton & Brier, 1989; Smart & Hamm, 1993; Berger & Milem, 2000 provide a thorough review of this literature). These environmental or organizational-culture clusters represent an important step toward finer-grained and more analytically powerful analyses of the influences shaping student outcomes. These clusters, however, are relatively abstract, describing an organization's general operational behaviors and dispositions toward making decisions in one fashion rather than another. Thus, in their level of aggregation and generality, these "organizational behavior" clusters are conceptually analogous to the conventional structural descriptors and, as such, are still relatively distal from students' learning. They also provide little guidance to faculty leaders and administrators seeking to enhance the educational effectiveness of their institutions or for policy analysts' efforts to develop educationally effective public policies.

In addition to *internal* organizational characteristics, administrators and faculty members shape their institutions' culture(s) in ways that can influence students' experiences and learning. A small number of researchers have recently turned their attention to the impact of collective faculty action on student experiences and learning (Chen, Lattuca, & Hamilton, 2008). The findings from *Engineering Change: A Study of the Impact of EC2000* (Lattuca, Terenzini, &

Volkwein, 2006) indicate that faculty in engineering programs influence student learning outcomes (primarily indirectly) through the nature and emphases of the curricula they construct, the policies they devise, and the instructional practices they adopt. For example, faculty engagement in professional development activities are positively related to their use of student-centered teaching approaches and, indirectly, to students' learning of a range of engineering skills. Faculty engagement in learning-centered teaching and assessment practices also increases the level of engagement students report in both in- and out-of-class activities.

It seems reasonable to suggest that a variety of more specific institutional features, such as peer environments, faculty cultures, and *internal* structural, programmatic, and policy considerations are more proximal to students' experiences and, consequently, more likely to shape student outcomes through their effects on the kinds of experiences students have. Smart, Feldman, and Ethington (2000) provide a detailed examination of the subtle and varying effects faculty cultures have on student outcomes across academic disciplines, but few other studies assess finer-grained institutional effects on student experiences or learning (Lattuca, Terenzini, Harper, & Yin, 2010; Reason, Terenzini, & Domingo, 2005, 2006 are exceptions).

Pascarella and Terenzini's (1990, 2005) proposition that variables more proximal to students' experiences may be more powerful influences than conventional, structural institutional features has been specifically put to the test only once. Terenzini, Volkwein, and Lattuca (2007) found some supporting evidence for that hypothesis, but the pattern was inconsistent and, thus, inconclusive. None of the other studies reviewed above evaluates the relative influence of conventional descriptors vs. internal organizational features on the kinds of college experiences students have.

This study sought to extend Terenzini, et al. (2007) by assessing the relative influence of conventional and internal organizational features on students' learning-related experiences.

Specifically, the study examined the proposition that what institutions *do* affects learning more than what those institutions *are*. The study tests the proposition that internal organizational structures, policies, and faculty culture have more influence on students' learning-related experiences than do such conventional institutional features as type of control, size, wealth, or selectivity.

METHODS

Conceptual Framework

This study evaluates the construct validity of one portion of Terenzini and Reason's (2005) conceptual framework (Figure 1) suggesting that college effects on student learning are the product of a quasi-causal sequence that begins with the characteristics undergraduate students bring to college. Once students enroll, their college outcomes are shaped primarily by their individual curricular, classroom, and out-of-class experiences. Those experiences, however, are shaped to some degree by the peer environment on a particular campus. According to Terenzini and Reason, however (and this is the focal point of this study), the nature of a student's individual experiences (nested within the peer environment) is *still* partially a function of the internal organizational practices, policies, and faculty culture of the student's institution, a set of "between-college" characteristics more proximal than conventional descriptors to students' experiences and, thus, more potentially relevant to identifying and explaining between-college differences in student outcomes. This study assessed the validity of that claim by examining the comparative explanatory power of conventional institutional descriptors to affect student learning experiences compared with that of program-level structures, practices, and policies, as well as faculty practices and cultures.

Figure 1: A comprehensive model of influences on student learning and persistence
    (Terenzini & Reason, 2005)
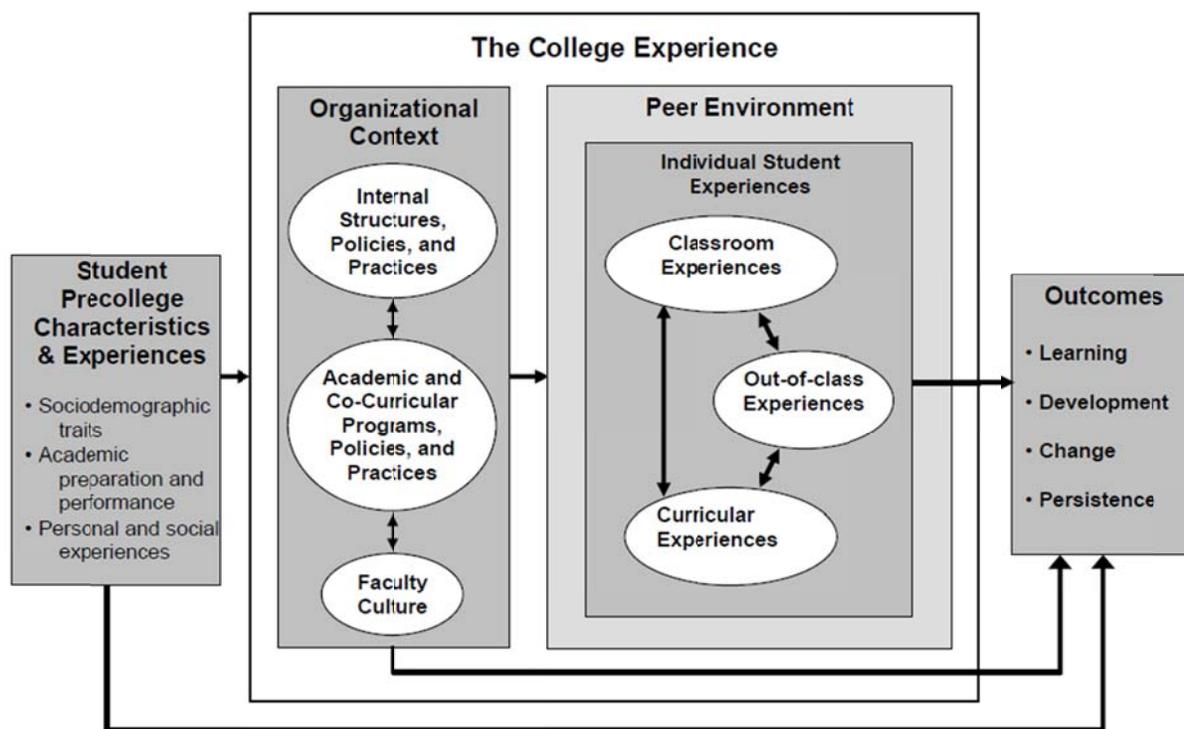
Design, Population, and Samples

This study used cross-sectional survey data from the *Prototype to Production* (P2P) study, a National Science Foundation-supported investigation of the effects of curricular, instructional, and organizational practices and policies (as well as the educational experiences of engineering students) on the learning of students in a nationally representative sample of undergraduate engineering programs. The P2P study was designed using the Terenzini-Reason model in Figure 1.

The institutional population was defined as all four-year U.S. engineering schools that offer two or more ABET-accredited programs in the "Big Five" engineering disciplines: chemical, civil, electrical, industrial, and mechanical. Biomedical/ bioengineering programs were added to the population and sample based on the recommendation of the project's National

Advisory Board and the growing presence of that field in engineering schools and the engineering workplace. Because the P2P study was also designed to inform analyses of a closely related set of six case studies (one of which offered only a baccalaureate-level general engineering program), the sample was also refined to include three institutions that also offered a general engineering program. The sampling frame drew from the American Society for Engineering Education's database using institution and program-level information on faculty and currently enrolled students. In the aggregate, these six disciplines accounted for 70 percent of all baccalaureate engineering degrees awarded in 2007.

A 6x3x2 disproportional stratified random sample of institutions was drawn using the following strata: six discipline levels, three levels of highest degree offered (bachelor's, master's, or doctorate), and two levels of type of control (public or private). The total sample of 32 four-year colleges and universities was "pre-seeded" with eight pre-selected institutions. These included the six case study institutions participating in a companion project *(Prototyping the Engineer of 2020)* and three institutions with general engineering programs. Penn State's Survey Research Center selected 25 additional institutions at random from the population within the 6x3x2 framework. The final sample also included three historically black colleges and universities (HBCUs) and three Hispanic-serving institutions (HSIs). The sampling design ensured that the sample institutions are representative of the population with respect to type, mission, and highest degree offered.

The four-year student population for the study was defined as all sophomore, junior, and senior students in one of the six focal engineering disciplines. Since some engineering programs do not allow students to declare a major until their sophomore year, the study's sample does not include first-year students.

The study also surveyed faculty members and program chairs. The faculty population was defined as all full-time instructional staff (non-tenure track, tenure-track, and tenured teaching faculty members) in each of the focal engineering disciplines and programs at participating institutions. All faculty members meeting the study's population specifications were invited to participate. Research staff also invited the chairs of these programs to participate in a survey of program characteristics, curricula, practices, and policies.

Data Collection Procedures and Response Rates

Institutions provided project staff with electronic files containing contact information and information on students' gender, race/ethnicity, class year, and engineering field; campus liaisons also provided e-mail addresses and information on faculty members' and program chairs' gender, race/ethnicity, academic rank, and engineering discipline. In April 2009 and in advance of the first mailing, the dean of engineering on each campus e-mailed students, faculty members, and chairs to advise them of their institution's participation in the study, alerting them that they would soon hear from the Penn State Survey Research Center (SRC), summarizing the potential benefits to the campus, and encouraging them to participate in the study. SRC conducted all data collection for the survey. Members of each population received an e-mailed invitation to complete a web-based survey instrument. Two weeks after the initial contact, non-respondents received an e-mail reminder. After two more weeks, non-respondents received a second e-mail request to participate. SRC removed all personally identifying information before releasing the dataset to the research team.

All students on each campus meeting the study's population specifications were invited to participate. Chi-square Goodness-of-Fit tests indicated that on some precollege student characteristics, respondents were marginally unrepresentative of the overall campus population of engineering students with respect to one or more of the following characteristics: discipline,

race/ethnicity, gender, or class level. The Chi-square test, however, is sensitive to large numbers. When comparing the population and sample distributions on these student characteristics, the proportions were relatively similar; differences between population and sample proportions ranged from 1% to 11%. Nonetheless, weights were developed to adjust for response bias (at the campus level) and for differences in institutional response rates. The weighting adjustments produced a nationally representative sample of students with respect to sex, race/ethnicity, class year, and engineering discipline. Consequently, the adjusted sample can be considered representative of the population of engineering students (as specified) both on each campus and nationally. Thus, the analyses reported below are based on the responses of 5,249 students (a response rate of 16% overall) in 31 colleges of engineering during the 2009 spring and summer terms (one of the institutions sampled was unable to provide the necessary student contact information in a timely fashion).

Of the 2,945 individuals in the faculty population, 1,119 (38%) responded to SRC requests and follow-ups. Chi-square Goodness-of-Fit tests indicated that on some characteristics, faculty respondents were somewhat unrepresentative of the overall campus population of engineering faculty with respect to discipline, race/ethnicity, gender, or academic rank. Differences between population and sample proportions, however, were small, ranging from 1% to 3%. Despite the similarity of the distributions, weights were developed to adjust for response bias (by sex, race/ethnicity, discipline, and academic rank) and institutional response rates. Of 125 program chairs invited to participate, 86 (69%) responded.

For student, faculty, and program chair respondents, missing data were imputed using procedures recommended by Dempster, Laird, and Rubin (1977) and by Graham (2009). Imputations were carried out using the Expectation-Maximization (EM) algorithm of the

Statistical Package for the Social Sciences (SPSS) software (v.18). Weights were developed

before missing data were imputed.

Scale Development[1]

The P2P research team completed a series of factor analyses to provide a more compact,

aggregated summary of the individual-item data. These widely used "data-reduction" procedures

identify individual survey items that correlate highly with one another, indicating they may be

measuring the same (or a similar) construct. This section contains information on the contents

and characteristics of the scales and other variables used in this study.

Although a variety of factor analytic procedures are available, the research group adopted

principal axis analysis. Only items with rotated factor loadings greater than .40 were considered

in forming a scale. Because the procedures adopted an Oblimin criterion with Kaiser

Normalization rotation, factors may be correlated, and some items may load above .40 on

multiple factors. In those instances, items were assigned to a factor based on the magnitude of the

loading, the effect of keeping/discarding the item on the scale's internal consistency (alpha)

reliability (see below), and on professional judgment. In some instances, items loading above .40

on more than one factor were discarded. Factor scale scores (Armor, 1964) were formed by

summing individuals' responses on the component items of a scale and then dividing by the

number of items in the scale.

Once scales were initially developed, Cronbach's *alpha* was used to evaluate their internal

consistency reliability. Alpha reflects the extent to which a scale's items are correlated and,

consequently, whether the scale is internally consistent, indicating that respondents who answer

one item higher or lower tend to answer other items in the scale higher or lower in a consistent

fashion. Alpha can range from .00 to 1.00. Psychometricians consider any scale with an alpha of

.70 or higher to be acceptable, although scales with alphas in the .5 or .6 ranges are occasionally used.

Analytical Procedures and Variables Used

Analyses proceeded in two stages. The first (essentially a variable-screening process) entailed identification of the primary student experiences associated with engineering-student skill levels in three areas: engineering design, communication, and project leadership. These outcomes were selected because they span the range of skills engineers need, from engineering design (the profession's primary activity) to professional skills that, as a result of industry and accreditation pressures, are receiving far greater attention than a decade ago. This first stage constituted essentially a process to screen variables and validate the fact that the student experiences used in the next analytical stage did, indeed (consistent with the study's conceptual framework) predict engineering students' learning.

The Design Skills scale contained 12 items and had an alpha = .92; the Communication Skills criterion had six items and an alpha = .86, and the Leadership Skills scale contained six items with an alpha = .90 (Appendix A gives each scale's item-content and metrics). Each of these outcomes was first regressed (model details are given below) on a set of students' precollege characteristics (sex, race/ethnicity, parents' education, class-year, and SAT scores) and then on measures of 12 academic and out-of-class student experiences that the literature indicates are related to learning and skill development (Pascarella & Terenzini, 1991, 2005). Variables included such experiences as students' reports of faculty classroom practices and pedagogical approaches and student participation in selected activities (e.g., undergraduate research, coop/internships, engineering design competition teams, and engineering and non-engineering clubs). Table 1 lists the control and student-experience variables (including two scales) and their descriptive statistics. These analyses not only validated the predictive power of

the focal experiences as influences on student learning for *these* engineering students, but also

identified the *primary* predictors of each outcome.

Table 1: Variables and Descriptive Statistics.

CONTROL VARIABLES	Percent	
Gender		
Male	72.8%	
Female	27.2%	
Race/ Ethnicity (Dummy coded, 1=yes, 0=no)		
African American	2.8%	
Asian American	8.1%	
Hispanic/ Latino American	5.8%	
Other	19.3%	
Caucasian American (reference group)	64.4%	
Class Standing (treated as interval scale)		
Freshman	2.3%	
Sophomore	17.1%	
Junior	34.5%	
Senior	35.8%	
More than senior year	10.3%	
Highest level of education attained by father (treated as interval)		
Did not finish high school	3.9%	
High school graduate/GED	13.1%	
Attended college but did not receive a degree	9.9%	
Vocational/technical certificate or diploma	3.8%	
Associate or other 2-year degree	13.7%	
Bachelor's or other 4-year degree	32.9%	
Master's degree (M.A., M.S., M.B.A., etc.)	18.6%	
Doctorate degree (Ph.D., J.D., M.D., etc.)	4.1%	
Highest level of education attained by mother (treated as interval)		
Did not finish high school	3.7%	
High school graduate/GED	11.4%	
Attended college but did not receive a degree	8.4%	
Vocational/technical certificate or diploma	4.3%	
Associate or other 2-year degree	8.3%	
Bachelor's or other 4-year degree	30.0%	
Master's degree (M.A., M.S., M.B.A., etc.)	21.9%	
Doctorate degree (Ph.D., J.D., M.D., etc.)	11.4%	
	Mean	**Std. Dev.**
SAT Composite Score	633.42	80.65

Table 1. Variables and Descriptive Statistics (continued).

FILTERING-VARIABLES ANALYSES: STUDENT EXPERIENCES	Mean	Std. Dev.
Student-Centered Teaching Scale[1] (Alpha = .84)		
Set clear expectations for performance	4.18	.68
Conveyed the same material in multiple ways (in writing, diagrams, orally, etc.)	3.76	.73
Explained new concepts by linking them to what students already know	3.88	.77
Used examples, cases, or metaphors to explain concepts	3.98	.78
Answered questions or gone over material until students "got it"	3.56	.86
Active/Collaborative Learning Scale[1] (Alpha = .77)		
Provided guidance or training in how to work effectively in groups	3.00	.94
Provided hands-on activities and/or assignments	3.48	.88
Used in-class, small-group learning	2.98	.94
Assigned group projects	3.58	.93
Co-curricular Experiences		
Undergraduate research activities[2]	3.69 months	6.30
Engineering internship[2]	3.33 months	5.72
An engineering cooperative education experience[2]	1.54 months	4.52
An engineering club or student chapter of a professional society (IEEE, ASME, ASCE, etc.)[3]	2.19	1.21
Other engineering-related clubs or programs for women and/or minority students (e.g. NSBE, SHPE, SWE, WISE, etc)[3]	1.61	1.00
Other clubs or activities (hobbies, civic or church organizations, campus publications, student government[3]	3.36	1.32
Study abroad or on an international, school-related tour[4]	.99 weeks	3.90
Humanitarian engineering projects (Engineers without Borders, etc.)[4]	1.04 weeks	4.66
Non-engineering related community service or volunteer work[4]	4.13 weeks	8.13
Student design project(s)/competition(s) beyond class requirements[4]	2.94 weeks	7.10

[1] The category includes Native American; Middle Eastern American; Multi-race; Foreign National; Naturalized Citizen; and other racial/ethnicity.

[2] Question stem for items in scale from student survey: "In your engineering courses, how often have your instructors . . ."

[3] Question stem for items in scale from student survey: "Since starting your engineering program, approximately how many months have you spent . . . ."

[4] Question stem for items in scale from student survey: "During the past year, how active have you been in . . . .?" Responses were given using a five-point scale, where 1 = "Not Active" and 5 = "Extremely Active (hold a leadership post)."

[5] Question stem for items in scale from student survey: "During the past year, about how many weeks did you spend participating in (each activity)."

Multiple regressions were used to examine the effects of students' precollege characteristics and experiences on each of the three learning outcomes. Ordinary least-squares (OLS) regression underestimates standard errors when complete independence of observations is violated, as is the case here, since data were collected from students clustered within an institution. To correct for this bias, we employed robust standard errors for OLS multiple regression to account for the clustering at the institution level (see Huber, 1967; Rogers, 1993;

White, 1980). We did not utilize a hierarchical linear model (HLM) for this preliminary stage because robust standard error estimates are comparable to those calculated for an HLM with the same predictors (Cheslock & Rios-Aguilar, in press).

Table 2 indicates that the regressions identified five student experiences that were consistent and statistically significant predictors of each of the three criterion outcome variables. Two of the five were "academic" factors: student reports of Student-Centered Teaching (five-item scale; alpha = .81) and Active and Collaborative Learning (four-items, alpha = .77). The other three experiences were single-item measures reflecting the extent of students' participation in an undergraduate research project, internship, or non-engineering clubs/activities.

Table 2. Five Student Experiences Significantly Predicting the Criterion Measures.

Student Experiences	Design Skills				Communication Skills				Leadership Skills			
	Coef	Robust S.E.	t		Coef	Robust S.E.	t		Coef	Robust S.E.	t	
Undergraduate Research	0.006	0.002	3.07	**	0.009	0.004	2.12	*	0.011	0.004	2.52	*
Internship	0.014	0.002	5.52	***	0.008	0.003	3.04	**	0.008	0.003	2.57	**
Non-Engineering Clubs	0.040	0.016	2.58	**	0.065	0.015	4.36	***	0.063	0.015	4.24	***
Student-Centered Teaching Scale	0.157	0.042	3.74	***	0.218	0.042	5.13	***	0.140	0.043	3.24	**
Active and Collaborative Learning Scale	0.297	0.045	6.59	***	0.167	0.033	5.12	***	0.215	0.042	5.08	***

*p<.05 **p<.01 ***p<.001

These five experiences became the criterion variables for the second analytical stage, in which we evaluated whether conventional institutional descriptors or internal organizational and operational features are the better predictors of the kinds of experiences students have. Because the study used both individual- (student) and institution-level characteristics, analyses entailed estimation of multilevel models for each experience criterion. Procedures followed the recommendations of Raudenbush and Bryk (2002). For each experience, four models (in addition to an unconditional model) were estimated. The unconditional model has no explanatory

variables and permits partitioning criterion-measure variance into within- and between-variance components. It allows assessment of whether sufficient between-institution variance exists to warrant further multi-level analyses.

Model 1 contained only student-level variables (the within, or Level-1 model); these precollege student traits were those used in the regressions. Because the study has no interest in the effects of student characteristics on a given experience, this model served essentially to control for differences in students' precollege traits before assessing the relative contributions of conventional and internal institutional characteristics to differences in the experiences students reported having. Models 2, 3, and 4 were Level-2 models containing combinations of two sets of institutional characteristics: a "conventional" set of five descriptors (size, type of control, highest-degree awarded, selectivity, and wealth) and a second set containing six "internal" organizational features (e.g., chairs' reports of their program's curricular emphasis on selected topics), faculty reports of their classroom practices and pedagogies, and their perceptions of selected school-wide policies (e.g., emphasis on selected criteria in promotion and tenure decisions). The institution-level variables and scales are described in Table 3.

Table 3. Institution-level Independent Variables

Conventional Characteristics		
Institutional Type		
Private (reference group)	38.7%	
Public	61.3%	
Highest Degree Awarded		
Bachelors (reference group)	19.4%	
Master	19.4%	
Doctorate	61.3%	
Institutional Size		
Small	9.6%	
Medium	20.4%	
Large	70%	
	Mean	**Std. Dev.**
Institutional Selectivity[1]	633.4	47.8
Wealth[2]	111341.8	21043.6

Table 3. Institution-level Independent Variables (Continued)

Internal Organizational Characteristics	Mean	Std. Dev.
Program Emphases on Professional Skills[3] (Alpha = .79)		
Leadership skills	3.56	.80
Working effectively in teams	4.20	.71
Professional skills	3.76	.88
Written and oral communication skills	4.24	.72
Project management skills	3.40	.96
Program Emphases on Design Skills[3] (Alpha = .78)		
Generating and evaluating variety of ideas about how to solve a problem	3.91	.67
Emerging engineering technologies	3.60	.73
Defining a design problem	4.16	.68
Creativity and innovation	3.81	.93
Solving problems from real clients (industry, government, etc.)	3.71	.96
Producing a product (prototype, program, simulation, etc.)	3.70	1.04
Systems thinking	3.77	.85
Faculty Members' Active Learning Pedagogy[4] (Alpha = .70)		
Hands-on activities and/or assignments	2.89	1.02
In-class, small-group learning	2.29	1.02
Group projects	2.52	1.11
In-class discussions	2.79	.85
Reverse-engineering exercises	1.64	.80
Case studies or real-world examples	2.93	.85
Faculty Perceptions of Value of Curriculum Enhancement Work in P&T Decisions[5] (Alpha = .78)		
Curriculum or course development	2.87	.92
Writing textbooks	3.03	1.00
Writing article/chapter/book on teaching, curriculum, or assessment	2.58	.90
End-of-course evaluation results	3.28	.99
Single Items		
Program emphases on application of math and science to engineering problems[3]	3.56	.95
Reward excellence in teaching commensurately with research[6]	3.90	24

[1.] An average of all the individual student's reports of the SAT verbal, math, and writing scores (from Student survey)

[2.] Average full professor salary equated to 9-month contracts of full-time instructors (from IPEDS)

[3.] Question stem for items in scale from program chair survey: "How much does your program curriculum emphasize…?"

[4.] Question stem for items in scale from faculty survey: "How often do you use the following instructional approaches (in a course you regularly teach)?"

[5.] Question stem for items in scale from faculty survey: "In general, how much do the following 'count' in annual promotion and tenure reviews in your department?"

[6.] Question stem for items in scale from faculty survey: "To what extent do you agree or disagree that the engineering curriculum should…"

Model 2 consisted of the Level-1 variables and the "conventional" institutional descriptors; Model 3 contained the Level-1 variables plus the Level-2 "internal" organizational features, and Model 4 was a "full" model with all Level-1 and Level-2 variables. We examined

the models summarized in Table 4 in which an institution's conventional and internal organizational characteristics are predictors of each of the five student experiences (the criterion variables identified in the regression analyses: time spent in undergraduate research, time spent in internship, time spent in non-engineering clubs, student-centered teaching, and active and collaborative learning scales).

Table 4. Model Descriptions

Model	Level-1 Variables	Level-2 Variables
Unconditional Model	None	None
Model 1: Student-Model	Student Background Characteristics	None
Model 2: Conventional Institutional Traits	Student Background Characteristics	Conventional Characteristics
Model 3: Internal Organizational Features	Student Background Characteristics	Internal Organizational Characteristics
Mode 4: Full Model	Student Background Characteristics	Conventional and Internal Organizational Characteristics

The intraclass correlation (ICC, or ρ) for each model was the primary analytical statistic in a series of estimations of the proportional reduction of variance (PRV, or variance explained) with the addition of each set of Level-2 variables. Using the unconditional model as the benchmark, the ρ for each subsequent model (containing institutional trait sets) was subtracted from the unconditional model's ρ and the difference then divided by the benchmark ρ to give an estimate of the PRV. The PRVs for each model were used to evaluate the tenability of the hypothesis that internal organizational characteristics are stronger predictors of students' experiences than are the more conventional institutional traits.

Results

The unconditional model results indicated that the intraclass correlations (ICC), reflecting the variance attributable to between-institution differences, was sufficiently large (Porter, 2005; Raudenbush & Bryk, 2002) to warrant further HLM analyses (Student-Centered Teaching Scale

ICC = 0.09, Active/Collaborative Learning Scale ICC = 0.15, Undergraduate Research

Participation ICC = 0.07, Internship Experience = 0.04, and Non-engineering Club Participation

ICC = 0.16). Subsequent model results indicate that, beyond the unconditional model, both

conventional and internal organizational characteristics produce substantial reductions in the

variance across institutions, suggesting clearly that, after controlling for their precollege

characteristics, students' experiences vary substantially across institutions, whether that

variability is attributable to conventional or to internal organizational features.

Table 5. Proportional Reduction of Variance

		Unconditional Model	Model 1 (Std. Chars. Only)	Model 2 (Std. Chars. + Conventional Chars.)	Model 3 (Std. Chars. + Int. Org. Chars.)	Model 4 (Std. Chars. + Conventional + Int. Org. Chars.)
Undergraduate Research	σ_u	3.13	2.74	2.29	1.40	1.37
	PRV*		.13	.27	.55	.56
Internship	σ_u	1.57	1.46	.80	1.45	.77
	PRV*		.07	.49	.08	.51
Non-Engineering Clubs	σ_u	.31	.15	.10	.13	.08
	PRV*		.52	.67	.57	.75
Student-Centered Teaching	σ_u	.03	.02	.01	.01	.01
	PRV*		.18	.57	.62	.58
Active and Collaborative Learning	σ_u	.09	.02	.05	.04	.04
	PRV*		.72	.44	.50	.52

*PRV or Proportion Reduction in Variance is calculated as $(\sigma_{u,\ unconditional\ model} - \sigma_{u,\ model\ x}) / \sigma_{u,\ unconditional\ model}$

Table 5 indicates relatively strong support for the proposition that internal organizational

features tend to be stronger predictors of the students' learning-related experiences than are

conventional institutional characteristics, even after controlling differences in the precollege

characteristics of the students attending those institutions. In some circumstances, however,

conventional predictors are stronger. In both of the "academic" experience models (students'

reports of their exposure to Student-Centered Teaching and engagement in Active/Collaborative

Learning), the PRVs for the set of internal features were greater (.62 and .50, respectively) than

those for the conventional predictors (.57 and .44, respectively). In predicting students'

undergraduate research experiences (arguably an "academic" experience), the PRV for internal

features (.55) is almost two times larger than that for conventional predictors (.27). For one out-of-class experience criterion variable (involvement in nonengineering-related clubs), however, the conventional-characteristics model produced a larger PRV (.67) than the internal-traits model (.57).

For students' internship experiences, the internal feature model explained essentially none of the variance in that experience while the conventional-characteristics model explained almost seven times as much as that in the null model. Engineering programs have historically provided internships to help engineering students develop their practical skills for an engineering profession. Undergraduate research opportunities, however, are not currently as widespread as internships. Since internship opportunities are common, the only differences that exist between institutions may be based on institutional characteristics, such as size and resources available to locate internships and promote them among students. On the other hand, for a school also to focus its resources effectively on undergraduate research, other internal organizational factors may also be involved, such as faculty members' emphasis on active learning, their willingness to take on undergraduates to assist in the faculty member's research, and a faculty reward system that values and recognizes teaching in multiple ways and venues.

Except in the case of Student-Centered Teaching, the full model findings indicate that adding the internal-characteristics set produces a moderate to substantial PRV over that of conventional-traits-only models. The full-model findings for Student-Centered Teaching indicated that including the internal-traits added little power in reducing variance beyond what the conventional set did by itself. Internal traits by themselves, however, did produce a greater PRV than the conventional-traits by themselves, lending some additional support to the proposition that internal organizational traits provide more explanatory power than conventional institutional characteristics.

Limitations

Like all studies, this one has several limitations. First, although the study was designed to capture significant aspects of organizational characteristics on selected academic and co-curricular experiences that undergraduate engineering students have, the "organizational context" portion of the conceptual framework shown in Figure 1, and its operational forms in this study, may be underspecified, overlooking or inadequately representing important internal programmatic dimensions. Moreover, the analytical models do not include measures of other engineering-related academic experiences (such as capstone course, service-learning courses, and course-related student-faculty interactions) and co-curricular experiences (such as those listed in in the bottom portion of Table 1 but not selected for use in the analytical models). In addition, the measures of students' levels of involvement in co-curricular activities are single-item measures of complex experiences that can vary within the category.

Second, the three engineering skills used in the regressions designed to reduce the number of student experiences in the models (and to verify the importance of those experiences) only partially reflect the range of skills engineering students need (National Academy of Engineering, 2004). The findings reported might not be replicated in similar analyses using other learning outcomes to "filter" predictor variables, although the present results would lead one to expect such replication. Nonetheless, the matter is an empirical question.

Third, although respondents were at least moderately representative of the national engineering student, faculty, and program chair populations from which they came, generalization of the results of the study to their counterparts in other academic areas is probably limited by the specialized and technical nature of engineering as a field of study. However, previous studies (Pascarella & Terenzini, 2001, 2005) have demonstrated the influence of both curricular and co-curricular experiences on student learning. Consequently, a modicum of

confidence can be placed in the validity and generalizability of these results to students in other fields.

Finally, the quasi-causal sequence of effects hypothesized in the study's conceptual framework is not directly evaluated in this study. Future studies would benefit from the use of structural equation modeling procedures. Nonetheless, the first stage of the study's analytical procedure adopted preliminary, multiple regression analyses with robust standard errors to identify student experiences that demonstrably influence learning outcomes. A considerable body of research, moreover, strongly supports the model's structure (Pascarella & Terenzini, 1991, 2005).

Conclusions

The study's findings provide moderate to strong and generally consistent support for Pascarella and Terenzini's (1990, 2005) proposition that, net of students' precollege characteristics, the conventional (largely structural) descriptors of the colleges and universities students attend (e.g., size, control, mission, selectivity) – and which dominate between-college effects studies may, indeed, be too removed from students' experiences to have much direct impact on learning outcomes. Those researchers and others (e.g., Pike, Smart, Kuh, & Hayek, 2006; Porter, 2006; Smart, Feldman, & Ethington, 2000; Terenzini & Reason, 2005) have suggested that institutional features more proximal to students' experiences may be more theoretically and practically noteworthy. The evidence of this study indicates that is very likely the case. In only two of five models did conventional institutional characteristics provide more power than internal organizational features in explaining between-institution variability in the kinds of experiences students reported. In at least one of those instances, the finding may be attributable to attenuated variance in the criterion measure (time spent in internships, a common experience in engineering education).

These findings have implications for theory, practice, and policy. First, they suggest that current theories or models of college effects on students may be underspecified, overlooking important internal organizational factors. Terenzini and Reason (2005) hypothesize a quasi-causal sequence in which internal organizational features shape the kinds of experiences students have (which, in turn, influence the knowledge students' acquire and the skills they develop) to a greater extent than do the conventional structural descriptors typically used in studies of between-college effects. The study's evidence supports Terenzini and Reason's proposition that college-effects researchers may be falling victim to the "*post hoc* fallacy," attributing all influence on some outcome to the most immediately prior influence, thereby ignoring earlier links in the "causal" chain that leads to differences in college effects on student outcomes. As such, the findings are also consistent with Pascarella and Terenzini's (2005) conclusion that current theories and models, as well as the research based on them, that focus narrowly on only one or a handful of selected student experiences may "present only a partial picture of the forces at work" (2005, p. 630). The consequences of this study's findings for theory development and testing are that potentially important factors and dynamics are being overlooked. The findings may also partially explain the apparent "ceiling" (of about 35-45%) on the variance typically explained in student outcomes studies.

The findings also have practical implications, pointing faculty and administrators toward the potentially important *internal* organizational and operational features – the things over which they have some programmatic and policy control – to shape the kinds of experiences students have and, thus indirectly, what students learn and how they change as a result of their college experience. A clear implication of this study's findings is that academic and student affairs administrators may not be taking full advantage of the range of organizational policy and

programmatic tools at their disposal to shape the undergraduate experience and, consequently, student learning and change.

Finally, the findings indicate that the underlying mechanisms shaping student learning are far more complex than those currently reflected in campus and public policy decision-making. For example, the findings fairly clearly point to the predictive impotence of some of the most widely used indicators of "institutional quality" (e.g., selectivity and mission). This study suggests that what colleges and universities "are" (in terms of their conventional characteristics) is less useful than what they "do" internally (e.g., how they organize themselves and operate structurally and programmatically) in identifying educationally effective institutions and student experiences. The educationally effective practices reviewed in Pascarella and Terenzini (1991, 2005) are as likely (perhaps more likely) to be in use at less prestigious campuses as at their "elite" counterparts. Thus, the common budget-allocation practices used in most state legislatures that privilege flagship campuses may have disadvantageous consequences for the undergraduates (and their tax-paying parents) who attend other campuses in a state's system. Moreover, administrators' and public policy makers' searches for specific "best practices" may be short-sighted. The decisions they make – and the resources they allocate – may benefit from more refined and systemic views of the colleges and universities for which these leaders are responsible. The conceptual framework adopted for this study implies a complex series of interactions between and among a broad array of factors, both institutional and individual, that in the aggregate lead to student learning and change. The validation of that framework in this study suggests that campus administrators' and state legislatures' search for "best practices" (specific programs, interventions, practices) may be short-sighted, even naïve, narrowing institutional attention to "silver bullets" that may ultimately have limited impact when compared to that of more comprehensive, planned, and integrated approaches.

Notes

[1] The project team developed each of the instruments for this study following extensive literature

reviews, focus group interviews with engineering faculty members, and (excepting the Program

Chair Survey) pilot testing. Details on this process are available from the lead author.

References

Allison, P. D. (2001). *Missing data*. Sage University Papers Series on Quantitative Applications in the Social Sciences, No. 07-136. Thousand Oaks, CA: Sage.

Astin, A. W. (1993). *What matters in college? Four Critical Years revisited*. San Francisco: Jossey-Bass.

Astin, A. W., & Scherrei, R. (1980). *Maximizing leadership effectiveness*. San Francisco: Jossey-Bass.

Bailey, T., Calcagno, J. C., Jenkins, D., Leinbach, T., & Kienzi, G. (2006). Is student-right-to-know all you should know? An analysis of community college graduation rates. *Research in Higher Education, 47*(5), 491-519.

Berger, J. B. (2000). Organizational behavior at colleges and student outcomes: A new perspective on college impact. *Review of Higher Education, 23*, 177-198.

Berger, J. B. (2001-2002). Understanding the organizational nature of student persistence: Empirically-based recommendations for practice. *Journal of College Student Retention, 3*, 3-21.

Berger, J. (2002). The influence of the organizational structures of colleges and universities on college student learning. *Peabody Journal of Education, 77*, 40-59.

Berger, J., & Milem, J. (2000). Organizational behavior in higher education and student outcomes. In J. C. Smart (Ed.), *Higher Education: Handbook of Theory and Research* (Vol. XV, pp. 268-338). New York: Agathon.

Best, J. W., & Kahn, J. V. (1986). *Research in education (5th ed.)*. Englewood Cliffs, NJ: Prentice-Hall.

Braxton, J., & Brier, E. (1989). Melding organizational and interactional theories of student attrition: A path analytic study. *Review of Higher Education, 13*, 47-61.

Cabrera, A. F., Colbeck, C. L., & Terenzini, P. T. (2001). Developing performance indicators for assessing classroom teaching practices and student learning. *Research in Higher Education, 42*, 327-352.

Chen, H. L., Lattuca, L. R., & Hamilton, E. R. (2008). Conceptualizing engagement: Contributions of faculty to student engagement in engineering. *Journal of Engineering Education, 97*(3), 339-353.

Cheslock, J. J., & Rios-Aguilar, C. (In press). Multilevel analysis in higher education research: A multidisciplinary approach. In J. Smart (Ed.), *Higher education: Handbook of theory and research*. New York: Agathon Press.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2009). *Internet, mail, and mixed-mode surveys: The tailored design method* (3rd ed.). Hoboken, NJ: Wiley.

Dey, E., Hurtado, S., Rhee, B., Inkelas, K. K., Wimsatt, L. A., & Guan, F. (1997). *Improving research on postsecondary outcomes: A review of the strengths and limitations of national data sources*. Palo Alto, CA: Stanford University, National Center for Postsecondary Improvement.

Ethington, C. A. (1997). A hierarchical linear modeling approach to studying college effects. In J. C. Smart (Ed.), *Higher education: Handbook of theory and research* (Vol. XII, pp. 165-194). New York: Agathon.

Gansemer-Topf, A. M., & Schuh, J. H. (2006). Institutional selectivity and institutional expenditures: Examining organizational factors that contribute to retention and graduation. *Research in Higher Education, 47*(6), 613-642.

Lattuca, L. R., Terenzini, P. T., Harper, B. J., & Yin, A. (2010). Academic environments in detail: Holland's theory at the sub-discipline level. *Research in Higher Education, 48*(2), in press.

Lattuca, L. R., Terenzini, P. T., & Volkwein, J. F. (2006). *Engineering change: A study of the impact of EC2000*. Baltimore: ABET.

National Academy of Engineering. (2004). *The engineer of 2020: Visions of engineering in the new century*. Washington, DC: National Academies Press.

Pike, G. R., Smart, J. C., Kuh, G. D., & Hayek, J. C. (2006). Educational expenditures and student engagement: When does money matter? *Research in Higher Education, 47*(7), 847-872.

Porter, S. R. (2005). What can multilevel models add to institutional research? In M. A. Coughlin (Ed.), *Applications of intermediate/advanced statistics in institutional research* (Resources in Institutional Research, No. 16) (pp. 110-131). Tallahassee, FL: Association for Institutional Research.

Porter, S. R. (2006). Institutional structures and student engagement. *Research in Higher Education, 47*(5), 521-558.

Raudenbush, S. W., & Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods* (2nd ed.). Thousand Oaks, CA. Sage.

Reason, R. D., Terenzini, P. T., & Domingo, R. J. (2005, November). Developing social and personal competence in the first year of college. Paper presented at the meeting of the Association for the Study of Higher Education, Philadelphia, PA.

Reason, R. D., Terenzini, P. T., & Domingo, R. J. (2006). First things first: Developing academic competence in the first year of college. *Research in Higher Education, 47*(2), in press.

Smart, J. C., Feldman, K. A., & Ethington, C. A. (2000). *Academic disciplines: Holland's theory and the study of college students and faculty*. Nashville, TN: Vanderbilt University Press.

Smart, J., & Hamm, R. (1993). Organizational culture and effectiveness in two-year colleges. *Research in Higher Education, 34*(1), 95-106.

Terenzini, P. T., Cabrera, A. F., Colbeck, C. L., Bjorklund, S. A., & Parente, J. M. (2001). Racial and ethnic diversity in the classroom: Does it promote student learning? *Journal of Higher Education, 72*, 509-531.

Terenzini, P. T., Volkwein, J. F., & Lattuca, L. R. (2007, November). The effects of conventional vs. internal organizational characteristics on student experiences. Paper presented at the meeting of the Association for the Study of Higher Education, Louisville, KY.

Terenzini, P. T., & Reason, R. D. (2005, November). *Parsing the first year of college: Rethinking the effects of college on students*. Paper presented at the meeting of the Association for the Study of Higher Education, Philadelphia, PA.

Titus, M. A. (2004). An examination of the influence of institutional context on student persistence at 4-year colleges and universities: A multilevel approach. *Research in Higher Education, 45*(7), 673-699.

Titus, M. A. (2006). Understanding college degree completion of students with low socioeconomic status: The influence of the institutional financial context. *Research in Higher Education, 47*(4), 371.

Appendix A: Student Outcome Variables

Student Outcome Variables	Mean	Std. Dev.
Design Skills[1] ***(Alpha = .92)***		
Evaluate design solutions based on a specified set of criteria.	3.72	0.96
Generate and prioritize criteria for evaluating the quality of a solution.	3.62	0.97
Producing a product (prototype, program, simulation, etc.).	3.33	1.13
Apply systems thinking in developing solutions to an engineering problem.	3.45	1.07
Brainstorm possible engineering solutions	3.83	0.93
Take into account the design contexts and the constraints they may impose on each possible solution	3.55	1.03
Define design problems and objectives clearly and precisely.	3.75	0.91
Ask questions to understand what a client/customer really wants in a "product."	3.67	1.08
Break down a design project into manageable components or tasks.	3.77	0.97
Recognize when changes to the original understanding of the problem may be necessary.	3.76	0.91
Develop pictorial representations of possible designs (sketches, renderings, engineering drawings, etc.).	3.67	1.09
Undertake a search before beginning team-based brainstorm	3.51	1.07
Communication Skills[1] ***(Alpha = .86)***		
Make effective audiovisual presentations	3.78	.93
Construct tables or graphs to communicate a solution.	4.06	.81
Write a well-organized, coherent report.	3.81	.92
Communicate effectively with people from different cultures or countries.	3.40	1.06
Communicate effectively with clients, teammates, and supervisors.	3.94	.85
Communicate effectively with non-technical audiences.	3.82	.94
Leadership Skills[1] ***(Alpha = .90)***		
Develop a plan to accomplish a group or organization's goals.	3.83	.90
Help your group or organization work through periods when ideas are too many or too few.	3.65	.95
Take responsibility for group's or organization's performance	3.92	.92
Motivate people to do the work that needs to be done.	3.60	1.01
Identify team members' strengths/weaknesses and distribute tasks and workload accordingly.	3.76	.99
Monitor the design process to ensure goals are being met.	3.70	.95

[1] Question stem for items in scale from student survey: "Please rate your ability to apply in a variety of areas:" Responses were given using a five-point scale, where 1 = "Weak/none" and 5 = "Excellent."