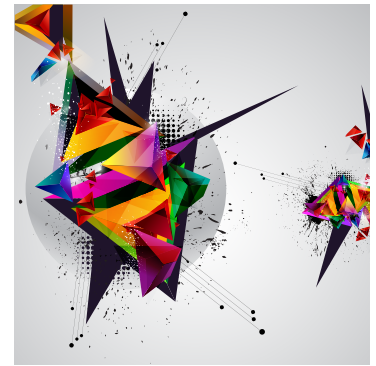


## Abstract

Students at many higher education institutions are expected to acquire effective written communication skills and strong critical thinking skills. Although these student learning outcomes are common, these skills are complex. Assessing students' attainment of these outcomes at an institutional level can be difficult as many approaches to measuring student learning have inherent flaws or biases. This study uses direct and indirect measures of student learning to triangulate freshmen and seniors' attainment of written communication and critical thinking outcomes. The data collected through these complementary methods allowed institutional stakeholders to examine student learning through different lenses and to create a detailed and nuanced portrait of student learning within the institution.



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# Holistically Assessing Critical Thinking and Written Communication Learning Outcomes with Direct and Indirect Measures

The ability to think critically and to write clearly are highly desirable skills in the workplace (Association of American Colleges & Universities (AAC&U), 2013). Higher education institutions also value these two domains, with 84% of institutions affiliated with the AAC&U reporting these skills are important outcomes for their undergraduates (AAC&U, 2016). However, in spite of this national recognition that critical thinking and effective written communication are important student learning outcomes, considerable diversity exists among higher education institutions in how students' attainment of these outcomes are assessed (e.g., Condon & Kelly-Riley, 2004; Douglass, Thomson & Zhao, 2012; Ennis, 1993; Haswell, 2000; Lui, 2011; Mazer, Hunt, & Kuznekoff, 2007; Moore, O'Neill, & Huot, 2009; Peach, Mukherjee, & Hornyak, 2007).

Differing cultures, needs, and student populations, along with the complexity of these higher-order skills, contribute to the lack of consensus about how to best assess critical thinking and written communication in higher education settings. For instance, some schools of thought have stressed the interconnection and positive relationship between students' writing skills and their critical thinking capabilities (e.g., National Center for Education Statistics, 1993, 1994, 1995), whereas other research points to the independence of these constructs (e.g., Condon & Kelly-Riley, 2004; Haswell, 1991). The range of assessment methods and measures may also make it difficult for stakeholders to understand how successful institutions are effectively teaching students critical thinking and written communication skills (e.g., Arum & Roksa, 2011; Council for Aid to Education, 2013).

Institutions are often motivated to use standardized assessments in order to provide employers and other external stakeholders with a snapshot of students' ability to critically think and to effectively communicate in writing. Standardized assessments are also useful because they allow for potential comparisons among institutions, and are typically rigorously vetted for validity and reliability issues. The pervasiveness of standardized testing in American

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educational systems mean their results are easily communicated to and consumable by wide and lay audiences. Indeed, over a third to a half of AAC&U member institutions who assess critical thinking as a general education outcome report using a standardized exam (AAC&U, 2015; see also, Council for Aid to Education, 2016).

Although institutions may use standardized tests to assess students' critical thinking and communication abilities, this type of assessment also has many limitations (Banta, 2006). A primary critique of many standardized exams is that the test scope may or may not fit with an institution's definition of effective critical thinking or written communication. The format of a particular test may also privilege certain disciplines, populations of students, and ways of knowing or quantifying knowledge. Large-scale assessment strategies are also often low-stakes for students, meaning there is no significant reward or consequence for how well or poorly a student performs. This can lead to low-motivated test takers and underestimations of students' abilities (Lui, Bridgeman, & Adler, 2012). Faculty may also be resistant to the notion of reducing student learning to a single score.

**Differing cultures, needs, and student populations, along with the complexity of these higher-order skills, contribute to the lack of consensus about how to best assess critical thinking and written communication.**

The reductionist approach of using a standardized assessment to measure student learning is compounded by institutional assessment strategies that involve the collection of many disparate pieces of data but lack a comprehensive lens for synthesizing different measures of student learning. According to the Wabash National Study (Pascarella & Blaich, 2013), a comprehensive, multi-institution longitudinal study of the impact of academic and nonacademic collegiate experiences on liberal arts outcomes, the institutions studied typically collected good-quality data on student outcomes using multiple measures. However, these institutions often lacked a synthesis across various data collected, and lacked a focused communication strategy designed to deeply engage relevant constituencies in conversations about how to act upon data in order to improve student outcomes (Blaich & Wise, 2011). An advantage of the triangulation approach presented here is that it is less reductionist and allows for a sophisticated discussion of student attainment, which may help assessment professionals develop more holistic, and perhaps more actionable, narratives about student outcomes than narratives produced by a single measure.

Triangulation is a way of increasing confidence in the conclusions about assessment data by using multiple data sources, measures, perspectives or methodological approaches (Denzin, 1973; see also Coats & Stevenson (2006) for an alternative approach to triangulation in higher education settings). Often triangulation is used to overcome validity issues and to confirm results by limiting the biases that come from using a single source (Thomas, Lightcap, & Rosencranz, 2005; Ghayeb, Damodaran, & Vohra, 2011). For instance, surveys can produce results that are not representative of the whole population due to sampling errors and issues with which individuals choose to respond to a given survey (Fowler, 2013). Responses on surveys may also be biased, or systematically different from the true scores, due to respondents' misremembering information or underreporting on certain issues. Although it is possible to mitigate some of these limitations when administering surveys, these limitations remain inherent to survey methodologies (Fowler, 2013). However, other methods may not share these specific intrinsic biases. Hence, if different methods all point to the same conclusion we can increase our confidence in that conclusion. Assessment experts advocate for the use of multiple methods (Banta 2002; Maki, 2002; Nelson, 2010; Springfield, Gwozdek, Peet, & Kerschbaum, 2012; Suskie, 2000); however, assessment practitioners may hesitate to utilize a triangulation approach because it is complex and time consuming (e.g., Guion, 2002).

This study used a direct measure (a standardized exam) and indirect measures (results from two student surveys) to gain a more holistic picture of student attainment of critical thinking and written communication learning outcomes. Direct measures are primary observations or examinations of student knowledge or skills, including results from exams, quizzes, and written assignments. Indirect measures are secondary observations or examination of student knowledge or skills, such as survey results of students' self-perceptions of their learning (e.g., Rogers, 2006). Our choice of exam and surveys was largely driven by what data was available on our campus. These measures were not only used in a confirmatory way to show agreement or disagreement with each other but also in parallel with each other to better inform what the results mean within this institutional context. To preview our results, we

found evidence for student attainment of written communication outcomes, but our evidence on students' attainment of critical thinking outcomes was mixed. However, the complementary information provided by the different methodologies and data sources used provided insight for how our institution may benefit from a focused plan to modify instructional strategies for teaching particular critical thinking subskills.

## Methods

### General Procedures

Our undergraduate participants were freshmen and seniors enrolled at a large, public four-year university in the southern United States. The focus of our analyses was on students from a single college (referred to throughout text as 'College A') located within the university. College A was chosen as a focus for this institutional assessment investigation by design so that the study findings had a clear constituency. All measures were administered in the same spring semester. Except where specifically indicated otherwise, participants assessed were independent samples on each measure.

For the ETS HEIghten standardized exams used, participants were drawn from core courses within College A. Freshmen and senior participants were randomly assigned to complete one of the two ETS HEIghten exams used for this investigation. A description of the exams used and the participants is provided in the "Measures and Participants" section. Participants completed their assigned exam during a typical course meeting time in a campus computer lab. Faculty were involved in the planning and logistics of administering these assessments. The ETS HEIghten exams were proctored and administered via a secure ETS testing browser. The ETS HEIghten exams were administered as a low-stakes assessment and our student participants did not receive course credit for their participation. A random selection of <15% of participants were provided with a gift card of a nominal monetary value after completing the HEIghten testing. Students completing the survey measures came from across the university, with students in College A identified based on their selected major or pre-major at the time the study was conducted.

For correlational analyses, Pearson's  $r$  correlational tests were conducted when both of the variables analyzed were continuous and normally distributed; Spearman's nonparametric  $r$  (sometimes denoted as  $\rho$ ) tests were applied to analyses using survey response data on a Likert scale. For independent-samples t-tests, equal variances were not assumed if the Levene's Test for equality of variances was significant. Degrees of freedom are rounded to the nearest integer for readability. Effect sizes are provided as Hedges'  $g$ , a variant of Cohen's  $d$  that corrects for unequal group sample sizes.

### Defining effective written communication and critical thinking

Effective written communication and critical thinking are included among our institution's student learning outcomes, as well as in student learning outcomes specific to the academic programs within College A. Our institutional definition of written communication includes: the effective development of written content, presented in a structured exposition that conveys and creates meaning consistent with the conventions appropriate for a given communicative context. Our associated institution-level student learning outcome states: Students will be able to demonstrate the ability to adapt and apply a variety of writing strategies (invention, research, analyses, organization, and revision) to communicate effectively with a target audience. Institutionally, we define critical thinking as including creative thinking, innovation, inquiry and analysis, evaluation and syntheses of information. Our associated outcome states: Students will be able to demonstrate critical thinking skills through a process of inquiry that explores evidence for developing innovative and creative solutions to make informed decisions and evaluations. Programs within College A include student learning outcomes that align to these institutional outcomes, as well as critical thinking-related outcomes pertinent to the College's discipline such as using numerical analysis skills to draw appropriate conclusions.

**This study used a direct measure (a standardized exam) and indirect measures (results from two student surveys) to gain a more holistic picture.**

For this investigation, we operationally defined the subskills that comprise effective written communication as follows: knowledge of rhetorical conventions in different contexts; awareness of audience and purpose of writing; appropriate content development and organization; knowledge of language use and conventions including appropriate spelling, grammar, tone, style; and knowledge of the writing process (i.e., drafting, revising). Our operational definition of critical thinking was a process that encompassed some or all of the following steps: a process of inquiry and hypothesis-generation; gathering information and data of good quality; evaluation of information's credibility, validity, reliability and logical strength; analysis of quantitative and qualitative information and data; interpretation of information's significance and meaning; drawing inferences from evidence, assessing alternatives, determining sufficiency of evidence, and evidenced-based decision-making; and communication of one's thought process and conclusions to others (see also Facione, 1990; Rhodes, 2010). For this study we did not seek assessment measures that would encompass all aspects of our definitions. Instead, our measures typically aligned to specific aspects of effective written communication or critical thinking, and we constrained our conclusions drawn accordingly.

## Measures & Participants

**ETS HEIghten Written Communication Assessment.** Freshmen (46 women, 69 men, age  $M \pm S.E.$ :  $19.4 \pm 0.1$  years) and seniors (46 women, 52 men, age  $22.6 \pm 1.4$  years) sat for the ETS HEIghten Written Communication Assessment (Rios, Sparks, Zhang, & Liu, 2017; Sparks, Song, Brantley, & Liu, 2014). This is a two-part test consisting of a constructed persuasive essay and multiple-choice questions based on presented reading passages. This exam assesses students' knowledge of rhetorical conventions in different contexts and ability to identify writing for certain purposes and audiences; students' knowledge of conceptual strategies including how to develop ideas in an organized, logical and coherent sequence; knowledge of language use and conventions; and knowledge of the writing process. The test is scored on a scale of 150 to 180.

**ETS HEIghten Critical Thinking Assessment.** Freshmen (38 women, 65 men,  $M \pm S.E.$  age:  $19.8 \pm 0.1$  years) and seniors (53 women, 51 men, age  $22.9 \pm 0.2$  years) sat for the ETS HEIghten Critical Thinking Assessment (Liu, Frankel, & Roohr, 2014; Liu, Mao, Frankel & Xu, 2016). This multiple-choice exam is a test of logical and deductive reasoning, and it addresses evaluation, interpretation, and inference skills. For example, it provides students with lists of evidence and asks questions about whether or not pieces of evidence support a given conclusion, and how strongly. It also asks test takers to identify assumptions in provided written arguments and to solve logic word problems. It is scored on a scale of 150 to 180.

**National Survey of Student Engagement (NSSE).** To complement the standardized test data generated by the ETS HEIghten Exams, we examined students' perceptions of their writing and critical thinking skills and experience using items from the National Survey of Student Engagement (NSSE; <http://nsse.indiana.edu/>). The NSSE is a large-scale, multi-institutional survey typically administered by participating institutions to first-year and senior bachelor's degree-seeking students. It has undergone extensive psychometric testing for validity and reliability (psychometric profile available at [http://nsse.indiana.edu/html/psychometric\\_portfolio.cfm](http://nsse.indiana.edu/html/psychometric_portfolio.cfm)). Broadly, the survey asks students about their engagement in educationally purposeful activities. At our institution, this survey was electronically administered using stratified random sampling to freshmen (19% response rate, freshmen survey population: 332 women, 235 men,  $M \pm S.E.$  age:  $18.4 \pm 0.1$  years; College A subpopulation: 20 women, 53 men, age:  $18.3 \pm 0.1$  years) and seniors (20% response rate, senior survey population: 447 women, 261 men,  $M \pm S.E.$  age:  $24.8 \pm 0.3$  years; College A subpopulation: 53 women, 40 men, age:  $23.7 \pm 0.6$  years). Survey respondents received no incentives. Specific items used are detailed in Table 1. For analyses using the NSSE data students in College A were generally compared to their peers at our institution who are not enrolled in College A.

**Senior Survey.** The Senior Survey is electronically distributed to seniors with their graduation application materials. This survey was developed for collective use by the public universities within our institution's state system and has been routinely used by our institution

We define critical thinking as including creative thinking, innovation, inquiry and analysis, evaluation and syntheses of information.

for several years. Participation is voluntary and not incentivized, but generally 60% of our graduating seniors respond to this survey. Data from 490 College A seniors (210 women, 280 men,  $M \pm S.E.$  age:  $23.8 \pm 0.2$  years) and 2,070 seniors (1136 women, 934 men, age  $24.9 \pm 0.1$  years) affiliated with colleges at our university other than College A were used for these analyses. This survey asks students questions about their satisfaction with their instructors and their educational experiences as well as their opinions about how much the institution has contributed to their knowledge, skills, and development in various areas including written communication and critical thinking.

## Results

### Evidence for attainment of effective written communication capabilities

The evidence examined suggests students in College A are developing effective written communication skills, although they may self-perceive less gains in writing than their peers in other colleges at our institution. As the ETS HEIghten exam suite is relatively new to market and this represents our institution's first use of the exams, as a basic validity check we first examined how scores on the HEIghten Written Communication exam correlated with students' cumulative grade point average (GPA) on a 4.0 scale. Across all participants who sat for the exam, we found that exam scores showed a small but significant positive correlation with students' GPA, with students with higher exam scores also having higher GPAs (Pearson's  $r$  correlational analysis,  $r(211) = .22$ ,  $p = .001$ ). This finding held for freshmen ( $r(113) = .36$ ,  $p < .001$ ), but was not significant for seniors alone ( $r(96) = .17$ ,  $p = .07$ ). We then examined how seniors' scores on the ETS HEIghten exam compared to those of freshmen. Seniors scored significantly higher on the exam than freshmen (Figure 1; mean scores  $\pm$  standard error for freshmen:  $162.5 \pm 0.5$ , seniors:  $164.1 \pm 0.6$ ; independent samples  $t$ -test:  $t(211) = 2.11$ ,  $p = .04$ ,  $Hedges' g = 0.3$ ), suggesting students in College A are making gains in their writing abilities and in their knowledge of the writing process.

**[Students] are developing effective written communication skills.**

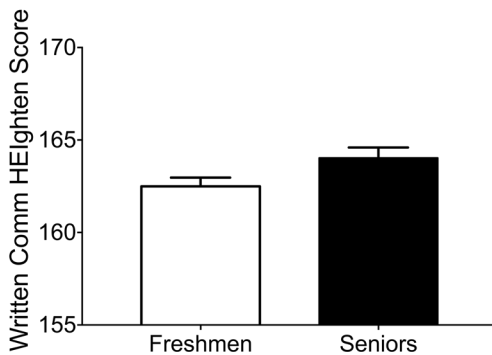


Figure 1. Seniors score higher on the HEIghten Written Communications exam than freshman. Bars represent the mean score on the ETS HEIghten Written Communications exam for freshman (white bar) and seniors (black bar). Error bars represent the standard error around the mean.

However, our survey data suggest students in College A self-perceive less gains in writing than their peers and that they may be producing fewer pages of academic writing during their senior year than their peers. College A seniors and seniors affiliated with other colleges within the university both report on average that their college education positively contributed to their written communication skills (Senior Survey item, 'To what extent do you think your college education contributed to your knowledge, skills, and personal development in writing effectively?'; response scale: very much (4), somewhat (3), very little (2) not at all (1)). However, students in College A give lower ratings than their peers (mean rating  $\pm$  standard error for College A seniors:  $3.25 \pm 0.03$ ; seniors from other colleges:  $3.46 \pm 0.02$ ; independent-samples  $t$ -test  $t(2537) = 6.13$ ,  $p < .001$ ,  $Hedges' g = 0.2$ ). One possibility of why students in College A may differ in their self-perceptions about writing may be because these students are assigned fewer pages of academic writing than their peers. According to

the NSSE survey data on how many pages of writing students were assigned in the current school year, seniors in College A reported they were assigned about 18 fewer pages of writing than their peers affiliated with other colleges (College A:  $62.1 \pm 6.1$  pages, other colleges:  $80.8 \pm 4.2$  pages; independent samples *t*-test,  $t(144) = 2.53, p = .01$ , *Hedges' g* = 0.2). This difference in pages produced does not mean College A students were assigned fewer writing assignments than students in other colleges; but, it is possible students who produce more pages of course writing are also more willing to attribute self-perceived gains in writing to their experiences in those courses.

### Mixed evidence for attainment of critical thinking capabilities

The examined evidence was mixed on whether College A students are gaining strong critical thinking skills during their undergraduate education. As with the Written Communication exam, we first examined whether students' scores on the ETS HEIghten Critical Thinking exam correlated with students' GPAs. Students' Critical Thinking exam scores indeed positively correlated with their cumulative GPA, with students with higher exam scores also exhibiting higher GPAs (Pearson's *r* correlational analysis,  $r(207) = .27, p < .001$ ; freshmen:  $r(101) = .23, p = .02$ , seniors:  $r(102) = 0.31, p < .01$ ). Next, we examined how seniors' scores compared to those of freshmen. We found seniors' scores increased but not significantly compared to freshmen (mean scores  $\pm$  standard error for freshmen:  $162.3 \pm 0.6$ , seniors:  $163.2 \pm 0.6$ ; independent samples *t*-test,  $t(206) = 1.07, p = .31$ , *Hedges' g* = .1).

[students] may differ in their self-perceptions about writing...because these students are assigned fewer pages of academic writing than their peers.

The Senior Survey and NSSE data proved useful for both interpreting the ETS HEIghten results and for more holistically examining the subskills that comprised our definition of critical thinking. In response to the Senior Survey item, 'To what extent do you think your college education contributed to your knowledge, skills, and personal development in using critical thinking skills?' (response scale: very much (4), somewhat (3); very little (2) not at all (1)), although all students rated this item fairly high, seniors in College A gave lower ratings than seniors affiliated with other colleges at our university (mean rating  $\pm$  standard error for College A seniors:  $3.53 \pm 0.03$ ; seniors from other colleges:  $3.66 \pm 0.01$ ; independent-samples *t*-test, equal variances not assumed,  $t(703) = 4.05, p < 0.001$ , *Hedges' g* = 0.4). Compared to students affiliated with other colleges at our institution, students in College A reported that their courses placed more emphasis on lower-level skills like memorization and less emphasis on higher-level skills like analyzing an idea and forming new ideas (NSSE items in Table 1; independent-samples *t*-tests, all  $t > 2.07, p < .04$ , *Hedges' g*  $> .2$ ). These results also held if only data from seniors was examined. From a triangulation perspective the lower ratings for the higher-order skills of analyzing and forming ideas are logically consistent with the findings from the ETS HEIghten Critical Thinking exam, given the exam's focus on interpretation and inference skills.

The large sample size of the Senior Survey enabled us to identify a subgroup of seniors ( $n = 80$ ) who sat for the ETS HEIghten Critical Thinking exam and who completed the Senior Survey. We conducted exploratory analyses on this subgroup to see if there were any correlational relationships between students' exam scores and students' responses to the Senior Survey items. Students' exam scores did not correlate with the broad item on the Senior Survey about the extent to which their college education contributed to their using critical thinking skills (Spearman's nonparametric *r*,  $r(79) = .002, p = .99$ ). However, students' exam scores did positively correlate with three survey items related to effective teaching practices: 'Overall satisfaction with instructors in my major department's:' (a) 'Ability to motivate me to do my best', (b) 'How quickly they provide feedback on my work', and (c) 'Effectiveness in using instructional technology' (Figure 2; response scale for all items: very satisfied (5), satisfied (4), neither (3), dissatisfied (2), very dissatisfied (1); Spearman's nonparametric *r*, all  $r > .23, p < .05$ ). For each of these items, students with higher levels of satisfaction also tended to have higher Critical Thinking exam scores. Students' exam scores did not correlate with any other item on the Senior Survey.

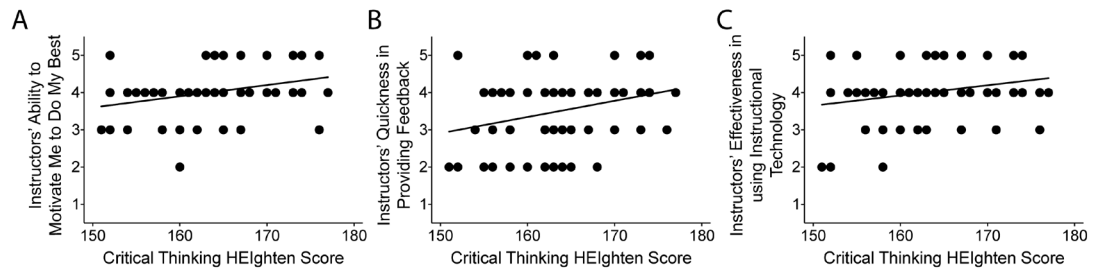
The survey data also provided insight into critical thinking subskills not covered by the ETS HEIghten Critical Thinking exam. Specifically, our definition of critical thinking included subskills related to the analysis of information and data. According to the NSSE data, students in College A perceive greater gains in analyzing data than their peers in other colleges (Table 1; independent samples *t*-test, equal variances not assumed,  $t(170) = 3.00$ ,  $p = .003$ , Hedges'  $g = .3$ ). Similarly, students in College A also reported engaging in quantitative reasoning skills more frequently than their peers (Table 1; independent samples *t*-tests, all  $t > 3.02$ ,  $p < .01$ , Hedges'  $g > 0.2$ ). Again, these results held if only data from seniors was examined. These data suggest College A students self-perceived gains in their ability and experience with analysis and quantitative reasoning skills.

Table 1  
National Survey of Student Engagement (NSSE) items used for critical thinking analyses.

Item Stem, Item Text, and Response Scale	College A	
	Students ( $M \pm SEM$ )	Other Students <sup>a</sup> ( $M \pm SEM$ )
During the current school year, how much has your coursework emphasized the following:		
<i>Memorizing course material</i>	3.17 ± 0.06	2.93 ± 0.03
<i>Analyzing an idea, experience or line of reasoning in depth by examining its parts</i>	2.90 ± 0.07	3.04 ± 0.02
<i>Forming a new idea or understanding from various pieces of information</i>	2.74 ± 0.08	2.92 ± 0.03
Very often (4), Often (3), Sometimes (2), Never (1)		
How much has your experience at this institution contributed to your knowledge, skills, and personal development in the following areas?		
<i>Analyzing numerical and statistical information</i>	2.96 ± 0.08	2.71 ± 0.03
Very much (4), Quite a bit (3), Some (2), Very little (1)		
During the current school year, about how often have you done the following?		
<i>Reached conclusions based on your own analysis of numerical information (numbers, graphs, statistics etc.)</i>	2.74 ± 0.07	2.56 ± 0.03
<i>Used numerical information to examine a real-world problem or issue (unemployment, climate change, public health, etc.)</i>	2.53 ± 0.07	2.29 ± 0.03
<i>Evaluated what others have concluded from numerical information</i>	2.48 ± 0.07	2.28 ± 0.03
Very often (4), Often (3), Sometimes (2), Never (1)		

Note. M = mean; SEM = standard error around the mean

<sup>a</sup>Other students are students affiliated with colleges at the university other than College A.



*Figure 2.* HEIghten Critical Thinking scores correlate with students' satisfaction with instructors' use of effective teaching practices. Each dot on the scatterplots indicates an individual College A senior's score on the HEIghten Critical Thinking exam versus the student's response to an item on the Senior Survey about students' level of satisfaction with (a) instructors' ability to motivate the student to do their best, (b) instructors' quickness in providing feedback, and (c) instructors' effectiveness in using instructional technology. Students rated the survey items on a scale of very satisfied (5) to very dissatisfied (1). Line on scatterplots represents the linear regression line for each plot. For each of these three survey items on effective teaching practices, students' level of satisfaction with their instructors' use of these practices positively correlated with students' scores on the critical thinking exam. These findings provide indirect evidence to support the idea that effective teaching practices can foster the development of stronger critical thinking skills.

## Discussion

This study brought together data from direct measures (standardized exams) as well as indirect measures (student surveys) to assess students' attainment of written communication and critical thinking outcomes, with a specific focus on how seniors compared to freshmen. The findings from this assessment work were written up in an executive summary and were orally presented to the faculty and senior leadership in the college studied.

**Students with higher levels of satisfaction also tended to have higher Critical Thinking exam scores.**

In the domain of written communication we found evidence that seniors showed more advanced writing abilities and knowledge than freshmen, an encouraging result for the college studied. Seniors also self-reported gains in writing abilities and knowledge, although to a slightly lower degree than seniors affiliated with other colleges within the institution. Students in the college studied also reported being assigned fewer pages of academic writing during their senior year than our other seniors within the institution. When these data were presented to faculty and leadership within the college, this data point sparked a discussion about how different disciplines may favor assignments of different lengths (e.g., public policy memos stress concise communication). As a follow-up to this study, it would be interesting to gain further details about how often seniors are writing for academic purposes and to better understand what disciplinary writing may 'count' in students' opinions as academic writing.

For critical thinking, students in the college studied self-reported their coursework placed more emphasis on memorization and less emphasis on skills that may contribute to critical thinking, such as logical reasoning, analyzing ideas based on examining its parts, and forming new ideas and understandings based on various pieces of information. This finding was particularly interesting considering it logically supported the conclusion drawn from the standardized exam data. On our standardized exam measure of logical reasoning, evaluation, and inference skills, our seniors did not score significantly higher than freshmen. These findings spurred intense faculty discussion over instructional practices, including how existing course activities and assessments might be revised to allow students to engage in evaluation and inference skills. More broadly, the college and the institution recently infused additional critical thinking teaching and learning opportunities in the undergraduate curriculum. Core courses within the college's curriculum have been rigorously revamped to focus on analysis and evaluation skills, and our institution has added an inquiry-based freshmen critical thinking seminar to our general education curriculum. The seniors tested here have not experienced the sum of these curricular changes, but future assessment findings may reveal evidence indicating current and future students are reaping the benefits of these changes.



The NSSE and Senior Survey data examined highlighted a strength for students in the college studied in the area of numerical analysis skills. The college studied is one that devotes considerable instructional time and attention in its curriculum to fostering students' quantitative analytic skills, and students in this college self-perceive higher gains in analyzing numerical information than students affiliated with other colleges. Quantitative reasoning and numerical analysis skills are outside the scope of the critical thinking standardized exam used here but do fit within our institutional definition of critical thinking. In this case using different data sources and measures was an asset because it allowed us to see a broader picture of how students perceive they are attaining different critical thinking subskills.

The correlational findings between students' critical thinking standardized test scores and those students' satisfaction rankings regarding certain instructional practices are intriguing because they suggest pedagogical strategies and instructional conditions that may foster students' critical thinking development (Tsui, 2016). For example, motivation is an important precursor for engagement of higher-order, cognitively demanding processes like engaging in critical thinking (Miel & Wigfield, 2014). Instructors adept at motivating students may also engender the best conditions for fostering growth in critical thinking. Timely, accurate feedback on performance is a key characteristic of deliberate practice, and deliberate practice of critical thinking skills is important for developing mastery (van Gelder, 2005). The interpretation of the correlation between satisfaction with instructors' effectiveness in using instructional technology and critical thinking skills is less straightforward. However, it may be that 'effective use of instructional technology' is a proxy for how effective instructors are at engaging students. Student engagement is likely critical for motivating students and creating conditions where students will be encouraged to stretch and grow their cognitive abilities, including critical thinking. These findings point to potentially fruitful areas for future empirical research on how pedagogical structures and instructional conditions can enhance students' critical thinking skills.

The triangulation approach was particularly useful for the discussion with faculty and senior leadership about this study's findings as it allowed us to evaluate students' attainment of outcomes through various lenses. Although standardized exams are commonly used to apply for admission into our university, our faculty largely saw standardized exams for assessing student learning as tools to be used to satisfy accountability purposes more than as tools to provide insightful data that could be used to improve teaching and learning. Bringing in students' perspectives, as well as discussing how the data presented did or did not match with the college's internal data on student performance, helped to engage the faculty in a discussion about how closely our students' outcomes are matching our objectives for their learning.

As the ETS HEIghten exams are more widely adopted we foresee additional possibilities for comparing exam results to results from other peer or aspirational peer institutions. At the time of our test administration the institutional comparisons available on the particular exams used here were rather limited. In some ways this limitation can be a benefit, as it strongly encourages institutions to create internal comparison groups of interest in order to contextualize the results. Though large-scale assessments may appease external stakeholders, our experiences also reinforced the best practice of starting these types of investigations with a clear question about student learning that the measures used will address. Similarly, institution-level assessment plans may have some appeal but we have found results are more actionable when situated within a particular college or academic program (Robinson, Sanders, Hobbs, Demeter, Singer-Freeman, 2019). Although the ETS HEIghten exams were too new to market at the time of our administration to conduct a longitudinal study, future options may also include tracking individual students' growth between freshmen and senior years.

Effective written communication and strong critical thinking skills will continue to be highly valued both within academia and within the workplace. Triangulating data from different methods and sources allowed us to develop a more holistic assessment of students' attainment of these two important outcomes. Although using multiple measures brings a complexity to assessment work, it also creates the opportunity to create more sophisticated narratives of student achievement.

**Our experiences also reinforced the best practice of starting these types of investigations with a clear question about student learning.**

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