

The Evolution of Student Engagement: Writing Improves Teaching in Introductory Biology Courses

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Abstract: In response to calls for pedagogical reforms in undergraduate biology courses to decrease student attrition rates and increase active learning, this article describes one faculty member's conversion from traditional teaching methods to more engaging forms of practice. Partially told as a narrative, this article illustrates a.) the way many faculty initially learn to teach by modeling the pedagogy from their own undergraduate programs; b.) the kind of support biology faculty may need to break out of traditional molds; c.) how writing can promote active learning; and d.) the impact of reformed pedagogy on student levels of engagement. The latter will be demonstrated through assessment results gathered from student surveys, reflective writing, and focus group interview. Ultimately, the study challenges misunderstandings some faculty might have regarding the value of writing in science classes and offers inspiration, urging critical reflection and persistence.

Key Words: traditional science pedagogy, high-impact practices, writing in the disciplines, student engagement, faculty development.

INTRODUCTION

Central to the study of evolutionary biology is the premise of adaptation for survival. However, some biology faculty have not recognized the changing environment in higher education and adjusted their teaching practices to be more suited to the needs of today's students. Traditional STEM teaching methods rely heavily on lectures, large classes, and multiple-choice exams. In some cases, the faculty member serves as the content expert and acts as a gatekeeper, "weeding-out" students deemed unfit to handle the course material. In this way, the burden of learning can rest heavily on the students' shoulders; the teacher may bear little responsibility for optimizing student success. Traditional pedagogical approaches promote a competitive culture that permeates STEM fields, signaling to "many potential students that they do not fit in...or are not welcome" (Baldwin, 2009, p. 11).

Science pedagogy literature identifies some of the potential harms associated with this culture. According to Hannauer and Bauerle (2102), perhaps most notable is students' failure to persist in college science classes at a national rate over 50%. Reasons for this range from lack of preparation to lack of engagement caused by perceptions of the courses as impersonal and irrelevant. With nearly one-third of undergraduates enrolled in a STEM major, with biological sciences the most popular field (Chen, 2013), steps should be taken to right the wrongs. Moreover, the increasing accountability pressure on

colleges and universities for outcomes-based competency (Cowan, 2013; DOE, 2015) might mandate such reforms.

STEM fields are looked to for solutions to some of society's most pressing problems, but identifying these solutions "requires attracting and retaining new generations of creative and versatile scientists who are well prepared to participate in fast-paced, information-rich, collaborative forms of science" (Hanauer & Bauerle, 2012, par. 2). This new generation of scientists must be drawn from a "broad and diverse talent pool of students who are interested in science" (*ibid*). Therefore, concern over the STEM attrition crisis has led to the launch of numerous initiatives. Amongst plans for improving student retention rates is reform of the classroom experience. Programs increasingly look for strategies to better support and engage students in their learning. Not surprisingly, a frequent suggestion is for science faculty to include more writing in their courses. Writing appears on Kuh's (2008) list of high-impact practices, is identified by Bean (2001) as "the most intensive and demanding tool for eliciting sustained critical thought" (xiii), and can create more authentic and inviting occasions for learning (Bain, 2004, 62-63). Moreover, "the relationship between the amount of writing for a course and students' level of engagement...is stronger than the relationship between students' engagement and any other course characteristic" (Light, 2001, p. 55).

The arguments for writing in the sciences are grounded in the beliefs that writing is thinking

(Menary, 2007), that writing can deepen learning by activating priming, calibration, chunking, synthesis, reflection, elaboration, and metacognition (Brown, Roediger & McDaniel, 2014), and that writing can empower student success by giving students space to digest course material, raise questions, and formulate opinions in ways that honor student agency (Gottschalk & Hjortshoj, 2004). Nevertheless, writing can be slow to make its way into widespread accepted practice in science classrooms, or when it appears, it primarily is used as an assessment tool (e.g., short answer questions on an exam) (Kalman, Aulls, Rohar, & Godley, 2008).

However, this study presents a possible avenue for reform - by integrating writing more comprehensively into daily classroom practice. This approach can transform both student learning and faculty teaching experiences. Also, it neither requires special faculty training nor necessitates sacrificing content or standards. Because science faculty training can create a culture where writing-as-learning is not standard, this article will briefly discuss that acculturation process. It will then describe how that norm might be disrupted and the subsequent effect on students, using surveys and focus-group interviews.

Inherited Practice: How Science Faculty Learn to Teach

Many faculty are initially drawn to careers in science by inspiring K-12 teachers. Unfortunately, graduate programs in the natural sciences generally train research specialists, not *teachers* of biology. Therefore, many science faculty learn to teach through models of traditional pedagogy from their own undergraduate programs. These models suggest that to be “challenging,” faculty have to be perceived as “hard,” which often means many students earning Ds and Fs. There is an assumption that “competent” students will easily understand material and do well on exams. High standards and efforts to optimize student success are mutually exclusive (i.e., in order to have “winners,” you have to have “losers”). While some faculty might try to make lectures memorable, “teaching” primarily means delivering all of the concepts itemized in the syllabus: a “checklist,” the completion of which means students are ready for the next course in the program’s sequence. Because such inherited pedagogical practices are the product of social reproduction (Bourdieu & Passeron, 1990), they are often unquestioned but can have dire effect on students. None of these beliefs or practices is necessarily spurred by malevolence; it is simply how things are done. However, in uncritically accepting the norm, even well-meaning biology faculty can become gatekeepers.

METHODS

Adding Writing and Changing Pedagogy

The following study features pedagogical experiments testing alternatives to traditional

teaching practices. The endeavor is framed as narrative to capture the emergent way the reform evolved, and the authors hope that others might identify with the authors’ concerns, benefit from their insights, and generalize from these particular endeavors to strengthen the experience of biology students across the board.

This study was started in 2014, in co-author and biology faculty member Land’s 4th year after tenure at a mid-sized, comprehensive, private university. At this time, he happened to teach a summer school course that had very low enrollment (by biology standards), only 22 students. It was impossible to ignore the fact that this group was far more engaged in their learning than generally found in his larger classes. Thinking like a scientist, he wondered why and began imagining pedagogical experiments. However, he might never have tested any of his theories were it not for another serendipitous event. In the fall, he joined a science faculty learning community, sponsored by the campus Writing in the Disciplines Program, run by co-author Camfield. He was initially hesitant to join because the main requirement was to incorporate more writing into classes, questioning how he might do that with 80-100 students per class. However, in part because of his friendships with and respect for the members of the group, he decided to try. During monthly meetings with science faculty from geosciences, mathematics, and physics, they discussed strategies: ideas for lab notebooks, process-narration of mathematical problems, and capstone essays. However, Land’s doubts continued to persist and took two forms: practical (e.g., Where was there room for more writing in introductory biology?) and cultural (e.g., How would adding writing impact the rest of the biology department, since there were multiple sections of the course?).

Nevertheless, he began to reflect. In upper division courses, students are often expected to compose research papers, grant proposals, and posters – even though students are never formally taught writing in courses beforehand. Contemplation of this dichotomy created a more focused question: When should programs incorporate writing into the curriculum? Perhaps the best time is during students’ foundational experiences in introductory biology. Writing not only helps stimulate critical thinking but also helps students develop the organizational study skills that could help them navigate a major that has traditionally been a “weeder.” It also signals that writing should be expected in all classes, including science courses.

In spring 2015, for two sections of introductory biology (one with large enrollment, one with small) Land added a major essay question on each of the three major midterm exams. The students were taken aback. Nothing was done to allay their misgiving; they were just expected to write. No surprise,

answers and their attitudes about writing were lackluster. He was also overloaded with grading. One might term this experiment a failure.

Even More Writing

Land recognized that the first hypothesis (that merely adding writing would automatically improve student learning) was incorrect. In the fall 2015 semester, he became more intentional, also keeping “field notes” about what he observed in his classrooms. At Camfield’s suggestion, he became more transparent in his teaching, explaining to students that writing could be a means to improve their understanding of the course material. This effort involved implementing short daily “writing wraps” at the end of each class where students summarized two main points from the lecture (Angelo & Cross, 1993). His intention was to give them practice so they would do better on the exam. Soon he came to realize that the wraps did much more, but first he had to push through student recalcitrance. Initially they resisted writing wraps; the responses he received were either blank or incomprehensible. He explained that failure to complete a writing wrap could be due to poor attention skills or a lack of preparation for class. In class discussions, he asked the students to reflect on the reasons why they were struggling. In dedicating this time, he simultaneously signaled the importance of this activity and helped students practice metacognition. They persevered. After a couple of weeks, students were anticipating the wraps at the end of class and there was improvement in their quality. From a workload perspective, it is important to note that he did not read every student’s wrap, but he did collect all of them and scan the responses to derive general impressions. He also encouraged students to use writing wraps outside of class as a study tool.

At the same time, he became more mindful about how he was constructing essay exam questions and became much more careful about providing instructions for how students should compose an answer. As his questions became more focused and manageable, he also talked with students about thesis writing, supporting paragraphs, and concluding with a “wow effect.” Essay responses on the first midterm were better than the previous year’s. He believed there was a direct link between the wraps and this improvement, but he knew it could be even better. So, instead of summaries, he started having students write thesis statements that captured the day’s class. This encouraged students to actively engage during the class and to spot relationships between concepts. Students rose to the challenge, and attitudes about writing were improving. They had almost 100% participation (even though the wraps were still not mandatory) and used this format for another 2-3 weeks in the semester.

He then had students peer review one another’s thesis statements for the rest of the semester, arguing

that two students might not have the same statement and that it was valuable to see what others surmised. He gave students about 5-7 minutes at the end of each class to analyze things like relevance, breadth, and depth. Students were encouraged to be critical, to disagree, and to not just rubber-stamp their peers’ papers as “good,” but to also avoid being overly harsh or unfair.

To be clear, the intention of adding writing to the class was not to make them master writers by the end of the semester but rather to help them more actively engage in their learning and to change their attitudes about writing in science classes, recognizing it as an excellent study tool for digesting course material. Land argued that clear writing was indicative of clear, logical thought processes and muddled writing was often reflective of illogical or unorganized thinking. In this way, he hoped to move students from seeing memorization and regurgitation as the main learning tasks of the class. Moreover, he no longer took it for granted that students knew how to study for the class and kept up a steady stream of general tips and strategies.

Along the way he became more understanding of students’ frustrations and responsive to their expressed concerns that the exam time limits forced them to rush on their essays and do less than their best work. Therefore, he began offering the opportunity for them to revise their midterm essays for a small number of points. At the end of the semester, students also had to reflect on their own development as writers by assembling a writing portfolio of their 3 essays, the 3 (optional) revisions, and a survey of their attitudes about writing.

RESULTS

Impact on Students

Because the authors of this article did not set out with the intention of studying the impact of these pedagogical interventions on student *performance* in biology class, it is difficult to make claims in this area. As published elsewhere (Camfield, McFall & Land, 2015), we knew that students in smaller classes out-performed their counterparts in larger classes on exams and in labs. Moreover, student writing in the wraps and on the exams seemed to improve over the course of the semester, from stream-of-consciousness associative writing to more focused arguments. We also have published elsewhere on the importance of positive student *dispositions*, particularly self-efficacy, as a proxy for subsequent skill development (Camfield, 2016) and on the degree to which student *attitudes* are more malleable in the short-term than their abilities and, therefore, are worthy of assessment (Camfield, 2015). For the purposes of this study, understanding student degrees of engagement with their learning best demonstrates the impact of the changes in the faculty’s attitude and pedagogical strategy. Evidence was gathered from students using

three instruments: a comprehensive survey, the writing portfolio learning reflections, and a summative focus group interview.

The survey

The survey was distributed as a write-in questionnaire at the end of the semester to all students enrolled in both sections of the introductory biology class. Students were given class time to complete the surveys, Land was not present as they were being completed, and students were assured of anonymity. Results pertaining to student attitudes about their levels of engagement with the course (i.e., senses of relevance, enjoyment, empowerment), about their perceptions of the faculty member’s engagement with their learning needs, and about their own learning were illuminating, indicating extremely positive attitudes about the course and the instructor. Interestingly, responses from the larger class seemed even more favorable than those from the smaller class, even though grades were higher in the smaller class. More significantly, the vast majority of students believed they could best demonstrate their learning through writing, not multiple choice questions. Given that this was a specific pedagogical innovation being tested in the classes, understanding more about student attitudes about writing further reveals the impact of the course.

Writing portfolio reflection.

At the end of the semester, students were asked to gather their exam essays and optional rewrites into a writing portfolio for which they were required to compose a reflective statement. In addition to narrative responses, students were asked to evaluate their attitudes about writing (Fig. 1) and about themselves as writers (Fig. 2) based on a Likert scale. As with the previous survey, responses here were positive.

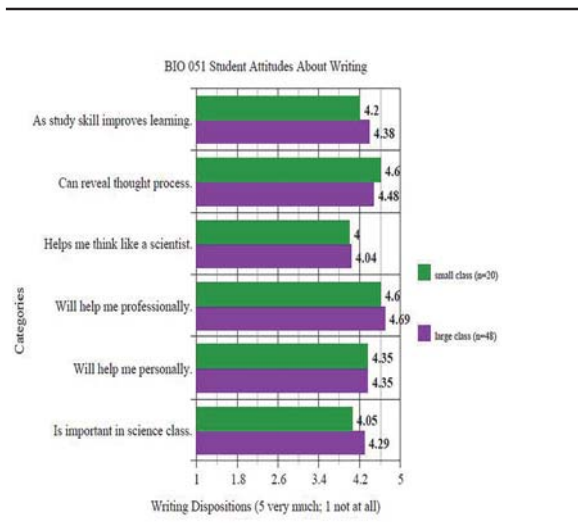


Fig. 1. Student attitudes about writing.

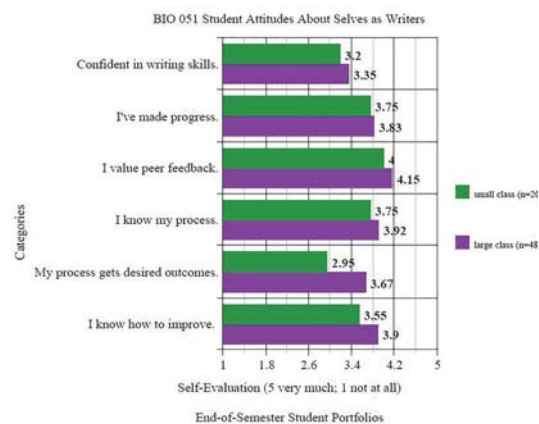


Fig. 2. Student attitudes about themselves as writers. Student attitudes about themselves as writers were a bit more modest, but still informative.

Most salient is the fact that all students recognized they can benefit professionally from writing well. Also gratifying was the fact that all students reported strongly valuing feedback from their peers, indicating they recognized how writing wrap peer reviews improved their communication of key ideas. Further, positive attitudes about peer review signaled student readiness for participation in collaborative forms of doing science.

Focus Group Interview

What closed-ended surveys miss is the nuanced and organic quality of face-to-face conversation. In order to illuminate and understand students’ lived experience of the classes, on the day the surveys were distributed, students were offered the opportunity to sign up for a focus group interview conducted by Camfield and a graduate student assistant. The interview was pitched as an opportunity for students to add detail to or raise issues not captured by survey items. Participation was voluntary, their identities would not be shared with the instructor, and their only compensation was a pizza lunch. The small group, composed of students who all had Land for the entire year (both fall and spring), met for an hour. Conversation was subsequently transcribed verbatim and coded for themes pertaining to engagement.

Some of these themes that related to liking the course simply confirmed what the survey had previously revealed. Other more complex motifs emerged. For these, the students’ own words will be used to capture their depth of meaning. Students extolled Land’s lecture style; they referred to his “stories” that made concepts memorable and called lectures “more like conversations.” His “interactive” approach “forced you to think on your feet” which “gave more motivation to learn biology.” Many associated this with being in the smaller class and compared Land’s teaching style favorably against their high school experiences.

The writing wraps were seen as “extending the conversation” beyond the lecture and allowed students to identify Land’s “code words” that signaled a concept was likely to appear on an upcoming exam. The wraps helped “brainstorm for the essay in advance.” One student observed that “biology is a lot of facts and to be able to put them all together [through writing] really helped me understand biology in general.” Writing on the exams provided “a way of taking smaller concepts and making connections [so that] you were almost re-learning it while you were writing the essay.” Essays allowed them to “defend their ideas” and “explain their thought process” in ways closed-ended multiple choice questions did not.

However, many did not start the semester with such a positive attitude about writing. Initially some thought it was “tedious” and doubted they could “encompass everything down into one idea.” One student confessed she “didn’t understand the purpose of it at the beginning” but came to see the wraps “helped you come up with ideas for the essays.” When asked if Land should have better explained the purpose of the wraps, other students chimed in that he did do that effectively: “He said you should be able to summarize the things you learn simply, to show that you actually understand it.” Indeed, they appreciated his recommendation that they write wraps in all of their classes because “it’s important to be able to see the connections.” Many then described links between their biology and chemistry classes.

The focus group also fleshed out the ways they believed writing would benefit them professionally. One particularly memorable response came from a student who connected his father’s professional struggle as a dentist whose first language is not English to his own future work as a dentist, recognizing the need to communicate with colleagues “clearly and memorably.” Another was well-aware that while she would “not have to write a thirty-minute essay in [her] professional career,” she would have to “organize her thoughts” and “make sure concepts are clear in her head.” The “process of writing” was important.

They valued peer feedback because it gave learners a “safe space to test out ideas” and to “see if others could follow the [author’s] thought processes.” Students lauded Land’s direction to just “find something the author could add, even if it’s not something that is wrong.” It seemed particularly liberating to be able to offer suggestions as “just a thought.”

Interestingly, several students were surprised to learn Land’s reputation according to students in other sections of introductory biology: “In lab, everyone asked me ‘who’s your lecture professor,’ and I said ‘Land,’ and they said ‘I’m so sorry for you; he’s so hard.’” Yet, the students in the focus group did not believe they were deserving of sympathy. They

recognized: “He wants you to understand...to learn better. You realize actually he’s helping you figure things out for yourself rather than him just giving you the answer.” One said: “A lot of people are afraid of his teaching style and the writing, but I think it’s actually really effective and more professors should do it.” They believe he has “adjusted” his techniques, becoming not easy, but “what he does makes more sense.” Students also recognized in making his PowerPoint slides available before class, in providing sample test questions, and in allowing rewrites of the exam essays, he was setting them up to be successful.

Others favorably compared their experiences in Land’s class to the experiences of their friends in other sections of biology. One revealed his sense of empowerment when he reported:

“I was studying with some people who don’t have Dr. Land and they were just going through the material trying to memorize terms. They were trying to convince me that I didn’t need to interact deeply with the material at all, just to memorize surface stuff. It was actually very irritating because I was like, ‘No, it is important that you understand because...you might actually discover something.’” They were inspired by Land’s “passion” and “intensity,” and this extended outside of the classroom. They believed “you have to make life a field trip,” not “like high school where you’re just regurgitating for a test.” Affectionately, they confessed: “Because Land is such a character, he doesn’t make you feel weird for wanting to know more or for wanting to ask more questions or to do outside-of-class thinking.” In their peers from other classes they “don’t see that as much.” Land has entered their hearts and minds to the extent that for some he has become an ally, an inner voice: “Sometimes you can be eating or walking to class and you suddenly say something weird biologically-related. Inside you’d be like ‘Land would be proud,’ even though I might sound weird right now, at least someone gets it.”

Such rich, thick description of the student experience partially demonstrates the power of engaged pedagogy, but what about its impact on the teacher?

Impact on Faculty

Looking back, Land realizes the degree to which he had become somewhat dissatisfied with his teaching, how far he had drifted from the impulse that initially impelled him to become a biology teacher. Ironically, while he feared the grading load associated with added writing, he underestimated that the corresponding exhilaration would offset the extra labor. The experience is one that demonstrates the reciprocal nature of gratification. As Land became more inspired, his students became more engaged, which in turn triggered his creativity and commitment – a beneficent cycle.

DISCUSSION

Readers may take note of three salient aspects of this narrative. First, throughout this process Land drew on his training as a scientist: He began experimenting with new teaching approaches, developed hypotheses, tested his ideas, kept field notes, recursively tweaked experiments to elicit different results, and developed a new theory that informed his pedagogy. Thus, even though it initially felt alien for him to include writing in his curriculum, he tapped into a methodology with which he was very familiar. Through the iterative process, Land came to realize he had the expertise to include writing-as-a-learning-tool and doing so did not necessitate sacrifice of essential course content. “Teaching like a scientist” also provided his students a model for their own inquiry, improving their perceptions of their learning, experiences in lab, and overall attitudes about the role of writing in studying and thinking. In these ways, “teaching like a scientist” can enhance the teacher-scholar model that has been adopted by many liberal arts colleges nationwide.

Secondly, some faculty fail to persist if a pedagogical innovation fails the first time it is tried. Land stuck with it and discovered that the antidote to bad writing on the mid-term essays (year one) was *more* writing (wraps with peer review, year two), not *no* writing. Therefore, sometimes pedagogical solutions may feel counter-intuitive but are worth exploring. The strong relationships he forged with key faculty development administrators also helped activate changes in his perspective and sustain his persistence. Additionally, intentional efforts to change one aspect of a course can trigger other efforts toward improvement (i.e., you cannot just “fix” one thing). Conversely, those things that are barriers to student learning success may also be barriers to faculty gratification.

Thirdly, the inherited practice that colors some faculty members’ attitudes about student success – that in order for there to be winners, there must be losers – must be critically examined. Readers should note that Land changed nothing in his curriculum; he simply made efforts to ensure all students received instructions on how to study effectively. There is a saying that a rising tide lifts all boats. When applied to undergraduate biology classes, we can say more engaged teaching empowers all students, and instructors can be lifted along with the tide.

Land’s departmental colleagues have become interested by what he is doing. “Engagement contagion” spreads – although more slowly than expected. It took almost two years for some to get curious; now another colleague will be implementing periodic writing wraps in her upper division genetics course. This will provide an opportunity to compare the retention of material, depth of thought, and quality of writing between students who had writing

in their introductory classes and those who did not have those experiences. The authors of this article also move forward with increased commitment to optimize student success and intend to continue experimenting. Up next will be piloting writing intensive sections of introductory biology courses for “at risk” students with enrollment caps of 20 students and with take-home essay exams that allow students ample time to express their thoughts. As we determine the best ways to sustain our model, we move forward with optimism.

ACKNOWLEDGEMENTS

Funding for these projects provided by internal Pacific Fund grants.

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