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ABSTRACT

This study sought to determine the extent to which instructional processes characterized by cognitive complexity influence the development of general cognitive abilities during the first, second, and third years of college. The sample for the study consisted of incoming first-year students at 18 four-year and 5 two-year colleges and universities located in 16 states chosen to represent differences in colleges and universities nationwide on a variety of characteristics, including institution type and control, size, location, student residence patterns, and student ethnic distribution. Initial data was collected in fall 1992 from 3,840 students at 23 institutions; three follow-up data collections were done in spring 1993, 1994, and 1995. Controlling for factors such as precollege cognitive ability and academic motivation, ethnicity, gender, socioeconomic status, age, college experiences, work responsibilities, and pattern of courses taken, the extent to which students reported instructor use of higher-order questions on examinations, assignments, and in classroom discussions was significantly and positively associated with end-of-year cognitive development for each year of the study. Additional analyses suggested that the net cognitive impact of the instructional processes were general rather than conditional. Four data tables are appended. (Contains 25 references.) (CH)

The Influence of Instructional Processes on Student Cognitive Development

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Abstract

This study sought to determine the extent to which instructional processes characterized by cognitive complexity influences the development of general cognitive abilities during the first, second, and third year of college. Controlling for such factors as precollege cognitive ability and academic motivation, ethnicity, gender, socio-economic status, age, college experiences, work responsibilities, and the pattern of courses taken, the extent to which students reporting instructor use of higher-order questions on examinations, assignments and in classroom discussions was significantly and positively associated with end-of-year cognitive development for each year of the study. Additional analyses suggested that the net cognitive impact of the instructional processes were general rather than conditional.

The Influence of Instructional Processes on Student Cognitive Development

Introduction

A central mission of American higher education has long been the development of students' intellectual skills and abilities. This has become especially relevant in today's rapidly changing society where content knowledge is quickly becoming obsolete, and undergraduate students are expected upon graduation to demonstrate their abilities to reason, evaluate, make decisions, and solve problems (McKeachie, 1986). The significance of this mission for higher education has been underscored by several national reports such as *Involvement in Learning* (National Institute of Education, 1984) and *Integrity in the College Classroom* (Association of American Colleges, 1985) both of which have identified the development of critical thinking skills as a desired and necessary outcome of undergraduate education. More recently, in a report by one of the nations' leading education-policy organizations, The Carnegie Foundation for the Advancement of Teaching, higher education is exhorted to reassess its approach to undergraduate education so that "the skills of analysis, evaluation, and synthesis will become the hallmarks of a good education, just as absorption of a body of knowledge once was."

There is a considerable body of evidence indicating that exposure to college in general has a significant impact on students' cognitive development (Astin, 1993; McMillan, 1987, Pascarella and Terenzini, 1991; Pace, 1984). There is also evidence to suggest that specific aspects of the college experience contribute to students' intellectual growth (e.g., curriculum design (Dressel and Mayhew, 1954), disciplinary majors and courses taken (Astin, 1993, Tsui, 1999), students' out of class experiences with peers (Edison, 1997; Terenzini et al. 1996), students' college residence (Pascarella et al., 1993), the quality of student effort (Pace, 1984), students' out of class interactions with faculty (Terenzini et al., 1995), student involvement in active learning (Astin, 1993), students' social and academic integration (Terenzini and Wright, 1987; Li et al., 1999), and institutional context (Hagedorn et al., 1999).

Within the literature on teaching in higher education, there is a body of research that addresses the relationship between instructional practices and students' growth and development (Dunkin and Barnes, 1986). In a meta-analysis of twenty-seven studies examining the influence of specific instructional or curricular approaches on student cognitive development, McKeachie et al. (1986) concluded that certain elements of instruction can, in fact, foster critical thinking skills. Specifically, they found that students' cognitive development can be enhanced through instructional processes such as those that stress student discussion, emphasize problem solving tasks, or actively engage students in the use of higher-order thinking. Similarly, in a comprehensive review of the relevant literature, Pascarella and Terenzini (1991) found that, while no one instructional practice appears to consistently enhance students' cognitive development, instructional practices that involve students and faculty in the learning process at a reasonably high intellectual level may enhance critical thinking in students. In a more recent review of the literature on critical thinking, Tsui (1998) reports somewhat similar findings regarding the impact of certain types of instructional practices on student self-reported gains in critical thinking. General findings from this review indicate that students make greater gains in critical thinking in courses where instructional practices engage students in problem solving, higher order thinking and inquiry, and the use of reading and writing to create meaning. What is clear from these reviews is that the cognitive level of classroom instruction appears to enhance students' development of higher order thinking. Efforts to identify the cognitive level of classroom instruction have relied mainly on Bloom's (1956) *Taxonomy of Educational*

Objectives which categorizes the intended learning outcomes in a hierarchy according to the intellectual skills and abilities they elicit from students. In ascending order, the six levels of cognitive complexity are: knowledge, comprehension, application, analysis, synthesis, and evaluation. The underlying principal of this taxonomy is that instructional practices that engage students in thinking at higher cognitive levels can enhance students' ability to think critically.

Employing data from the National Study of Student Learning, the present study sought to add to our knowledge of the factors that influence students' general cognitive development. The study had two purposes. First, it attempted to determine the net effects of teaching practices that elicit higher-order thinking on students' self-reported gains in general cognitive skills and abilities. Drawing from Bloom's taxonomy (1956), higher –order cognitive instruction is that which requires students to manipulate and synthesize information, while lower-order cognitive instruction elicits from students verbatim recall or recognition of factual information (Brown and Atkins, 1988). Second, the study attempted to determine the extent to which the effects of the variable representing the cognitive level of classroom instruction differed in magnitude for students with different background characteristics.

Research Methods

<u>Samples</u>

<u>Institutional sample</u>. The sample in this study consisted of incoming first-year students at 18 four-year and 5 two-year colleges and universities located in 16 states. Institutions were chosen from the National Center on Education Statistics Integrated Postsecondary Education Data System (IPEDS) data to represent differences in colleges and universities nationwide on a variety of characteristics, including institutional type and control (e.g., private and public

research universities, private liberal arts colleges, public and private comprehensive universities, two-year colleges, historically Black colleges), size, location, patterns of student residence, and the ethnic distribution of the undergraduate student body. Our sampling technique produced a sample of institutions with a wide range of selectivity. For example, we included some of the most selective institutions in the country, and some that were essentially open admission.

Student sample. The individuals in the sample were students participating in the National Study of Student Learning (NSSL), a large longitudinal investigation of the factors that influence learning and cognitive development in college. The initial sample was selected randomly from the incoming first-year class at each participating institution. The students in the sample were informed that they would be participating in a national longitudinal study of student learning and that they would receive a cash stipend for their participation in each data collection. They were also informed that any information they provided would be kept confidential and never become part of their institutional records.

Data Collection

Initial data collection. The initial data collection was conducted in the Fall of 1992 with 3,840 students from the 23 institutions. The data collected included an NSSL precollege survey that sought information on student demographic characteristics and background, as well as aspirations, expectations of college, and orientations toward learning. Participants also completed Form 88A of the Collegiate Assessment of Academic Proficiency (CAAP), developed by the American College Testing Program (ACT) to assess selected general skills typically acquired by students during the first two years of college (ACT, 1989, 1991). The total CAAP consists of five 40-minute, multiple-choice test modules: reading comprehension, mathematics, critical thinking, writing skills, and science reasoning. The reading comprehension, mathematics, and critical thinking modules of the CAAP were administered during the Fall 1992 data collection. A brief description of each follows.

The CAAP reading comprehension test is composed of 36 items that assess reading comprehension as a product of skill in inferring, reasoning, and generalizing. The test consists of four 900-word prose passages designed to represent the level and kinds of reading students commonly encounter in college curricula, including topics in fiction, humanities, social sciences, and natural sciences. The KR-20 internal consistency reliability for the reading comprehension test ranges between .84 and .86 (ACT, 1989).

The mathematics test consists of 35 items designed to measure a student's ability to solve mathematical problems. The test emphasizes quantitative reasoning, rather than formula memorization, and includes algebra (four levels), coordinate geometry, trigonometry, and introductory calculus. The KR-20 reliability coefficients for the mathematics test range between .79 and .81 (ACT, 1989).

The critical thinking test is a 32-item instrument designed to measure a student's ability to clarify, analyze, evaluate, and extend arguments. The test consists of four passages in a variety of formats (e.g., case studies, debates, dialogues, experimental results, statistical arguments, editorials). Each passage contains a series of arguments that support a general conclusion and a set of multiple-choice test items. The KR-20 reliability coefficients for the critical thinking test range between .81 to .82 (ACT, 1989). In a pilot test of instruments for use in the NSSL, the critical thinking test of the CAAP correlated .75 with the total score on the Watson-Glaser Critical Thinking Appraisal (Pascarella, Bohr, Nora, & Terenzini, 1995).

First follow-up data collection. The first follow-up data collection was conducted in Spring 1993. This data collection took about three and one-half hours, and included Form 88B of the CAAP reading comprehension, mathematics, and critical thinking modules; the College Student Experiences Questionnaire (CSEQ) (Pace, 1984); and a follow-up instrument developed for the NSSL. The CSEQ and the NSSL follow-up instrument were used to measure a wide range of students' experiences in the first year of college.

Of the original sample of 3,840 students who participated in the Fall 1992 testing, 2685 participated in the Spring 1993 data collection, for a first-year follow-up response rate of 69.92%. To adjust for potential response bias by sex, race/ethnicity, and institution, however, a sample weighting algorithm was developed. Follow-up participants in each institution were weighted up to the institution's first-year population by sex (male or female) and race/ethnicity (Caucasian, Black, Hispanic, other). Thus, for example, if institution A had 100 Black women in its first-year class, and 25 Black women in the sample, each Black woman in the sample was given a sample weight of 4.00. An analogous weight was computed for participants in each sex x race/ethnicity cell in each institution. Applying sample weights in this manner allowed us to adjust not only for response bias by sex and race/ethnicity, but also for response bias (i.e., differential response rates) by institution.

Second follow-up data collection. The second follow up of the NSSL sample was conducted in the Spring of 1994. Similar to the first follow-up, extensive measures of students' second-year experiences were taken from their responses on the CSEQ and the NSSL follow-up survey. Students also completed Form A of the CAAP writing skills and science reasoning modules.

Of the 2,685 students who participated in the first follow-up (Spring 1993), 1,761 participated in the second follow-up (Spring 1994), for a response rate of 65.6%. A second weighting algorithm was developed which was analogous to that applied in the first year to adjust for response bias by sex, race/ethnicity, and institution.

Third follow-up data collection. The third follow-up of the NSSL sample took place in the Spring of 1995 at the 18 four-year institutions. Measures of students' third-year experiences were taken from their responses on the CSEQ and the NSSL Follow-Up Survey. Participants also completed Form B of the CAAP reading comprehension and critical thinking modules.

Of the 1,613 four-year college students who participated in the Spring 1994 data collection, 1,054 participated in Spring 1995, for a third-year response rate of 65.3%. A third weighting algorithm was developed to adjust for sample response bias by sex, race/ethnicity, and institution.

Analytical Model

The independent variable of primary interest in analyses of all three years of the study was the 10-item Cognitive Level of Instruction Scale. The dependent variables/outcomes measures for each of the three years were the end-of-the-year scores on three CSEQ self-reported gains scales: writing and thinking skills, understanding science, and understanding the arts and humanities. These scales were constructed from items on the CSEQ for which students indicated how much they felt they had gained or made progress in a variety of aspects of college learning and cognitive growth.

Two sets of potentially confounding variables -- individual-level variables and institutional-level variables -- also were included in the analytic model. A number of factors extraneous to the study might influence students' involvement with peers, as well as their cognitive growth during college. As a consequence, simple correlations might yield a misleading estimate of the impact of peer involvement on students' cognitive development (cf., Astin, 1993; Pascarella, 1985; Pascarella & Terenzini, 1991).

In selecting individual-level confounding variables, we were guided by evidence on the factors independently influencing learning and cognitive development in college (cf., Astin, 1968, 1977, 1993; Astin & Panos, 1969; Kuh, 1993; Pascarella, 1985; Pascarella & Terenzini, 1991). Individual-level variables incorporated in the analytic model were: precollege (Fall 1992) cognitive development; race/ethnicity (white/non-white); sex; age; precollege (Fall 1992) academic motivation; socioeconomic status; total credit hours completed at the end of the first year; hours per week spent studying; on- or off-campus residence; hours employed per week; and the number of courses taken in social sciences, mathematics, technical/professional, arts and humanities, and natural science and engineering.

Because evidence also suggests that the academic preparation of an institution's student body can influence the climate of an institution (cf., Pascarella & Terenzini, 1991), an estimate of student academic preparation was considered an institutional-level confounding variable. The measure of student academic preparation was estimated with the average precollege (Fall 1992) composite cognitive development score (CAAP reading, math, and critical thinking) for the sample of first-year students at each of the 23 institutions. Each student in the sample was given the mean estimate of academic preparation for her or his institution, and the institutional mean estimate was used in the analysis of end-of-first-year cognitive development and the four areas of self-reported gains. Operational definitions of all variables in the analyses are shown in Table 1.

Insert table 1 about here

Analysis

In the first stage of the data analysis we estimated the net impact of the Cognitive Level of Instruction Scale on the outcome measures while applying statistical controls for the potentially confounding variables specified above. Using an ordinary least squares approach, each of the outcomes was regressed on all the potentially confounding variables and the Cognitive Level of Instruction Scale. Separate analyses were conducted for end-of-first-, second-, and third-year outcomes.

The second stage of the analysis sought to determine if the potential cognitive effects of the Cognitive Level of Instruction Scale were general or conditional. That is, is the cognitive impact of these instructional processes similar in magnitude for all students in the sample (general effects), or does it differ in magnitude for different kinds of students (conditional effects)? To test for the presence of conditional effects, a set of cross-product terms was formed between the Cognitive Level of Instruction Scale on the one hand and the background variables on the other. The cross-product terms were then added to the general effects equations employed in the first stage of the analysis. A significant increase in explained variance (R^2) due to the cross-product terms indicates the presence of significant conditional effects (Pedhazur, 1982).

Useable data were available for 2,189 four-year college students in the analysis of end-of-first-year outcomes; 1,507 four-year college students in the analysis of end-of-second-year outcomes; and 1,017 four-year college students in the analysis of end-of-third-year outcomes. All analyses were conducted with weighted samples, corrected for the unweighted (actual) sample size to obtain correct standard errors. Because of the relatively large unweighted sample sizes, the critical alpha level was set at .01.

Results

End-of-First-Year Outcomes

Table 2 shows the estimated net effects (expressed as Beta coefficients) of the Cognitive Level of Instruction Scale on the three end-of-first-year Gains scales. In the presence of statistical controls for the battery of confounding influences, the Cognitive Level of Instruction Scale had significant effects on all three of the outcome variables. Standardized and unstandardized regression coefficients can be found in Table 2.

Insert table 2 about here

For both the Gains in Writing and Thinking Analytically Scale and the Gains in Understanding Arts and Humanities Scale, the Cognitive Level of Instruction Scale had by far the greatest influence of any of the control variable, as indicated by the standardized coefficient (beta). In each of these cases, the beta associated with the Cognitive Level of Instruction Scale was more than double that of any other significant influences. When the Gains in Understanding Science and Technology Scale was the dependent variable, the Cognitive Level of Instruction Scale was still significant, but its beta was not the highest.

As the table indicates, selected background and control variables also had significant effects on the dependent variables. The significant effects of gender and membership in a minority group influenced the decision to examine the sample for interactive effects (see below); the significance of the Academic Motivation Scale will be described in the Discussion section of the paper.

End-of-Second-Year Outcomes

Second year results are very similar to those of the first year. Again, in the presence of background and control variables, the Cognitive Level of Instruction Scale had significant effects on all three of the outcome variables. Standardized and unstandardized regression coefficients can be found in Table 3.

Insert table 3 about here

As in the first year, the Cognitive Level of Instruction Scale had by far the greatest influence of any of the control variables on both the Gains in Writing and Thinking Analytically Scale and the Gains in Understanding Arts and Humanities Scale, as indicated by the standardized coefficient (beta). And when the Gains in Understanding Science and Technology Scale was the dependent variable, the Cognitive Level of Instruction Scale was still significant, although its beta was not the highest.

In the second year, the influence of number of science courses taken on Gains in Understanding Science and Technology, and the influence of number of arts and humanities courses taken on Gains in Understanding Arts and Humanities are also worth noting.

End-of-Third-Year Outcomes

Third year results exhibit the same pattern as those of the first two years. Again, in the presence of background and control variables, the Cognitive Level of Instruction Scale had significant effects on all three of the outcome variables. Standardized and unstandardized regression coefficients can be found in Table 4.

Insert table 4 about here

Additional Analysis

Conditional Effects

Because we found that gender to be significant in the full model for Gains in Understanding Science and Technology in years 1 and 2, and membership in a minority group to be significant for Gains in Understanding Science and Technology in year 1 and Gains in Understanding Arts and Humanities in years 2 and 3, we decided to test these outcomes for conditional effects. Hence we created a set of cross-product terms between the Cognitive Level of Instruction Scale and the other variables in the model. We then added these terms to the full model to test for interactions.

The addition of the sets of cross-product terms was associated with modest, but statistically significant R^2 increases (less than 2%) in each case. However, none of the variables of interest were significant in this regression, that is, there were no interactive effects. Based on this analysis, there is no reason to believe that the effects of the Cognitive Level of Instruction Scale on the dependent variables differ by gender or by ethnic group. For example, although being a male student is associated with significant Gains in Understanding Science and Technology, the impact of the Cognitive Level of Instruction Scale on that outcome is not significantly different for male and female students.

Summary and Discussion

Previous research has indicated that classroom instructional processes delivered at a reasonably high intellectual level have positive associations with student gains in general cognitive skills. The present longitudinal study of students in 18 four-year institutions examined the extent to which higher-order cognitive instruction, as defined in Bloom's (1956) taxonomy, influenced students' cognitive development during each of the first three years of college. Specifically, we investigated the net effects of these instructional practices, the extent to which the effects varied over time, and the extent to which the effects were general or conditional for this student population. With controls made for an extensive set of confounding influences, including precollege cognitive development, the Cognitive Level of Instruction Scale had significant, and overwhelmingly positive, effects on self-reported measures of student self-reported gains in general cognitive skills in each of the three years of the study. Of special note is the finding that the variable representing instructional practices that stressed higher-order thinking exerted the strongest influence on student gains in writing and analytical thinking in each of the three years. Additional analyses found no conditional effects for the cognitive level of instruction scale, thus indicating that the influence of this scale did not differ by gender or ethnicity for this population.

One interesting finding deals with the significance of an "Academic Motivation" Scale on the self-reported gains scales. This variable was significant in each of the three years and for each of the three outcomes, often with an effect nearly as strong as that of the Cognitive Level of Instruction Scale, as measured by the standardized regression coefficient (beta). We hypothesize that students who are highly motivated to succeed may be more aware of what transpires in the classroom, and of variations in instruction; they also may be better at monitoring their progress and assessing the impact of teaching methods on their learning.

When we talk about the ability to think critically about issues, we are generally referring to the skills and capabilities individuals possess that allow them to perform the following tasks: identify central issues and assumptions in an argument; recognize important relationships; make correct inferences from data; draw conclusions from information or data; interpret whether conclusions are warranted based on give data; and evaluate evidence or authority (Furedy and Furedy, 1985). In the presence of teaching practices designed to elicit higher-order thinking, students in this study consistently reported gains in their ability to perform these intellectual tasks, both in general, and in specific discipline areas (i.e., Art/History/Humanities and Science and Technology). These findings add to our understanding of the factors which foster students' acquisition of these general cognitive skills, and thus have implications for practitioners who seek to assess and improve the quality of American undergraduate education. While much of the interest in assessment has focused on the desired cognitive outcomes of higher education, little attention has been paid to the instructional processes that influence these outcomes (Braxton and Nordvall, 1996). With this study, we have gained insight into specific cognitive aspects of classroom instruction that can influence students' intellectual growth. A dominant myth surrounding the acquisition of higher-level thinking is that these complex skills are a natural by-product of knowledge acquisition. However, as Bloom (1956) has noted, the opposite is actually true - such skills do not develop automatically, but require deliberate instruction. The current research supports the notion that specific types of instruction can impact students' growth; it further suggests that the college classroom and the educational encounters that occur within can not be discounted in the on-going effort to better understand how students change and grow during college.

References

ACT. American College Testing Program. (1989). *Report on the technical characteristics of CAAP: Pilot Year 1: 1988-89.* Iowa City, IA: Author.

Association of American Colleges. (1985). *Integrity in the college curriculum: A report to the academic community.* Washington, DC.: Author.

Astin, A. (1986). Undergraduate achievement and institutional "excellence." *Science*, 161, 661-668.

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

Bloom, B. S. (1956). *Taxonomy of education objectives.* New York: Longman, Greens and Company.

Boyer Commission on Educating Undergraduates in the Research University. *Reinventing Undergraduate Education: A Blueprint for America's Research Universities* (1998). *Stony Brook, New York.:* Author.

Braxton, J. and Nordvall, R. (1985). Selective liberal arts colleges: Higher quality as well as higher prestige? *Journal of Higher Education*, 56, 538-554.

Brown. G. and Adkins, M. (1988). *Effective teaching in higher education.* London: Methuen and Company.

Dressel, P., and Mayhew, L. (1954). *General Education: Explorations in Evaluation.* Westport, CT: Greenwood Press.

Edison, M. I. (1997). Out-of-class activities and the development of critical thinking in college. *Dissertation Abstracts International* 58:763A.

Hagedorn, L. S., Pascarella, E., Edison, M., Braxton, J., Nora, A., and Terenzini, T. (1999). Institutional context and the development of critical thinking: A research note. *The Review of Higher Education* 22(3): 265-285.

Li, G., Long, S., & Simpson, M. (1999). Self-perceived gains in critical thinking and communication skills: Are there disciplinary differences? *Research in Higher Education* 40(1): 42-60.

McKeachie, W., Pintrich, P., Lin, Y., and Smith, D. (1986). *Teaching and learning in the college classroom; A review of the research literature.* Ann Arbor: University of Michigan, National Center for Research to Improve Post-secondary Teaching and Learning.

References (cont.)

McMillan, J. (1987). Enhancing college students' critical thinking: A review of studies. *Research in Higher Education. 26: 3-29.*

Pace, C. R. (1984). *Measuring the quality of college student experiences.* Higher Education Research Institute. Graduate School of Education, University of California, Los Angeles.

Pascarella, E. (1985). College environmental influences on learning and cognitive development: A critical review and syntheses. In J. Smart (Ed.). *Higher Education: Handbook of theory and research,* New York: Agathon, pp. 1-64.

Pascarella, E. (1989). The development of critical thinking: Does college make a difference? *Journal of College Student Development* 30: 19-26.

Pascarella, E. T. and Terenzini, P. T. (1991). *How college affects students.* San Francisco: Jossey-Bass.

Pascarella, E., Bohr, L., Nora, A., and Terenzini, P. (1996). Is differential exposure to college linked to the development of critical thinking? *Research in Higher Education,* 37(2), 159-174.

Pascarella, E., Bohr, L., Nora, A., Zusman, B., Inman, P., and Desler, M. (1993). Cognitive impacts of living on campus versus commuting to college. *Journal of College Student Development,* 34: 216-220.

Pedhazur, E. (1982). Multiple regression in behavioral research: Explanation and prediction. (2nd edition). New York: Holt, Rinehart and Winston.

Study Group on the Condition of Excellence in American Higher Education (1984). *Involvement in learning: Realizing the potential of American higher education.* Washington, DC: U.S. Government Printing Office.

Terenzini, P. T. and Wright, T. M. (1987). Influences on students' academic growth during four years of college. *Research in Higher Education* 26(2): 161-179.

Terenzini, P. T., Pascarella, E. T. and Blimling, G. (1986). Students' out-of-class experiences and their influence on learning and cognitive development: A literature review. *Journal of College Student Development* 37(2): 149-162.

Tsui, L. (1998). A Review of Research on Critical Thinking. Paper presented at the meeting of the Association for the Study of Higher Education, Miami, FL.

Table 1-- Variables

Background Variables

1. Individual precollege (Fall 1992) scores on either the critical thinking module of the CAAP critical thinking score, or on the composite measure combining math, reading comprehension, and critical thinking CAAP scores.

2. Precollege (Fall, 1992) academic motivation: an 8-item, Likert-type scale (5 = strongly agree to 1 = strongly disagree) with an internal consistency reliability of .65. The scale items were developed specifically for the NSSL and were based on existing research about academic motivation (e.g., Ball, 1977). Among the constituent items were the following: "I am willing to work hard in a course to learn the material, even if it won't lead to a higher grade," "When I do well on a test it is usually because I was well prepared, not because the test was easy," "In high school I frequently did more reading in a class than was required simply because it interested me," and "In high school I frequently talked to my teachers outside of class about ideas presented during class."

3. Gender: coded: 1 = female, 0 = male.

4. Ethnicity: coded: 1 = non-white, 0 = white.

5. Age

6. Socio-economic Status: a three item scale comprised of standardized values for "Mother's Education," "Father's Education," and "Family Income" (taken from the pre-college survey).

7. Residence: coded: 1 = lived off campus; 2 = lived on campus

8. Number of credit hours taken: total number of credit hours each student expected to complete during the first year of college (taken from the follow-up questionnaire).

9. Number of hours worked: total number of hours a student worked per week both on- and off-campus (taken from the follow-up questionnaire).

10-14 Number of courses taken in five areas. Respondents were given 61 different courses across the five broad areas to select from, and they were asked to indicate how many of each of the 61 courses they had taken during the year. In the first year, the number of freshman courses was used; in the third year, each variable reflects the sum of freshman, sophomore, and junior year courses. This information was taken from the follow-up questionnaires.

10. Natural sciences (Astronomy, Biology, Botany, Chemistry, Engineering, Geology, Microbiology, Physics, Zoology)

11. Arts and humanities (Art history, Art Appreciation, Studio Art, Dance, Theater, Music Appreciation, Music Performance, Composition or Writing, English Literature, Foreign Language, Humanities, Women's Studies, Latin-American Studies, African-American Studies, Philosophy, Linguistics, Classics, Religious Studies)

Table 1-- Variables (cont.)

12. Social sciences (Anthropology, Audiology/Speech Pathology, Child and Family Studies, Communications, Economics, Geography, History, Political Science, Psychology, Sociology, Social Work)

13. Mathematics (Pre-Algebra, Algebra, calculus, Statistics, Computer Science, Geometry, Matrix Algebra, Accounting, Business Math)

14. Technical or preprofessional (Drawing, Drafting, Architectural Design, Criminology, Education, Study Skills, Reading Skills, Agriculture, Business, Physical Therapy, Pharmacy, Physical Education, Nursing, Computer Programming).

15. Average precollege (Fall 1992) CAAP composite scores for the sample of incoming students at each of the 18 institutions.

16. Number of Hours spent Studying-(total number of hours each week that the student spend studying (taken from the follow-up questionnaire).

Independent Variable

17. Cognitive Processes--a 10-item Likert-type scale (1 = never to 4 = very often) with an internal consistency reliability of .85. Scale items are from the follow-up survey. Questions included: "Instructors engage me in classroom discussion or debate of course ideas and concepts," " Instructors ask challenging questions in class," " Instructors' questions in class ask me to show how a particular course concept could be applied to an actual problem or situation," "Instructors' questions in class ask to argue for or against a particular point of view," "Course exams require me to write essays and/or solve problems," "Course exams require me to compare and contrast dimensions of course content," "Course exams require me to point out the strengths and weaknesses of a particular argument or point of view," "Examinations require me to argue for or against a particular point of view and defend my argument," "Course papers or research projects require me to apply course content to solve an to actual problem," "Course papers or research projects require me to argue for or against a particular point of view and defend my argument."

Dependent Variables

18-20. Gains Scales in three areas: Scale items are from the CSEQ. Students were asked: "In thinking over your experiences in college up to now, to what extent do you feel you have gained or made progress in each of the following respects?"

18. Gains in Understanding Science and Technology--a 4-item Likert-type scale (1 = very little to 4 = very much) with an internal consistency reliability of .86. Specific items included: "Understanding the nature of science and experimentation," "Understanding new scientific and technical developments," "Becoming aware of the consequences (benefits, hazards, dangers, values) of new applications in science and technology," "Quantitative thinking--understanding probabilities, proportions, etc."

19. Gains in Broadening Thinking About Art/History/Humanities---a 5-item Likert-type scale (1 = very little to 4 = very much) with an internal consistency reliability of .76. Specific items included: "Developing an understanding and enjoyment of art, music, and drama," "Broadening your acquaintance and enjoyment of literature," "Becoming aware of different philosophies, cultures, and ways of life," "Seeing the importance of history for understanding the present as well as the past,"

acquaintance and enjoyment of literature," "Becoming aware of different philosophies, cultures, and ways of life," "Seeing the importance of history for understanding the present as well as the past," "Gaining knowledge about other parts of the world and other people--Asia, Africa, South America, etc."

20. Gains in Writing and Thinking Analytically--a 4-item Likert-type scale (1 = very little to 4 = very much) with an internal consistency reliability of .77. Specific items included: "Writing clearly and effectively," "Ability to think analytically and logically," "Ability to put ideas together, to see relationships, similarities, and differences between ideas," "Ability to learn on your own, pursue ideas, and find information you need."

TABLE 2
Regression Analysis Summaries--First Year

PREDICTOR	Perceived Gains in Understanding Science	Perceived Gains in Analytical Skills	Perceived Gains in Understanding Arts
Individual Composite Cognitive Development Scores	-009 (-.028)	.002 (.008)	-.014 (-.054)
Average Precollege Composite Cognitive Development	.023 (.044)	-.018 (-.043)	.036* (.079)
Precollege Academic Motivation	.274* (.191)	.114* (.097)	.144* (.117)
Gender	-.267 (-.175)	.035 (.028)	.021 (.016)
Minority	.097* (-.063)	-.020 (-.016)	.019 (.014)
Age	-.013* (-.084)	-.006 (-.051)	-.027 (-.020)
Number of Credit Hours Taken	.011 (.020)	.013 (.030)	.0009 (.002)
Number of Hours Worked	.0009 (.003)	-.015* (-.067)	.005 (.024)
Number of Courses Taken in the Natural Sciences or Engineering	.183* (.092)	.134 (.083)	.121* (.071)
Number of Courses Taken in the Arts/Humanities	-.136* (-.074)	-.018 (-.012)	.087 (.056)
Number of Courses Taken in the Social Sciences	-.046 (-.025)	-.012 (-.008)	.035 (.0422
Number of Courses Taken in Mathematics	-.122 (-.077)	-.005 (-.004)	-.007* (-.057)
Number of Courses Taken in Technical/Professional	-.030 (-.048)	-.003 (-.006)	.004 (.009)
Campus Residence	-.002 (-.002)	.036 (.029)	.053 (.041)
Socio-economic Status	.004 (.013)	-.001 (-.005)	-.003 (.-.012)
Hours Spent Studying	.053* (.092)	.038* (.082)	.017 (.034)
Cognitive Level of Instruction Scale	.228* (.156)	.415* (.349)	.358* (.286)
R^2	.151	.186	.142

Note: Top number is the metric or unstandardized coefficient; number in parentheses is the standardized (beta) coefficient. * p < .01

TABLE 3
Regression Analysis Summaries--Second Year

PREDICTOR	Perceived Gains in Understanding Science	Perceived Gains in Analytical Skills	Perceived Gains in Understanding Arts
Individual Composite Cognitive Development Scores	-.017 (-.050)	-.007 (-.027)	-.024* (-.089)
Average Precollege Composite Cognitive Development	.015 (.028)	-.019 (-.046)	.029 (.069)
Precollege Academic Motivation	.267* (.171)	.178* (.151)	.144* (.116)
Gender	-.174* (-.106)	.044 (.036)	.029 (.022)
Minority	-.022 (-.013)	-.008 (-.007)	.094* (.070)
Age	-.014* (-.086)	-.013* (-.108)	-.003 (-.025)
Number of Credit Hours Taken	-.007 (-.013)	.008 (.019)	-.028* (-.062)
Number of Hours Worked	.0009 (.030)	.007 (.032)	.013 (.057)
Number of Courses Taken in the Natural Sciences or Engineering	.107 (.443)	.009 (.052)	-.006 (-.033)
Number of Courses Taken in the Arts/Humanities	-.015 (-.088)	.014* (.110)	.029* (.210)
Number of Courses Taken in the Social Sciences	-.0009 (-.042)	.008 (.052)	.008 (.045)
Number of Courses Taken in Mathematics	.015 (.042)	-.003 (-.012)	-.028* (-.103)
Number of Courses Taken in Technical/Professional	-.002 (-.007)	-.009 (-.034)	-.011 (-.038)
Campus Residence	-.038 (-.023)	.044 (.036)	.242* (.186)
Socio-economic Status	.012 (.035)	.0009 (.004)	.0002 (.001)
Hours Spent Studying	.052* (.087)	.055* (.122)	-.011 (-.023)
Cognitive Level of Instruction Scale	.274* (.171)	.401* (.332)	.385* (.302)
R^2	.380	.240	.288

Note: Top number is the metric or unstandardized coefficient; number in parentheses is the standardized (beta) coefficient * $p < .01$

TABLE 4

Regression Analysis Summaries--Third Year

PREDICTOR	Perceived Gains in Understanding Science	Perceived Gains in Analytical Skills	Perceived Gains in Understanding Arts
Individual Composite Cognitive Development Scores	-.005 (-.014)	.033* (.118)	-.011 (-.039)
Average Precollege Composite Cognitive Development	.031 (.054)	-.005 (-.011)	.035 (.079)
Precollege Academic Motivation	.345* (.213)	.161* (.132)	.228* (.182)
Gender	-.018 (-.011)	.074 (.058)	-.024 (-.018)
Minority	-.119 (-.069)	.084 (.065)	.116* (.087)
Age	-.017 (-.104)	-.005 (-.046)	.002 (.013)
Number of Credit Hours Taken	.029 (.048)	.083 (.177)	-.011 (-.022)
Number of Hours Worked	.012 (.039)	.007 (.031)	.012 (.049)
Number of Courses Taken in the Natural Sciences or Engineering	.060* (.415)	-.004 (-.003)	-.003 (-.023)
Number of Courses Taken in the Arts/Humanities	-.016* (-.119)	.004 (.046)	.026* (.266)
Number of Courses Taken in the Social Sciences	-.011 (-.069)	-.002 (-.014)	.008 (.071)
Number of Courses Taken in Mathematics	.012 (.054)	.006 (.038)	-.014* (-.079)
Number of Courses Taken in Technical/Professional	.002 (.007)	-.004 (-.025)	-.008 (-.045)
Campus Residence	.026 (.016)	.114* (.091)	.053 (.041)
Socio-economic Status	-.022 (-.061)	-.007 (-.027_	.005 (.018)
Hours Spent Studying	.030 (.048)	.083* (.177)	.026 (.054)
Cognitive Level of Instruction Scale	.286* (.174)	.461* (.370)	.382* (.299)
R^2	.309	.285	.402

Note: Top number is the metric or unstandardized coefficient; number in parentheses is the standardized (beta) coefficient * $p < .01$