THE HIDDEN ROLE OF "BUY-IN": HOW FACULTY AND STUDENT ATTITUDES IMPACT CURRICULAR REFORM

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Abstract

Vision & Change recommends transformation in undergraduate biology education, but some faculty may be reluctant to reform their courses for fear of student resistance, or a perception that such change is unnecessary. This student resistance may arise because of an unfamiliarity with an active-learning environment, or from non-STEM students who believe they are disadvantaged in a mixed-majors introductory biology course. Faculty may use many measures to evaluate the extent of student resistance, such as student evaluations of teaching or verbal comments from students or colleagues. It is less common for faculty to use a thorough assessment of both student learning gains and self-efficacy to inform curricular change. We assessed both of these measures in a mixed-majors biology course at a small liberal arts college. Students self-reported increases in learning gains on surveys, and pre- and post-course concept assessment demonstrated actual learning and performance gains. Because we found that STEM majors were more likely to report positive opinions than non-STEM majors, we suggest that offering a non-majors introductory biology course may be more successful in engaging these students. Overall, we found that positive student opinions were more frequent than negative opinions regardless of major; we conclude that student resistance was much less than some faculty expected. Without a thorough use of assessments, the extent of positive student opinions may not become apparent, and a disproportionate bias toward negative opinions may instead drive curricular decisions.

Subject/Problem

The Vision & Change initiative calls for change in undergraduate science education and provides recommendations based on the educational literature (AAAS 2009). In response to this initiative, we developed a new introductory biology curriculum called Integrating Biology and Inquiry Skills (IBIS). IBIS integrates student-centered inquiry and critical thinking in open-ended laboratory investigations aligned with an active lecture curriculum. Class time is devoted to group discussions of student-generated questions and peer review under the guidance of faculty and experienced upper-level students.

Through the IBIS program, we were able to assess transformation efforts in biology education in the context of a small, liberal arts college. These institutions are often characterized by small class sizes and an emphasis on achievement of faculty in teaching rather than research. Some faculty may believe that these traits ensure high levels of student engagement, making any reform efforts at these institutions unnecessary. Faculty may also fear possible negative student evaluations of their teaching that could accompany curricular reform. Understanding how student opinion influences faculty resistance to teaching reform may aid biology curricula transformation at small colleges.

Furthermore, identifying the nature of student discontent with new classroom experiences is critical. According to Expectancy Violation Theory (EVT), student resistance can occur when class requirements conflict with student expectations based on their previous experiences (Brown et al. 2017). If students expect to passively take notes during class, then an active learning environment will violate their expectations and cause dissatisfaction. However, as a new curriculum is assimilated into the culture of the institution over time, it is possible that student expectations will also change, leading to reduced expectancy violation and decreased student dissatisfaction. To detect if this change occurs, documentation of student opinions year after year is required, yet these patterns are understudied at small colleges.

Student attitudes may also be related to individual motivations for attending college. A mixed-majors introductory course is an efficient strategy for small colleges with relatively few faculty and may help prepare students to enter the workforce, as many employers expect hired college graduates to collaborate in multidisciplinary teams (Hart Research Associates 2015). On the other hand, students who do not intend to major in STEM fields may perceive themselves to be disadvantaged in a mixed-majors introductory biology course. The student perception of a mixed-majors experience by non-majors at a small, liberal arts college needs to be explored to learn if programmatic efficiency affects engagement.

To address this need, we evaluated the IBIS program at a small, liberal arts college over a four-year period. We assessed student learning gains and compared these gains to students' evaluations of their own performance. Student learning gains were measured with a pre- and post-course concept assessment, while attitudinal changes were assessed with a post-course Student Assessment of Learning Gains (SALG) survey. Students demonstrated significant learning gains in course outcomes by the conclusion of the course. Despite these gains, there was the perception among some faculty that the curricular reform undertaken by the IBIS program was not effective or appropriate for a mixed-majors introductory course. To determine if students were similarly divided, we surveyed student attitudes toward the IBIS curriculum and biology as a discipline. We assessed whether learning gains and attitudes changed over time as the IBIS curriculum was assimilated into the educational experience and culture at this institution. Additionally, we compared student learning gains and attitude between STEM and non-STEM students.

Design/Procedure

Over the life of the program, 724 students were enrolled in the IBIS curriculum, which was taught by 13 faculty members, six of whom taught in the IBIS curriculum in multiple years. The number of students enrolled in the program during one year varied from 136-245. The number of faculty members instructing the course varied from 4-7 each year (Table 1).

Table 1. Faculty and Student Participation in the IBIS Program.

Year	Total Faculty	Faculty with Previous IBIS Experience	Total Students	STEM Majors / Non-majors
2013	7	5	245	40.7% / 59.3%
2014	6	4	182	50.4% / 49.6%
2015	6	4	161	61.1% / 38.9%
2016	4	3	136	78.1% / 21.9%

Assessments

The institution's IRB approved all data collection (PC-201221). Beginning in 2013, we evaluated student performance and student assessment of learning gains to assess course effectiveness and to guide curricular revisions. First, we designed a pre- and post-course concept survey aligned with our learning outcomes, which included attitudinal questions related to course perceptions, interests, and self-efficacy. To examine student learning self-efficacy further, we also developed questions for the SALG instrument (www.salgsite.org, Instruments #63255, #67010, #67900, #71380, #72672, #76196). We unambiguously matched pre- and post-course responses for 542 students (74.9%); the remainder of responses remained unmatched due to a missing pre- or post-course instrument.

Items used to evaluate student attitudes quantitatively utilized a Likert scale in the pre- and post-course concept survey. The SALG instruments had similarly structured questions. The first type provided descriptions of course content/competency and asked students to identify the level of learning gain they perceived as a result of the course. The second type of question asked students to report how helpful they found different elements of the course to be (course structure, components, and other resources). The SALG instruments also asked open-ended questions in which students could expand upon their responses to each set of ranking questions.

Data analysis methods

Pre- and post-course performance on the concept survey were compared using linear mixed effects models (with student as a random effect, binomial error family). In addition, we constructed network diagrams to visualize the migration of individual attitudes for the same time period.

We used sentiment analysis methods on the open-ended SALG questions to quantify positive *vs.* negative feelings to different aspects of the curriculum. We used the R packages *tm* (Feinerer et al. 2008, Feinerer and Hornik 2017) and *RWeka* (Hornik et al. 2009) to format the text for analysis and extract trigrams (three consecutive words from a response). We analyzed trigrams, rather than shorter or longer sets of consecutive words because trigrams are the smallest set of consecutive words in which sentiments could be assigned. For each detected trigram, we assigned a sentiment of positive, negative, or unknown. Positive vs. negative sentiment frequency for each category was compared across years using tests of association with Bonferroni corrections for multiple comparisons to discover if student attitudes toward learning biology shifted between 2016 and all other years. In 2016, we offered a non-majors biology course, which changed the population of students enrolled in the IBIS program to primarily (aspiring) biology majors. Logistic regression was used to examine the relationship between sentiment (positive vs. negative) and year to learn if time since implementation has an influence on student attitudes toward pedagogical methods. All statistical and text analyses were conducted in R (R Development Core Team 2016).

Analyses and Findings

Student performance indicators

In each year, students were more likely to answer questions correctly after the course (*p* < 0.05 for all years). For concepts, the normalized learning gains were above 20 percent on average each year, except for the scientific method in 2013 and 2014 (19.4% and 20.3% respectively) (Figure 1). For critical thinking skills (knowledge, comprehension, application, analysis), the normalized learning gains were above 30 percent on average for all years (Figure 1). Thus, the curriculum appears effective when compared to other reported learning gains. Elliot et al. measured normalized learning gains between 23% (energetics) and 50% (biological membranes) in a collaborative, student-centered curriculum (2016). Cleveland et al. reported normalized learning gains between 7-16% (cellular and molecular biology) in two student-centered environments (2017). Normalized learning gains of 48% (cellular respiration) were reported when using a student-centered case study approach (Rybarczyk et al. 2007).

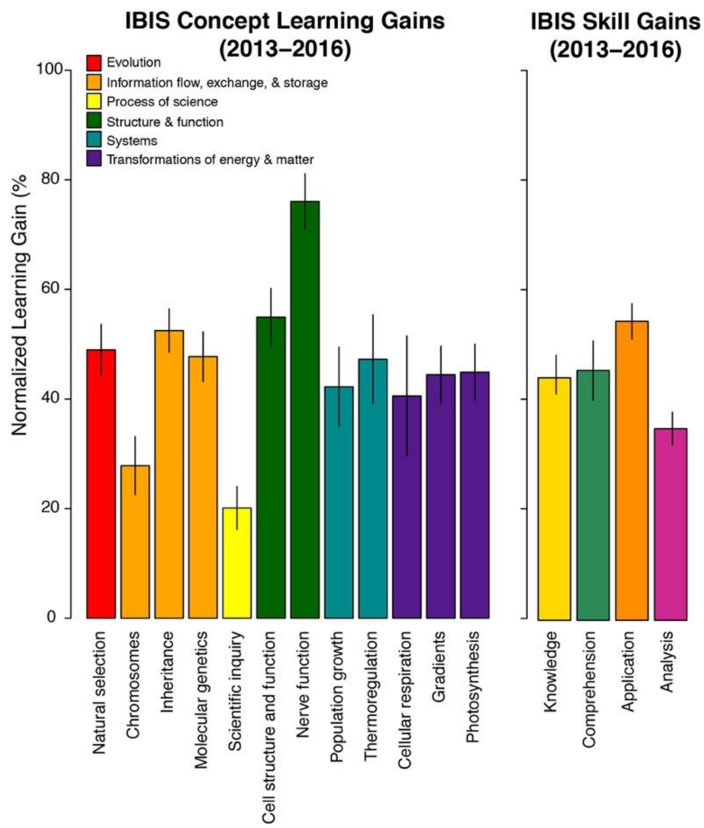

Figure 1. Normalized learning gains across concepts and skills were above 20%, compiled across all years of the study.

Student attitudes

An overwhelming majority of students perceived their gains as moderate or higher in teamwork and critical thinking skills as a result of the course (compiled across all years; Figure 2). When asked to comment on how the course helped them remember key ideas, we found a higher frequency of positive compared to negative trigrams, and more positive trigrams were found over time (*p*<0.001; Figure 3). “Clicker questions” were most frequently identified as helpful, supporting the findings of Brazeal and Couch (2017). Within each year, students became less interested in learning about biology after taking the course ($p < 0.05$ for all years). For example, in 2014, 10% of students either Disagreed or Strongly Disagreed with the statement “I am interested in learning more about biology” prior to taking the course. On the post-course survey, this increased to 24.4% (Figure 4). From 2013 to 2015, most of the disinterest came from students who did not intend to major in STEM fields. Importantly, very few STEM majors reported a reduction in their interest in biology (e.g., in 2014, from 0% Disagree to 3.8% Disagree; no STEM majors Strongly Disagreed). To address this reduction in non-STEM students, we offered an alternative, non-majors only course in 2016. We found that there was a higher probability of positive sentiments being expressed in 2016 compared to all other years ($p < 0.0001$, Figure 5), and we infer that the difference is a result of fewer or no non-STEM students being present to express negative sentiments.

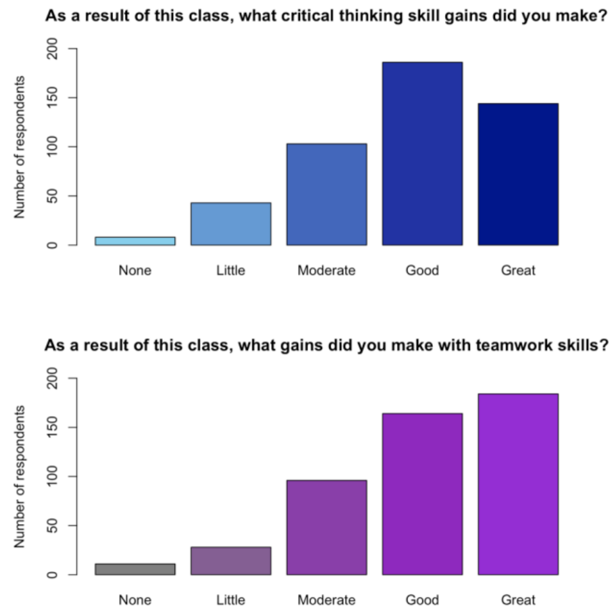

Figure 2. An overwhelming majority of students, compiled across all years of the study (2013-2016), ranked their gains as moderate or higher in teamwork (top) and critical thinking skills (bottom) as a result of the course.

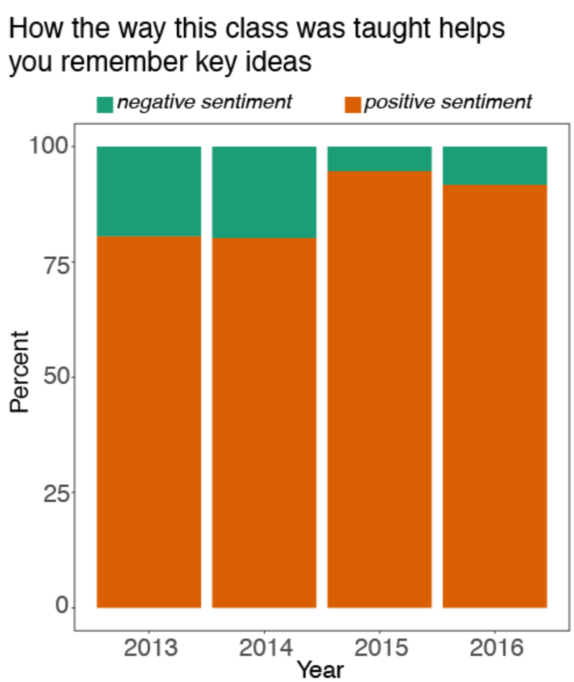

Figure 3. Regarding pedagogy, positive sentiments were more abundant than negative sentiments, and this proportion increased over time (p<0.0001). Sentiments were assigned to trigrams (three consecutive words) that were extracted from the free-response survey question.

Further interpretations

Across all four years, overall course grades did not differ (median grades ranged from 76.2% to 77.1%, $p = 0.101$). However, we found a trend of increased positive trigrams in response to course pedagogy (Figure 3). It is possible that, through the years, the student population has acclimated to the way the course is taught. Although an expectation of passive rather than active learning experiences may exist in each new set of students (Brown et al. 2017), changes in institutional culture may markedly improve post-course perspectives with time. We propose that instructors should address student expectations of a passive instruction style/classroom early in the semester by sharing the motivation and data behind active-learning instruction. This introduction may help students connect these new experiences to positive impacts on their learning, in other words, increase student buy-in (Cavanagh et al., 2016). Alternatively, the increase in positive trigrams could be associated with the increasing percent of students who aspired to be STEM majors (Table 1). This possibility suggests that aspiring STEM majors could be more receptive to course pedagogy than non-majors, and student buy-in for majors-only courses may be less difficult to attain.

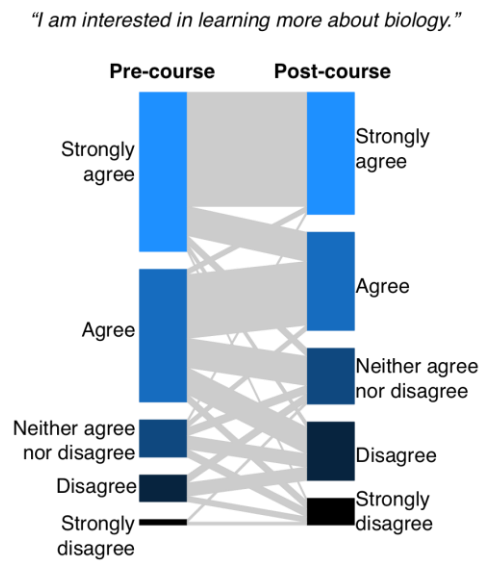

Figure 4. Migration of student attitudes toward biology. Most students maintained a positive view of the subject, though the percentage of students who are uninterested did increase.

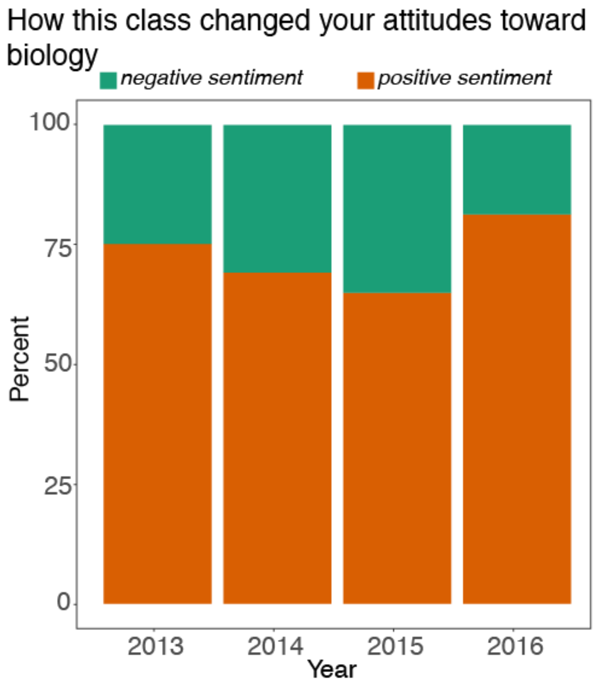

Figure 5. With attitudes toward biology, positive sentiments were more abundant than negative sentiments. The higher percent of positive sentiments in 2016, when the course became majors-only, is significantly higher than all other years (all *p*<0.0001). Sentiments were assigned to trigrams (three consecutive words) that were extracted from the free-response survey question.

Throughout the implementation of this curriculum, faculty members who taught in the program were polarized in their opinions of course efficacy. While some used student learning gains to justify revisions, others did not believe the curriculum was justifiable or effective. We suggest that unsupportive faculty members had a biased perception of student performance and student attitudes. Perhaps these faculty members focused on individual student complaints, rather than the true distribution of student opinions. Alternatively, some instructors may be sensitive to any expression of resistance, while others may use a broader array of information to form their opinion of curricula (Seidel and Tanner 2013). Faculty members that are sensitive to student resistance may have failed to fully or correctly implement the curriculum because of preconceived fears of student dissatisfaction. The fidelity with which faculty members implement evidenced-based educational practices can affect the efficacy of those practices (Daubenmire et al. 2015; Stains & Vickery 2017; Turpen & Finkelstein 2009). In turn, improperly executed active learning environments can decrease student performance (Andrews et al. 2011) and satisfaction. It is possible that faculty members who failed to correctly or fully implement the curriculum of the IBIS program caused the very student dissatisfaction that they feared in the first place, thereby perpetuating a positive feedback loop of discontent among some faculty members and students.

We also propose that biased perceptions of student discontent among faculty may be common at small colleges and other institutions where student evaluations of teaching are important for personnel decisions. Biased perceptions by faculty could affect successful curricular reform at these types of institutions. This makes emphasizing student buy-in towards curricular and pedagogical changes of utmost importance, because student buy-in is crucial to maintain classroom interactions and to improve student performance (Brazeal and Couch, 2017; Cavanaugh et al., 2016; Seidel and Tanner 2013).

Our finding of reduced interest in biology by non-STEM students has influenced how we design accessible biology curricula. Although it is efficient to offer one course, doing so may inadvertently create a negative experience for non-majors. Offering a nonmajors introductory course may be more successful in creating a classroom community where non-majors are engaged and receptive to collaborative learning.

Contribution

When transforming undergraduate curricula to align with Vision & Change, tracking learning gains is essential because student performance is an indicator of successful transformation. However, student attitudes must also be considered. While some amount of resistance to change may always exist, there may be a large contingent of students who view the new curriculum positively, but whose voices are unheard because of a tendency to respond to the discontented minority. Administrators should be aware of this, as they can play pivotal roles in the potential success of transformative efforts and are often guided by negative rather than positive student opinion. Additionally, instructors and administrators should examine the instruments and methods they use to assess student opinion. Traditional end-of-course evaluations may not adequately assess the student-centered nature of the course or accurately correlate with student learning gains in a course (Uttl et al. 2017), potentially increasing negative perceptions of the curricular changes among students and faculty. Our study thus underscores the need for instruments that adequately assess the learning environment's effect on student performance and perceptions during curricular transformation.

General Interest

Our findings also may apply to other types of institutions, such as large, public universities. The methods used to analyze student perceptions in our study may also be of interest to K-12 biology instructors.

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