Beyond Reflection: Using ePortfolios for Formative Assessment to Improve Student Engagement in Non-Majors Introductory Science

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ABSTRACT

Success rates in non-majors introductory biology courses tend to be lower than those in courses for majors. The use of student learning ePortfolios correlates with increased retention and improved learning. Additionally, when ePortfolios are used for periodic formative assessment, they have been shown to stimulate student response to feedback and improve the quality of student work—both indicators of increased student engagement. In our study, the implementation of low-stake assignments in ePortfolio fostered a dialogue between the instructor and student outside of class time and provided opportunities for formative assessment of individual student and overall class learning prior to larger, high-stakes summative assessments. Furthermore, ePortfolio allowed the instructor to give students feedback on their work, creating opportunities for confirmation of learning or extended learning outside of class. Through intentional and embedded use of ePortfolios, we have created a learning environment that fosters more interaction with course material outside of class, better assignment turn-in rates, and improved exam scores, for increased success rates in the course. These results describe a promising intervention that can improve success rates in introductory biology courses.

Key Words: *ePortfolio; portfolio; engagement; assessment; biology; student success.*

○ Introduction

Introductory college science courses have low success rates, particularly for non-science students (hereafter referred to as non-majors). The literature attributes this lack of success to students' low learning motivation and inability to connect with the material. Even student perception that science is difficult can negatively affect a student's ability to do well in a science course. However, when students believe that they can do well in introductory science courses, they are more likely to persist in the course, and undergraduate students who persist in science courses have a higher graduation rate than students who do not take science courses. Further, science courses for non-majors are often a part of the general education requirement and therefore serve as a pre-requisite to courses in the major. Given the emphasis on science courses and the challenges non-majors students face in successfully passing them, we must make improvements in undergraduate science pedagogies that address these tensions.

Spurred by the emerging science of teaching and learning (SoTL) movement, biology educators are beginning to unpack the underlying causes of barriers to student success in introductory biology courses and address them with innovations in classroom pedagogies. In particular, the Association for the Advancement of Science's Vision and Change Call to Action (2011) recommends the use of active learning pedagogies in biology courses to support the learning paradigm of education reform that suggests less didactic instruction and more emphasis on student construction of knowledge. This shift toward a more student-centered approach to teaching and learning in undergraduate biology has the potential to improve student learning outcomes. It would appear then that innovations in introductory biology teaching are a direct route to improved persistence in the educational pathway and college completion rates.

One of the challenges of teaching introductory biology courses for non-majors is that students often feel disconnected from the material.

○ Student Engagement in Introductory Biology Courses

One of the challenges of teaching introductory biology courses for non-majors is that students often feel disconnected from the material. Rather than making associations between studying biology and the content in their majors, they see the non-majors course as a barrier to studying exclusively in their major. Increasing student engagement

can address these barriers and allow non-major students to be successful in an introductory biology course. Faculty who make an effort to connect with students outside of class (e.g., by encouraging students to participate in recitations or office hours) can improve engagement of students who are not intrinsically motivated. Ideally, faculty would recognize these students early and give each of them the individualized attention necessary to capture their involvement in the course; however, time restraints limit this level of commitment during class to improving engagement.

As scholars continue to grapple with the nuances of student engagement, more recent work grounded in student engagement theory describes three domains of student engagement: emotional, cognitive, and behavioral. Emotional engagement relates to students' feelings about the content and classroom environment, and cognitive engagement relates to student's willingness to personally invest in the learning process. Behavioral engagement encompasses a broader range of activities related to student interaction with the course and classroom activities themselves, including completion of homework or in-class tasks, asking questions during class, and "paying attention." Although all three of these domains contribute to overall student success, as instructors, we can have the most influence on cognitive and behavioral engagement. Therefore, this paper will focus here on the interface of cognitive and behavioral engagement and their role in student learning in an introductory non-majors biology course.

○ Using Formative Assessment as a Tool for Behavioral Engagement

Knowing where students are excelling and where the gaps in their knowledge lie is an important part of planning the kind of learning activities that most engage students. This can be achieved through formative (continual and ongoing) assessment. Bell and Cowie (2001) describe formative assessment as a process by which teachers and students can respond to and enhance student learning "during the learning." However, college learning environments tend to rely heavily on summative assessment through exams. Although summative assessments are important in evaluating learning outcomes, they contribute very little to student learning, as they generally occur at the end of a module or concept block. Therefore, the learning-centered biology classroom should also employ formative assessments, which allow both student and instructor to be able to identify gaps in knowledge.

Kuh, Pace, and Vesper (1997) highlight quality feedback on student work as an important instructional practice to promote engagement. Through timely feedback and encouragement for improvement, the instructor facilitates student capacity to focus on the learning they need to meet the instructor's expectations of understanding. Providing feedback on student work also shows a professor's interest in student's attempts at learning, which can foster engagement through appreciation. Understanding students' grasp of the content in real-time also allows the instructor to stage as-needed learning interventions on an individual or whole-class basis. Therefore, we can see that the use of formative assessment in a biology classroom can improve student competencies "by short-circuiting the randomness and inefficiency of trial-and-error-learning" (Sadler, 1989, p. 120). Many researchers correlated

the use of well-implemented formative assessments with an increase in student conceptual learning.

A growing body of literature suggests that many science educators are not using formative assessment productively. Instructors are assessing the wrong aspects of the curriculum (case study details vs. concepts), choosing the wrong methods of assessment (open-ended writing without proper guidance), and taking too long to respond to student work. As science educators' current examinations of effective use of formative assessment demonstrate, it is important that an instructor select the method of formative assessment carefully, then make sure that she has the time to implement it in a way that is beneficial to student learning.

○ Student Learning Portfolios for Formative Assessment

Traditional Portfolios

The impact of constructivist learning theory on educational environments has resulted in a large-scale effort to support active learning pedagogies that support integration of knowledge. In theory constructivist pedagogies should enhance application of knowledge. To put theory to practice, instructors have sought ways to facilitate student growth through learning acquisition. As previously discussed, one proposal from the education reform community was to move away from traditional knowledge assessments (summative assessment) toward tracking student acquisition of intermediate learning goals (formative assessment). Best practices in this method of instruction encourage giving feedback to students in a timely manner. In doing so, instructors and students can work together to create a learning environment that supports depth and application of knowledge instead of superficial learning. One way to assist this process is to incorporate the use of student learning portfolios in the classroom.

A student learning portfolio is a student-curated collection of the student's work that provides evidence of their progress, application of learning, and achievement by creating a physical record of student growth over time using learning artifacts. In recent years, there has been a shift in portfolio pedagogies to include space for student self-reflection and self-analysis of work to support students as engaged learners. By viewing student evidence of work together with student reflections on their progress, instructors can use student portfolios to evaluate learning performance.

Hays (2001) described the use of portfolios in medical science education as a means to evaluate how well instruction is being delivered and received. Portfolios in the medical sciences have also been successful in facilitating integrated learning by allowing students the space to make visible connections across content and formative assessment of applied knowledge.

Using a planned cycle of student input of evidence → instructor feedback → and student reflection promoted student awareness of growth in learning. Hays observed that receiving constructive feedback helps students develop their personal learning pathway, which is an important tool, particularly for scientific inquiry.

Giving prompt and constructive feedback to students on their laboratory reports is a best practice at all levels of science study because it provides an additional learning opportunity for students

and an opportunity for instructors to assess student learning between topics.

Electronic Portfolios (ePortfolios)

One criticism of the learning portfolios is that the feedback/review process can be cumbersome and time-consuming because instructors not only have to find the time to review the portfolios, but also create a way to comment on the portfolio (generally, by writing or typing feedback or scheduling a discussion with students). Although instructors appreciate the learning benefits of portfolio building, they often abandon the effort because they can't overcome this hurdle. One way to minimize this hurdle is to use portfolios on a web-based platform (ePortfolios) that hosts student portfolios and supports commenting directly in the portfolio by an outside viewer. The portability of ePortfolios allows students to curate their portfolio wherever they have access to a computer and an internet connection. It also allows the instructor to give feedback in the same portable way, so that students receive online feedback immediately. By responding to quick, low-stakes reflective assignments, an instructor can use the ePortfolio to give individualized support to students outside of class and for formative assessment.

The National Science Teachers Association (NSTA) advocates for the use of collaborative technology and blended learning experiences to enhance the science classroom experience, and cites the ability of thoughtfully integrated instructional technology to promote interactions between instructor and student beyond the confines of the classroom, which in turn promotes learner-centered engagement and overall academic growth. Previous studies have highlighted ePortfolios as improving instructor-student and student-student communications, supporting collaboration and learning exchange outside of class.

The process of reflecting on and rationalizing the inclusion of artifacts selected for a student's ePortfolio promotes higher-order thinking and integrative learning, as students visibly connect knowledge across content areas to show evidence of learning. Perhaps the stimulation of deep learning and connection to the material is why students who used ePortfolios in three large-scale studies at community and four-year colleges had a cumulative rise in course pass rates, grade point averages, retention, and persistence.

Implementation of ePortfolios as evidence of growth in student learning has been successful in the humanities and medical education, and we propose this same use to be beneficial for learning in introductory biology classes as well.

In this paper, we examine how ePortfolio as a teaching and learning tool can be integrated into the classroom to support retention of knowledge and content mastery. Combining the principles of engaged learning with ePortfolio pedagogy, we propose the use of ePortfolio for formative assessment in an introductory biology course. Using a quasi-experimental, explanatory, mixed-methods approach, this study compares the level of engagement in four sections of a non-majors introductory undergraduate biology course (hereafter referred to as Intro to Bio) at a public urban community college. Qualitative data collected from student and faculty surveys, as well as quantitative survey and grade data, allow us to assess the efficacy of the use of ePortfolios for learning interventions outside of class, as well as for active learning pedagogy during class. By studying the influence of ePortfolio use in a biology classroom setting, we hoped to demonstrate the effectiveness of ePortfolios in formative assessment and establish correlations between ePortfolio-based formative assessment and student engagement.

○ Methods

Aim

The aim of this study is to show that students in an introductory biology course that uses ePortfolios for formative assessment are more likely to interact with course materials outside of class time and perform better than those that do not. Furthermore, we hope to show that the use of ePortfolios in this manner also correlates with increased student performance.

Population & Context

This study was completed in Intro to Bio, a non-majors biology course at a small urban community college with nearly seven hundred enrolled students, 90 percent attending full-time. Eighty-seven percent of the students identify as Hispanic, Black, or Asian/Pacific Islander. The Intro to Bio enrollment mirrors that of the college, and the majority of students in the course were full-time students of color.

Seventy-eight first and second year community college research subjects were enrolled in four sections during two subsequent semesters of Intro to Bio. All sections used a common course ePortfolio template, managed by the instructor, as a digital repository for all course-related material, including the syllabus, daily schedule, and related course information, as well as copies of the lecture slides, supplementary educational material, and a digital bulletin board of supportive information (e.g., events, links to current media articles, study groups, etc.).

Thirty-six of the students were in a control group, and 42 were in an experimental group. Students were not aware which group they were assigned to. In the control group, the instructors curated and maintained the basic course ePortfolio as previously described. The instructors used responses to a series of discussion questions pertaining to the lecture topics as formative assessment. In the control group, students were assigned to type or write their responses to the questions on paper and to turn them in during class a week later, at the next course meeting time. It should be noted that all students at the community college have their own ePortfolio, but are not necessarily required to use them in every course. Thus, students in the control group were given the option to create a section for the course in their personal ePortfolios to submit the low-stakes assignments. However, the course default was that students would turn in their work during class (Figure 1).

In addition to using the course ePortfolio template, the experimental group's course ePortfolio contained post-class notes from classroom discussions, class data from experiments, or other opportunities for learning extension on the topic. Additionally, the course ePortfolio is used during the class as a teaching tool to access lecture slides and other course materials. A modeling exercise was presented so that students would know where to access information from the course ePortfolio outside of class and could refer to the supplemental material to bridge any gaps between what happened in class and meeting the expectations for work done outside of class.

In the experimental group, students were given two days to respond to the discussion questions in their personal ePortfolios, and were told that the instructor would respond to individual

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	Module 1 lecture A		Module 1 lecture B	Module 1 lab			
				Module 1 discussion questions assigned			
Week 2	Module 2 lecture A		Module 2 lecture B	Module 2 lab			
				Module 1 discussion questions due			
Week 3	Module 3 lecture A		Module 3 lecture B	Module 3 lab			
				Module 1 discussion questions returned with feedback			

Figure 1. The module schedule of the control group.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week 1	Module 1 lecture A		Module 1 lecture B	Module 1		Module 1 discussion questions due	
				Module 1 discussion questions assigned			
Week 2	Module 2 lecture A		Module 2 lecture B	Module 2 lab			
	Module 1 discussion questions returned with feedback by this date						

Figure 2. The module schedule of the experimental group.

student work before the next class meeting (Figure 2). Within two days of the assignment due date, the instructor used the comment function in the students' ePortfolios to give feedback before the next class meeting. Students in the experimental group had an additional required low-stakes assignment: the instructor posted a general concept question about the topic to the course ePortfolio, and students were required to respond to the question in the comments group of the ePortfolio page. Also, students were encouraged to comment on each other's responses.

Data Collection

A quasi-experimental research design was selected to account for the lack of random assignment of students into the course sections. Students were not randomly assigned to the control or experimental groups by the researcher; rather, students were assigned to course sections by self-enrollment or by advisor enrollment. The four sections were taught by two instructors, and each section was randomly assigned to the control or experimental group of the course after enrollment was complete.

   To measure engagement, I measured the following:

1. The number of times students viewed the course ePortfolio outside of class;
2. Self-report study of student ePortfolio use outside of class;

3. The number of low-stakes assignments students turned in;
4. Survey response regarding faculty's attitudes toward student engagement through ePortfolio.

Six weeks into the semester, students answered a survey with three specific questions about their own self-guided study habits. I compared the number of times students in the control and experimental groups viewed the course ePortfolio outside of class. At the end of the semester, both instructors also responded to this open-ended question: Please describe the steps you took to engage students during the semester. For the experimental group, faculty were also asked to reflect on the feedback aspect of the student ePortfolios.

   Another measure of engagement was a comparison of the rate at which students in the two groups turned in the low-stakes assignments. To measure performance, we compared final course letter grades for the control and experimental groups.

Data Analysis

To count the number of ePortfolio views outside of class time, we recorded the number of views for each course ePortfolio at the beginning of each class and at the end of each class (the number of views during class time). Then we subtracted the number of ePortfolio views during class time. The remaining views were those that occurred between class meeting times (outside of class). Adding all of these times together gave us the number of views outside of class for the entire semester.

   Reponses to the survey, assignment turn-in rates, and final grade comparisons between the control and experimental groups were subjected to statistical analysis by t-test. Each statement in the open-ended reflections from the participating faculty were categorized as positive or negative by a research assistant. Those responses were then independently categorized by a researcher. If there was a disagreement between the two researchers, a third researcher categorized the response as positive or negative and had the final decision.

○ Results

EPortfolio Views

Over the course of the study, students in the experimental group accessed the course ePortfolio outside of class time shows 2.7 times more often as those in the control group (Figure 3). Table 1 shoes that almost twice as many students in the experimental group reported using ePortfolio to prepare for class than those in the control group. Students in the experimental group also reported using ePortfolio as
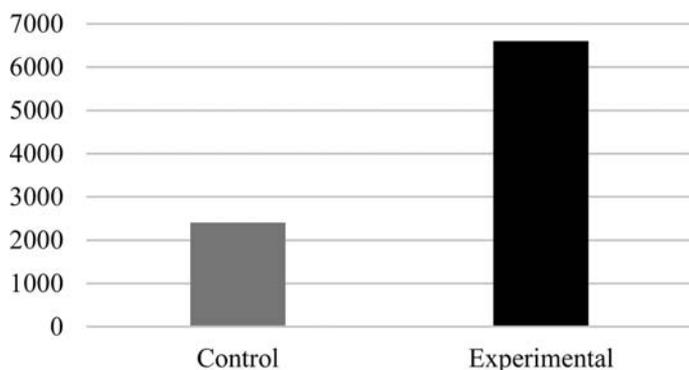
Course ePortfolio Views

Figure 3. Total number of times students accessed the course ePortfolio outside of class for the control (C) and experimental (E) groups.

Table 1. Student survey of ePortfolio use in control (C) and experimental (E) groups.

	C	E
I check the syllabus on the course ePortfolio.		
Never	30%	24%
Once a week	35%	29%
Two or more times a week	35%	47%
I view/download the lecture slides from the course ePortfolio before coming to class.		
Yes	24%	45%
No	24%	40%
Not yet, but I plan to	48%	15%
To study for this course, I use:		
My class notes	22%	100%
The textbook	56%	43%
Material from the course ePortfolio	89%	100%

C = control (*n* = 36); E = experimental (*n* = 42).

a study aid more than 10 percent more than those in the control group. Furthermore, students in the experimental group referred to the syllabus more often during each week on the course ePortfolio than those in the control group (Table 1).

Student Performance

The turn-in rate for the low-stakes assignments was also higher in the experimental group than the control group (Figure 4).

Students in the experimental group consistently scored higher on exams than those in the control group (Figure 5). Accordingly, the higher exam scores were associated with better performance, as more students in the experimental group earned an overall letter grade of C or better than those in the control group (Table 2). Interestingly, the percentage of students earning an A in the
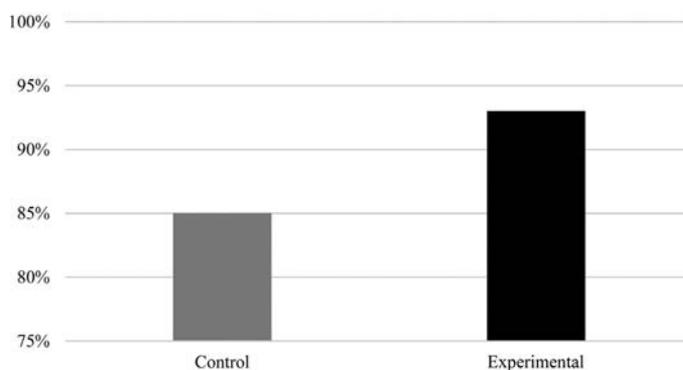
Turn-in Rate

Figure 4. Percentage of assignments turned in during the entire course for the control (C) and experimental (E) groups.
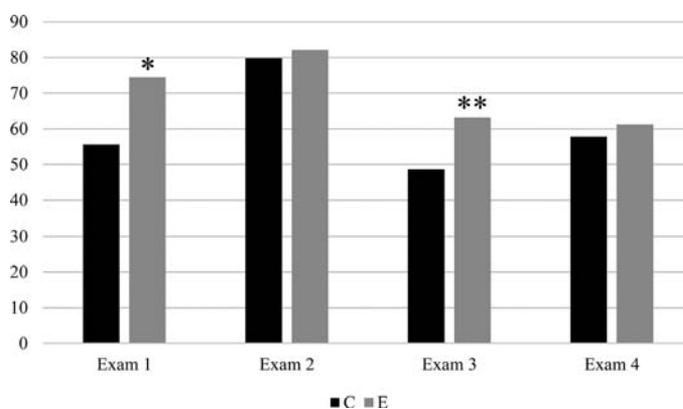

Figure 5. Student exam scores in the control (C) and experimental (E) groups. Grades are calculated on a 100% scale. * $p < 0.01$; ** $p < 0.05$.

Table 2. Final course grades in control (C) and experimental (E) groups.

Course letter grade	C	E
A	6%	24%
B	19%	21%
C	47%	38%
D	17%	7%
F	11%	10%

experimental group is also higher than those in the control group ($p < 0.05$).

Instructor Feedback

At the end of the semester, each the instructors teaching the experimental group responded to the prompt: Please describe the steps you took to engage students during the semester. For the experimental group, faculty were also asked to reflect on the feedback aspect of the student ePortfolios. In both the control and experimental groups, instructors also encouraged students to go to tutoring sessions. The majority of comments were coded as positive and included the following statements:

- "Using the comments group of the course ePortfolio as a discussion space encouraged high student participation and allowed students to identify and correct inaccuracies in each other's posts."
- "The fact that the students knew their answers were public to the class in the ePortfolio meant that in general students put thoughtful effort into their responses."
- "Many students noted in their end of the semester course evaluations that they found [the ePortfolio use] to be the element in the course that most positively impacted their learning."
- "The opportunity to engage students in topical discussions outside of class time provided depth to the topics and gave students the latitude to explore the topics on their own terms."

The two negative responses had to do with the time investment of formative feedback. However, both comments were countered by the faculty in describing the benefits of the practice.

- "It took more time to write a really good reflection question that could give a good assessment of student learning than it would to throw together a multiple choice quiz. But, at the end of the week, I really did know what students knew. I realized that quizzes were really great for vocabulary, but did not necessarily indicate students understood the concepts."
- "It took almost an extra 2 hours each week to go through the reflection questions and comment on each one. But I do think I saved time in class because I wasn't baiting students 'Are you guys getting this? Does anyone have questions? Are you ready to move on? Yes? No?' and waiting for students to be brave enough to speak up. Also, they did better on the quizzes and I only had to go over one or two questions rather than the whole thing. So I guess it all evens out."

○ Discussion

The results presented here support our hypothesis that students in a non-majors introductory biology course using ePortfolio would be more engaged than students not using ePortfolio, as evidenced by an increase in students interacting with online course material outside of class time and an increase in assignment turn-in rate. Furthermore, the data show a correlation between ePortfolio use and increased student performance. More students in the experimental group earned a grade of C or better upon completion of the course, with almost a 50 percent increase in the number of students earning a grade of A or B. This agrees with previous studies of students using ePortfolios in humanities courses in a community college environment

As most students in both the control and experimental groups used the course ePortfolio to study and prepare for class, some portion of the high number of course ePortfolio views by the experimental group may be attributed to the post-class notes and materials that the instructor posted after class and to the instructor's requiring students to complete the low-stakes assignments on the course ePortfolio. Nonetheless, we believe that the combination of pre- and post-class materials on the course ePortfolio created a multimedia platform containing "reusable" objects that students could use outside of class as a learning resource and as a way to stay connected to the material between classes.

The increase in the number of low-stakes assignments that students turned in between the control and experimental groups can also be attributed to the ePortfolio platform. In the control group, students were given the assignment at the end of the lab session, and then turned it in a week later at the beginning of the next lab session, finally receiving feedback at the lab session after that—two weeks after the material was covered in class (Figures 1 and 2). Using this method, the course has moved on to new content before the instructor has a chance to give feedback to students. It is possible that the opportunity for students to get timely feedback via ePortfolio accounted for the increased turn-in-rate. Additionally, the instructors reported that many students in the experimental group took the opportunity to revise their assignments before the next class meeting, further increasing their engagement with course materials. Stellmack et al. (2012) reported a similar observation and concluded that the promise of pleasing the instructor motivates students to revise and resubmit work, and that the increase in grades is a positive side-effect.

The digital platform of ePortfolio provided a decreased turn-around time between assignment submission, feedback, and revision, and also allowed the instructor to direct students that needed extensive help to academic support before the next class meeting. Therefore, these opportunities for formative assessment between classes enhanced the student-instructor relationship by increasing the amount of contact outside of class, which has a well-documented correlation with increased retention, student learning, and student's sense of belonging—all significant markers of student engagement, particularly in urban, commuter, and students of color such as those in our community college student population. These findings suggest that formative assessment via ePortfolio is an effective way to improve student engagement and performance for non-majors students in an introductory biology course. To continue to explore the linkages between ePortfolio, engagement, and performance, we will consider using other evaluative learning assessments common to both groups and then comparing those scores and completing a larger-scale study.

As non-majors introductory science courses have the highest dropout and failure rate across colleges nationwide, it is important to improve strategies for success. Student engagement is the most likely culprit, as the nature of the course itself is a barrier for student connection to the content. The findings in this article highlight the importance of formative assessment in creating a student-centered learning environment, and the role of ePortfolio in sustaining this practice by supporting timely and effective lines of communication between instructor and student. Though the research presented in this article focused on a small set of non-majors community college students, we find the data to have promising implications for connecting introductory biology students to learning. Instructors using embedded ePortfolios for formative assessment can perhaps think of themselves more as facilitators of a student-centered learning process by offering constructive feedback to students during learning, rather than providing judgment of learning through a high-stakes summative assessment toward the end of the learning pathway. Though it is not our intention to make generalizable statements based on this exploratory study, we believe that there is promise that the technique described here has positive implications to improve teaching and learning in introductory biology classes as well as courses in the major.

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