**Deep Learning and College Outcomes:
Do Fields of Study Differ?**

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Abstract

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Students have more learning potential than traditional pedagogical methods often tap. To more fully develop student talents, many campuses are shifting from a passive, instructor-dominated pedagogy to active, learner-centered activities. This study uses data from the National Survey of Student Engagement to assess a proxy for deep learning and to examine the relationships between deep learning and selected educational outcomes. The results indicate that students who engage more frequently in deep learning behaviors report greater educational gains, higher grades, and are more satisfied with college. However, these patterns vary by disciplinary area.

Deep Learning and College Outcomes: Do Fields of Study Differ?

Students have more learning potential than traditional pedagogical methods often tap. With this in mind, colleges and universities are devoting significant effort to redesigning teaching and learning environments. Findings from the National Survey of Student Engagement (2000, 2001, 2002, 2003, 2004) suggest that these efforts are paying off in that the vast majority of students at least "sometimes" engage in various forms of active and collaborative learning activities during a given academic year. This shift from passive, instructor-dominated pedagogy to active, learner-centered activities promises to take students to deeper levels of understanding and meaning as they apply what they are learning to real life examples in the company of others (Lave & Wegner, 1991, Tagg, 2003).

Students take different approaches to learning, with the outcomes of learning closely associated with the chosen approaches (Ramsden, 2003). The phrase "deep learning" is attributed to Marton and Säljö (1976) who discerned qualitative distinctions in the ways students responded to various learning tasks that were linked to certain approaches to processing information. Students using "surface-level processing" focus on the substance of information and emphasize rote learning and memorization techniques (Biggs, 1989; Tagg, 2003).   The goal of studying for a test or exam is to avoid failure, instead of grasping key concepts and understanding their relation to other information and how the information applies in other circumstances (Bowden & Marton, 1998).

In contrast, students using "deep-level processing" focused not only on substance but also the underlying meaning of the information. Scholars (Biggs, 1987, 2003; Entwistle, 1981; Ramsden, 2003; Tagg, 2003) generally agree that deep learning is represented by a personal commitment to understand the material which is reflected in using various strategies such as

reading widely, combining a variety of resources, discussion ideas with others, reflecting on how individual pieces of information relate to larger constructs or patterns, and applying knowledge in real world situations (Biggs, 1989). Also characteristic of deep learning is integrating and synthesizing information with prior learning in ways that become part of one's thinking and approaching new phenomena and efforts to see things from different perspectives (Ramsden, 2003; Tagg, 2003). As Tagg (2003, p. 70) put it, "Deep learning is learning that takes root in our apparatus of understanding, in the embedded meanings that define us and that we use to define the world."

The reason deep learning is important is because students who use such an approach tend to earn higher grades, and retain, integrate and transfer information at higher rates (Biggs 1988, 1989; Entwistle & Ramsden, 1983; Prosser & Millar, 1989; Ramsden, 2003; Van Rossum & Schenk, 1984; Whelan, 1988). Additionally, deep learning is associated with an enjoyable learning experience while the surface approach tends to be less satisfying (Tagg, 2003).

Surface and deep approaches to learning are not unalterable behaviors, though they may be influenced by personal characteristics such as ability (Biggs, 1987). But using one or the other approach is also affected in part by the learning task itself and the conditions under which the task is performed (Biggs, 1987; Ramsden, 2003). Thus, students may use both surface and deep approaches at different points in their studies. Although students may adopt different approaches in different situations, the general tendency is to adopt a particular approach and stick with it (Biggs, 1987; Entwistle, 1981; Ramsden, 2003).

In addition, the learning context seems to have a substantial effect on how students approach learning tasks (Beatie, Collins, & McInnes, 1997; Biggs, 1978; Biggs & Moore, 1993; Eley 1992; Gow, Kember & Cooper, 1994; Ramsden 2003; Tagg, 2003; Zeegers, 2001). That is,

the interaction between a student and the course structure, curriculum content, and methods of teaching and assessment shape whether a student will gravitate toward a surface or deep approach (Biggs, 1989; Entwistle & Ramsden, 1983).

If the teaching context influences the chosen learning approach, it is possible that the learning approaches students use vary in systematic ways between fields of study as does the content of these fields (National Research Council, 1999; Zeegers, 2001). That is, because academic tasks differ from one discipline to another, perhaps the patterns of learning approaches students use will vary in similar ways (Ramsden, 2003).

For example, accounting students are more likely to use surface learning approaches compared with other students (Booth, Luckett, & Mladenovic, 1999; Eley, 1992, Gow, Kember & Cooper, 1994). Until recently, surface learning tended to dominate in engineering (Myer, Parsons & Dunne, 1990), as Felder and Brent (2005, p. 57) noted: "A single approach has dominated engineering education since its inception: the professor lectures and the students attempt to absorb the lecture content and reproduce it in examinations. That particular size fits almost nobody: it violates virtually every principle of effective instruction established by modern cognitive science and educational psychology." Other studies examined deep learning in chemistry (Zeegers & Martin, 2001), geography (Hill & Woodland, 2002), health sciences (Newble & Clarke, 1985), and physics (Prosser & Millar, 1989).

Measuring Deep Learning

The two most widely used assessments of deep learning are Bigg's Study Process Questionnaire (SPQ) and Entwistle and Ramsden's Approaches to Study Inventory (ASI) (Biggs, 1987, Ramsden & Entwistle, 1981, Entwistle & Ramsden, 1983). Both inventories were designed for use in higher education (Entwistle & McCune, 2004) and have been revised in

recent years to update wording, reduce items, and incorporate new research on learning (Biggs, Kember & Leung, 2001; Gibbs, Habeshaw, & Habeshaw, 1989; Entwistle & Tait, 1994). The SPQ consists of 42 items, with three "main approach" scales (deep, surface, and achieving) and six sub-scales that divide the core scales into motives and strategies. SPQ scores are indicators of the preferred, ongoing, and contextual approaches to learning (Biggs, Kember & Leung, 2001). SPQ items address higher-order learning (e.g., "While I am studying, I often think of real life situations to which the material that I am learning would be useful"), integration (e.g., "I try to relate what I have learned in one subject to that in another") and reflection (e.g., "In reading new material I often find that I'm continually reminded of material I already know and see the latter in a new light"). Similar to the SPQ in design, the ASI contains 64 items and 16 subscales that contribute to three main factors: reproducing orientation, meaning orientation, and achieving orientation (Entwistle & McCune, 2004).

Purpose of the Study

The purpose of this study is twofold. First, we examine how the amount students engage in a deep approach to learning varies by disciplinary area. To what extent do college students engage in deep learning behaviors? Does the preference for deep learning approaches vary systematically by field of study? Because most students report participating in active and collaborative learning activities, it is likely that we will find many students engaging in deep learning. At the same time, deep learning practices will likely vary across major fields, as suggested by previous research.

The second purpose of the study is to examine whether deep learning approaches are linked with student self-reported gains in personal and intellectual development, satisfaction with

college, and self-reported grades. We are also interested in whether the patterns of the

relationships between deep learning and student outcomes vary by disciplinary area.

Methods

Data Source

The data for this study come from the 2004 administration of the National Survey of

Student Engagement (NSSE), an annual survey of college students at four-year institutions that

measures students' participation in educational experiences that prior research has connected to

valued outcomes (Chickering & Gamson, 1987; Kuh, 2001, 2003; Pascarella & Terenzini, 2005).

About 500,000 first-year students and seniors were randomly selected from files provided by the

473 participating colleges and universities. The standard NSSE sampling scheme draws equal

numbers of first-year and senior students, with the size determined by the number of

undergraduate students enrolled at the institution. Students at about two-fifths (42%) of the

institutions had the option of responding either via a traditional paper questionnaire or online.

Slightly fewer of the colleges and universities (37%) opted to administer only online, where

students received an introduction letter through the mail and all further contact was online. The

remaining institutions opted to administer primarily online with a paper survey being sent to non-

responders.

Sample

The sample for this study, after deletion for missing data, consists of 51,233 seniors from

439 four-year colleges and universities across the country. Given our focus on disciplinary area,

seniors were selected because they have the most experience in their chosen fields. Of the seniors

in the sample, 16% were in the arts and humanities, 7% were in a biological science, 18% were

in business, 10% were in education, 6% were in engineering, 4% were in a physical science

(including mathematics), 6% were in a professional field such as architecture, urban planning or nursing, 15% were in a social science, and the remaining 18% were in other fields such as public administration, kinesiology, and criminal justice.

Out of the total number of respondents, approximately 62% were female, 81% were white (5% African American, 5% Asian, 3% Hispanic, 1% Native American, < 1% other racial/ethnic background, and 5% multi-racial or ethnic), and 31% were first generation college students. In addition, 33% transferred from another institution, 51% lived on or near campus, about 14% were members of a social fraternity or sorority, and 89% are full-time students.

All of the students in this study completed the online version of the NSSE survey, since the experimental items, including the reflective learning items, are only administered online. Online completers differ in some ways from those students who fill out the paper survey. For example, a larger percentage of women and students of certain racial/ethnic groups (African American, Latino/a, and American Indian) fill out the paper version of the survey. Also, paper completers are more likely to be older, part-time, live off campus, have parents with less formal education, and have transferred from a different institution. However, after controlling for these differences, online and paper completers do not appear to engage in effective educational practices at appreciably different levels (Carini, Hayek, Kuh, Kennedy, & Ouimet, 2003).

Response rates at the participating institutions ranged from 9% to 89% with an average institutional response rate for NSSE 2004 of 40%. Although response rates varied by institution, the average for paper schools (institutions where students had the option of completing either the paper or the Web version of the survey) was nearly identical to that of Web-only schools (institutions where students only had the option of completing the survey online), about 40% and

41%, respectively. In 2004, about 22% of the respondents completed the paper version of the survey and approximately 78% completed it using the Web.

Measures

The survey itself, *The College Student Report*, focuses on student participation in effective educational practices. For example, students are asked to identify how often they make class presentations, participate in a community-based project as a part of a course, and work with faculty members on activities other than coursework. In addition, students identify the degree to which their courses emphasize different mental processes (e.g., memorizing, evaluating, synthesizing), how many hours per week they spend studying, working, or participating in co-curricular activities, as well as how they would characterize their relationships with people on campus. The survey is available at the NSSE website, www.iub.edu/~nsse.

Each year, NSSE tests new survey items. In 2004, based on growing interest in deep learning, a set of items about reflective learning were included at the end of the online NSSE survey to augment core survey questions about higher order learning and integrative learning.

Taken together, the items in Table 1 are reliable proxy measures of student participation in activities that represent a deep approach to learning ($\alpha = 0.89$). These behaviors are divided into three sub-scales—higher order learning, integrative learning, and reflective learning—that reflect areas tapped by other measures of deep learning (Biggs, 1987, Ramsden & Entwistle, 1981, Entwistle & Ramsden, 1983). The higher order learning subscale ($\alpha = 0.82$) focuses on the amount students believe that their courses emphasize advanced thinking skills such as analyzing the basic elements of an idea, experience, or theory and synthesizing ideas, information, or experiences into new, more complex interpretations. The integrative learning subscale ($\alpha = 0.71$) contains items that center around the amount students participate in activities that require

integrating ideas from various sources, including diverse perspectives in their academic work, and discussing ideas with others outside of class.

The reflective learning sub-scale ($\alpha = 0.89$) was developed for the 2004 administration of NSSE to complement the higher order and reflective learning items that have been on the core survey for several years. Central to the reflective learning behaviors is the notion that students can learn and expand their understanding by investigating their own thinking and then applying their new knowledge to their lives. The items ask, for example, how often students examined the strengths and weaknesses of their own views, learned something that changed their understanding, and applied what they learned in a course to their personal life of work.

The three outcome measures are (Appendix B):

(1) student gains in personal and intellectual development, a 16-item scale ($\alpha = 0.91$) that measures how much students believe they have gained in areas such as acquiring a broad general education, writing clearly and effectively, thinking critically and analytically, learning effectively on their own, understanding themselves, and solving complex real-world problems.

(2) Grades, a single self-reported item that ranges from C- or lower to A. Self-reported grades correlate well (.8 or so) with actual grades (Olsen et al., 1998).

(3) Satisfaction, a two-item measure of students' satisfaction with their collegiate experience ($\alpha = 0.79$) represented by students' rating of their entire educational experience at an institution and the likelihood that they would attend the same institution if they were to start over again.

Control variables include student characteristics such as gender, race, and first generation college student status (Appendix A).

Data Analyses

For our analyses, we divide students into nine disciplinary areas based on the primary major they indicated on the survey: arts and humanities, biological sciences, business, education, engineering, physical sciences, professional, social sciences, and other. The first eight categories reflect groups of fields and disciplines common on college campuses. The "other" category contains those fields or disciplines that were not easily categorized, such as family studies, criminal justice, and military science.

To examine disciplinary differences in the amount students engage in a deep approach to learning, we conducted three analyses. First, the means for each group are calculated and a mean difference is computed between each disciplinary area and the biological sciences. Biology was selected as the comparison group because the mean of biology students across the four deep learning scales (the total scale, higher order learning, integrative learning, and reflective learning) was consistently middling. Consequently, we could test to see whether students in other areas scored significantly above or below this middle group.

To test the significance of differences between disciplinary areas and to gauge how meaningful the differences were, we calculated effect sizes for the mean difference both with and without the addition of control variables such as gender, race, and full-time/part-time status (see Appendix A for all control variables used). To calculate the effect sizes, regression analyses were run, first without controls and then with controls, on each deep learning scale. In the regression models, all non-dichotomous variables were standardized prior to entry. As a result, in each model, the unstandardized coefficient is an estimate of the effect size.

The relationships between the deep learning scales and the three student outcomes (see Appendix B) are explored using partial correlations that control for the same variables used in

the regression analyses. Partial correlations were computed for each of the nine disciplinary

groupings to determine if the strength of the relationships varied by discipline.

Results

Tables 2 through 5 contain the results of the mean comparisons for the deep learning scale

and its subscales by disciplinary area. In each table, disciplinary groupings are listed in rank

order according to their mean on the corresponding deep learning scale. The results suggest that,

on average, seniors "frequently" (often or very often) engage in deep approaches to learning as

the means for all seniors range from 2.80 to 3.15 where 1 is either "never" or "very little" and 4

is either "very often" or "very much".

Deep learning varies across disciplines. The difference of the means for the lowest scoring

group and the highest scoring group is about two-thirds of a standard deviation for each scale.

While these are appreciable differences, they are not so large so as to indicate that some fields

are essentially void of such activities. In fact, many seniors in every area use deep learning

approaches at least some of the time.

For the deep learning scale (Table 2), seniors in the social sciences have the highest

average score even after controlling for student characteristics (effect size with controls = 0.26, p

< 0.001), Carnegie classification, and institutional control (public or private). Not far behind are

seniors from the arts and humanities (effect size with controls = 0.23, p < 0.001) and seniors

from professional fields (effect size with controls = 0.18, p < 0.001). The effect size calculations

suggest that seniors in these disciplinary areas score moderately higher than seniors in biology

(the reference group), a group that ranks in the middle of the nine disciplinary areas.

Senior averages in the physical sciences (effect size with controls = -0.11, p < 0.001),

business (effect size with controls = -0.07, p < 0.001), other fields (effect size with controls = -

0.08, p < 0.001), and engineering (effect size with controls = -0.13, p < 0.001) are significantly

lower on the deep learning scale than seniors in biology. After the addition of controls, the effect

sizes are generally small suggesting that some of the differences between biology and these

disciplinary areas may be due to differences in the characteristics of students who choose to

major in these areas.

Figure 1 plots the effect sizes (after controls have been introduced) for the deep learning

scale and each of its subscales. Only eight groupings are shown because all of the effect sizes

are relative to biology. The pattern of effects is quite similar for the deep learning scale, the

integrative learning scale, and the reflective learning scale. Seniors in the social sciences, arts

and humanities, professional fields, and education score above biology while seniors in business,

other fields, physical sciences, and engineering score below.

However, the pattern of effects for higher-order learning stands out as different. For this

scale, seniors in professional fields (effect size with controls = 0.34, p < 0.001) and engineering

(effect size with controls = 0.20, p < 0.001), on average, score the highest after controls are

introduced. For engineering this is dramatically different from their low scores on the other

scales. Like seniors in engineering, seniors in the physical sciences have a higher relative score

on higher-order learning than on the other scales. However, the difference in effect for the

physical sciences is less dramatic.

Additionally, the pattern of effects for higher-order learning seems to separate the

disciplinary areas into two groups: a higher scoring group (professional, social science, and

engineering) and a lower scoring group (physical science, arts and humanities, biology,

education, business, and other). For the other scales, the effects seemed to separate the

disciplinary areas into three groups (high, middle, and low). This may, in part, result from the

averages across disciplinary areas being relatively high on this subscale (means range from 3.05 to 3.35) compared to the others (means on the other subscales range from 2.60 to 3.13).

Table 6 contains partial correlations between the deep learning scales and three student outcome variables (gains in personal and intellectual development, grades, and satisfaction) calculated within each of the disciplinary areas. We were primarily interested in determining if the relationships between deep approaches to learning and student outcomes were consistent with scores on the deep learning scales. If this were the case, one could argue that students are less likely to use deep approaches to learning in certain areas because of the nature of the field of study and may not have a dampening influence on desired educational outcomes. We did not, however, find such a pattern.

Overall, we found that deep approaches to learning are positively related to our educational outcomes and that the relationship is strongest for gains in personal and intellectual development, moderate in strength for satisfaction, and relatively week for grades. In addition, there appears to be no relationship between students' average score on a deep learning scale within a disciplinary area and the relative strength of the relationship between deep learning and the outcomes within that area.

For gains in personal and intellectual development, the partial correlations suggest that there is a strong connection between using deep approaches to learning more frequently and reporting higher scores on this outcome (partial correlations range from 0.58 to 0.63 for the deep learning scale). The relationships between students' grades and the deep learning scales are relatively weak (partial correlations range from 0.09 to 0.20 for the deep learning scale). In fact, for the physical sciences and professional fields, the relationship was indistinguishable from zero for higher-order learning. Satisfaction appears to be moderately related to deep approaches to

learning (partial correlations range from 0.28 to 0.37 for the deep learning scale). For each of the outcomes, the strength of the relationships differed little by disciplinary area for all four deep learning scales.

Limitations

The primary limitations of this study pertain to the sample of students used in the study and to the disciplinary groupings created for the analyses. Only students who completed the NSSE 2004 survey online were given the reflective learning items. This led us to limit our sample to web completers only. However, the odds of being a web completer vary by disciplinary area. For example, 89% of engineering seniors completed the survey online while only 63% of seniors majoring in professional fields did so. These differences have the potential to introduce bias into our estimates of the differences between disciplinary areas on the deep learning scale and its sub-scales. However, for the higher-order and integrative learning subscales, we found that only very small differences existed between web and paper completers and that, in most cases, the differences that exist would not change or would accentuate the results we report.

The disciplinary categories we use are those used by NSSE in reporting results to participating institutions. The goal is to represent common groupings found on college campuses at the school and college-level or, in the case of colleges of liberal arts, major sub-groupings (e.g., social science). Although these groupings are useful, they are neither theoretically nor empirically derived. As a result, perhaps some differences or similarities related to discipline were masked within these categories. For example, music seniors have deep learning scores closer to seniors in the biological sciences than to seniors in philosophy, another arts and

humanities field. However, our analyses suggest it is much more frequently the case that averages within disciplinary groupings are similar.

In addition, institutions choose to participate in NSSE and then students are randomly selected from the student populations at those institutions. Although NSSE institutions mirror all four-year institutions on most institutional characteristics (National Survey of Student Engagement, 2004), the fact that college and universities volunteer to participate requires that some caution be used when generalizing the results to students at other four-year institutions.

Discussion and Implications

Across disciplines, seniors are using deep approaches to learning, at least some of the time, and use of these approaches is related to self-reports of personal and intellectual gains during college. This finding confirms something we already know—if we structure students' educational experiences to induce them to invest more energy in taking responsibility for their learning and reflecting on what they are learning, students benefit more from the college experience (Pascarella & Terenzini, 2005).

In addition, seniors who use deep approaches to learning are more satisfied with their collegiate experience, which is in line with the notion that deep learning is more personally rewarding than surface learning (Tagg, 2003). Admittedly, satisfaction is affected by many aspects of college life. Nonetheless, this finding suggests that, at least in part, student satisfaction is based on intellectual experiences that are rigorous in nature and not routine or easy. In other words, student satisfaction is not all about their social life and academic work that is easy to master.

Interestingly, only a weak relationship exists between grades and student uses of deep approaches to learning. Should this relationship be stronger? If we believe that grades should

reflect the type of learning students are participating in, then yes. What can be done to make grades better indicators of deep learning? One place to start is to make sure that the activities and assignments upon which we base students' grades require students to employ higher-order, reflective, and integrative thinking skills.

To some degree, the findings from this study corroborate previous research showing that students majoring in engineering and the physical sciences use deep approaches to learning less frequently than students from other fields (Myer, Parsons & Dunne, 1990; Felder & Brent, 2005; Zeegers & Martin, 2001; Prosser & Millar, 1989). However, there are also aspects of deep learning on which students in these fields perform relatively well, suggesting that any field holds the promise for deep learning. By looking at different aspects of deep learning, each disciplinary area can identify places for improvement. So, for engineering and physical science, increased emphasis on activities that require reflective and integrative learning could yield improvement in student outcomes while in the arts and humanities a greater emphasis on higher-order learning could produce educational improvement.

Conclusion

Are all college students learning as deeply as we would hope? Probably, not. However, the results of this study suggest that many students are engaged in deep approaches to learning and that such engagement is associated with higher levels of personal and intellectual development as well as general satisfaction with college. Overall, it appears that most college and university seniors are being exposed to and benefiting from pedagogies that encourage deep learning.

Are there ways to improve? Absolutely. By examining the patterns of deep learning behaviors by disciplinary area, we found that no disciplines score at the top in all aspects of deep learning and there are none always at the bottom. Consequently, there are aspects of deep

learning upon which each disciplinary area can improve. In addition, the relatively high scores

across disciplines suggest that there are probably good examples of how to improve both within

one's discipline as well as in other disciplinary areas.

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Appendix A
Control Variables

Name	Description
Major[a]	Arts and Humanities, Biology, Business, Education, Engineering, Physical Science, Professional, Social Science, Other
Gender	0 = Male; 1 = Female
Age	0 = 24 or over, 1 = 23 or younger
Ethnicity[b]	African American, American Indian, Asian American, White, Hispanic, Other, Multiple Ethnic Identifications
Parent's Education Level	0 = Either father or mother completed at least an associate's degree, 1 = Neither father nor mother complete an associate's degree or higher
International Status	0 = US National, 1 = International student or foreign national
Transfer Status	0 = Did not transfer; 1 = Tranfered
Enrollment Status	0 = Part-time; 1 = Full-time
Live on campus	0 = Live off campus; 1 = Live on or near campus
Fraternity or Sorority Membership	0 = Non-member; 1 = Member of a social fraternity or sorority
Student Athlete	0 = Non-athlete; 1 = Student athlete on a team sponsored by the institution's athletic department
Carnegie Classification[c]	Doctoral - Extensive, Doctoral - Intensive, Master's Colleges and Universities I & II, Baccalaureate - Liberal Arts, Baccalaureate - General, Other classification
Institutional control	0 =Public; 1 = Private

[a] Coded dichotomously (0 = not in group, 1 = in group), Biology was the reference group

[b] Coded dichotomously (0 = not in group, 1 = in group), White was the reference group

[c] Coded dichotomously (0 = not in group, 1 = in group), Baccalaureate - Liberal Arts was the reference group

Appendix B
Outcomes Scales and Component Items

Gains in Personal and Intellectual Development (16 items; α = .91)

Developing a personal code of values and ethics

Contributing to the welfare of your community

Developing a deepened sense of spirituality

Understanding yourself

Understanding people of other racial and ethnic backgrounds

Solving complex real-world problems

Voting in local, state, or national elections

Learning effectively on your own

Working effectively with others

Writing clearly and effectively

Speaking clearly and effectively

Thinking critically and analytically

Acquiring a broad general education

Acquiring job or work-related knowledge and skills

Analyzing quantitative problems

Using computing and information technology

Grades

What have most of your grades been up to now at this institution?[a]

Satisfaction (2 items; α = .79)

How would you evaluate your entire educational experience at this institution?[b]

If you could start over again, would you go to the *same institution* you are now attending?[c]

Note: Except where noted, variables were measured on a 4-point scale (1=Very Little, 2=Some, 3=Quite a Bit, 4=Very Much)
[a] Responses for this item were 1=C- or lower, 2=C, 3=C+, 4=B-, 5=B, 6=B+, 7=A-, 8=A
[b] Responses for this item were 1=Poor, 2=Fair, 3=Good, 4=Excellent
[c] Responses for this item were 1=Definitely No, 2=Probably No, 3=Probably Yes, 4=Definitely Yes

Table 1.
Deep Learning Scale, Subscales, and Component Items

Deep Learning (15-item scale; α = .89)

    Scale consists of all 15 items listed below

Higher-Order Learning[a] (α = .82)

    Analyzed the basic elements of an idea, experience, or theory, such as examining a particular case or situation in depth and considering its components?
    Synthesized and organized ideas, information, or experiences into new, more complex interpretations and relationships?
    Made judgments about the value of information, arguments, or methods, such as examining how others gathered and interpreted data and assessing the soundness of their conclusions?
    Applied theories or concepts to practical problems or in new situations?

Integrative Learning (α = .71)

    Worked on a paper or project that required integrating ideas or information from various sources?
    Included diverse perspectives (different races, religions, genders, political beliefs, etc.) in class discussions or writing assignments?
    Put together ideas or concepts from different courses when completing assignments or during class discussions?
    Discussed ideas from your readings or classes with faculty members outside of class?
    Discussed ideas from your readings or classes with others outside of class (students, family members, co-workers, etc.)?

Reflective Learning[b] (α = .89)

    Learned something from discussing questions that have no clear answers?
    Examined the strengths and weaknesses of your own views on a topic or issue?
    Tried to better understand someone else's views by imagining how an issue looks from his or her perspective?
    Learned something that changed the way you understand an issue or concept?
    Applied what you learned in a course to your personal life or work?
    Enjoyed completing a task that required a lot of thinking and mental effort?

Note: Except where noted, variables were measured on a 4-point scale (1=Never, 2=Sometimes, 3=Often, 4=Very Often)
[a] Responses for this item were 1=Very little, 2=Some, 3=Quite a bit, 4=Very much
[b] These were experimental items on the 2004 survey.

Table 2.
Deep Learning Differences by Discipline

	N	Mean	SD	Mean Difference From Biology	Effect Size w/o Controls	Effect Size with Controls
Social Science	7837	3.09	0.51	0.14	0.27 ***	0.26 ***
Arts and Humanities	8054	3.07	0.54	0.12	0.23 ***	0.23 ***
Professional	3041	3.01	0.49	0.06	0.11 ***	0.18 ***
Education	5223	2.96	0.52	0.01	0.02	0.08 **
Biology	3480	2.95	0.51		*reference group*	
Physical Science	1921	2.88	0.52	-0.07	-0.13 ***	-0.11 **
Business	9406	2.88	0.51	-0.07	-0.14 ***	-0.07 ***
Other	9029	2.86	0.53	-0.09	-0.17 ***	-0.08 ***
Engineering	3242	2.79	0.49	-0.16	-0.30 ***	-0.13 ***
Total	51233	2.95	0.53			

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

Table 3.
Higher-Order Learning Differences by Discipline

	N	Mean	SD	Mean Difference From Biology	Effect Size w/o Controls	Effect Size with Controls
Professional	3041	3.35	0.62	0.19	0.29 ***	0.34 ***
Social Science	7837	3.22	0.64	0.06	0.09 ***	0.08 ***
Engineering	3242	3.20	0.62	0.04	0.06 **	0.20 ***
Physical Science	1921	3.19	0.63	0.03	0.04	0.06 *
Arts and Humanities	8054	3.16	0.67	0.00	0.00	0.01
Biology	3480	3.16	0.63		*reference group*	
Education	5223	3.14	0.65	-0.02	-0.04	0.01
Business	9406	3.11	0.64	-0.05	-0.07 ***	-0.03
Other	9029	3.05	0.66	-0.11	-0.17 ***	-0.09 ***
Total	51233	3.15	0.65			

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

Table 4.
Integrative Learning Differences by Discipline

	N	Mean	SD	Mean Difference From Biology	Effect Size w/o Controls	Effect Size with Controls
Social Science	7837	2.95	0.56	0.16	0.29 ***	0.27 ***
Arts and Humanities	8054	2.94	0.58	0.16	0.27 ***	0.27 ***
Professional	3041	2.83	0.55	0.05	0.09 ***	0.14 ***
Education	5223	2.83	0.56	0.04	0.08 ***	0.12 ***
Biology	3480	2.78	0.56		*reference group*	
Business	9406	2.73	0.55	-0.06	-0.10 ***	-0.05 **
Other	9029	2.71	0.57	-0.07	-0.12 ***	-0.05 **
Physical Science	1921	2.67	0.59	-0.11	-0.20 ***	-0.18 ***
Engineering	3242	2.60	0.55	-0.18	-0.32 ***	-0.17 ***
Total	51233	2.80	0.57			

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

Table 5.
Reflective Learning Differences by Discipline

	N	Mean	SD	Mean Difference From Biology	Effect Size w/o Controls	Effect Size with Controls
Social Science	7837	3.13	0.64	0.18	0.26 ***	0.26 ***
Arts and Humanities	8054	3.12	0.67	0.16	0.25 ***	0.25 ***
Biology	3480	2.95	0.65		*reference group*	
Education	5223	2.95	0.66	0.00	0.00	0.06 *
Professional	3041	2.93	0.64	-0.02	-0.04	0.03
Other	9029	2.86	0.67	-0.09	-0.14 ***	-0.05 **
Business	9406	2.85	0.64	-0.10	-0.15 ***	-0.09 ***
Physical Science	1921	2.85	0.66	-0.10	-0.15 ***	-0.13 ***
Engineering	3242	2.68	0.64	-0.27	-0.40 ***	-0.26 ***
Total	51233	2.95	0.67			

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

Table 6.
Partial Correlations between Deep Learning Scales and Educational Outcomes

Scales	Deep Learning	Higher-Order Learning	Integrative Learning	Reflective Learning
Gains in Personal and Intellectual Development				
Arts and Humanities	0.59	0.47	0.46	0.55
Biology	0.60	0.45	0.45	0.55
Business	0.63	0.48	0.49	0.57
Education	0.59	0.45	0.45	0.55
Engineering	0.59	0.45	0.44	0.52
Physical Science	0.61	0.45	0.44	0.58
Professional	0.58	0.43	0.45	0.52
Social Science	0.60	0.47	0.46	0.56
Other	0.62	0.49	0.48	0.55
Grades				
Arts and Humanities	0.18	0.11	0.18	0.17
Biology	0.18	0.07	0.17	0.17
Business	0.14	0.08	0.13	0.14
Education	0.13	0.08	0.12	0.12
Engineering	0.09	0.05	0.08	0.08
Physical Science	0.12	0.04*	0.11	0.12
Professional	0.11	0.02*	0.12	0.11
Social Science	0.20	0.11	0.19	0.18
Other	0.13	0.09	0.12	0.12
Satisfaction				
Arts and Humanities	0.35	0.27	0.28	0.33
Biology	0.34	0.23	0.26	0.32
Business	0.36	0.27	0.26	0.34
Education	0.34	0.25	0.26	0.32
Engineering	0.34	0.25	0.25	0.31
Physical Science	0.34	0.24	0.23	0.33
Professional	0.28	0.17	0.23	0.26
Social Science	0.37	0.28	0.28	0.34
Other	0.37	0.29	0.27	0.34

Note: Partial correlations calculated controlling for gender, race, age, parents' education, transfer status, living on campus, international student status, social fraternity/sorority membership, participation in athletics, full-time/part-time status, Carnegie classification, and institutional control (public or private).

*Not significant, all other correlations significant at p<.01

Figure Caption

Figure 1. Disciplinary Effect Sizes With Controls