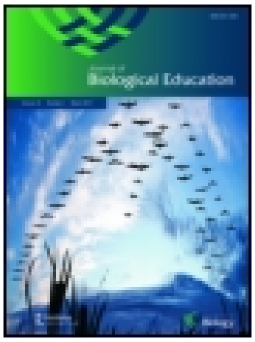

Journal of Biological Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rjbe20

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JOURNAL OF BIOLOGICAL EDUCATION
https://doi.org/10.1080/00219266.2021.1877782

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ABSTRACT
Gateway science courses are an ongoing obstacle to recruitment into STEM (Science, Technology, Engineering, and Mathematics) fields, in part due to the large gains in vocabulary that are fundamental to scientific literacy. Students also struggle to achieve the technological literacy necessary for a STEM career. We implemented an ePortfolio-based project in 12 sections of General Biology I (n = 164) at an urban community college. This project was designed to aid students at integrating general biology vocabulary around a central topic – an organism of their choice – while also increasing their facility in using ePortfolio. We assessed the effectiveness of the project using a set of 17 survey questions, 12 of which were also delivered to control sections. Students responded positively to the project, and the project was effective at increasing scientific literacy and understanding of the technological platform. However, the project did not help students make gains in technological literacy. This project demonstrates that integrating general course-specific vocabulary around a central topic may be useful in helping students succeed in gateway STEM courses.

KEYWORDS
Introductory biology; learning; stem; vocabulary

Introduction

With approximately 34% of all undergraduate students, community colleges are foundational to the American education system, providing the first higher education experience for many students who did not think college was accessible to them (Cohen et al., 2013; Snyder et al., 2019). Yet, many of these students are unprepared for the demands of college-level coursework. A national study of students who were tracked from eighth grade through college (from 1988 until 2000) showed that of those who attended community college, 58% required at least one developmental course and 14% required more than three developmental courses (Attewell et al. 2006). In addition to developmental education, it is commonplace for community college students to require help in developing technological literacy, defined as the ability to use, manage, and understand technology (Baskette and Fantz 2013; Pearson, Greg, and A. Thomas Young 2002). Thus, more than just providing an education, community colleges play a large role in determining a student's future academic success (Bowen 1977). These issues are particularly exacerbated within the STEM fields.

STEM students are a particularly vulnerable population in terms of retention and success metrics (Sithole et al. 2017). A critical window is their participation in their first STEM major's courses, often called 'gateway' courses due to their high failure rates. Such courses can be defined by three main criteria: foundational learning, high-risk of failure, and high enrolment (Koch and Rodier, 2016). Yet, for the most part, the interventions that have been implemented by colleges have focused on first-year seminars, learning communities, and orientation

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Supplemental data for this article can be accessed here.

programmes (Barefoot et al., 2005; Greenfield et al., 2013), while gateway courses have largely been ignored (Koch 2017). Early success in gateway courses has been linked to an increased completion of a bachelor's degree (Adelman 2005). Studies have also shown that excessive course withdrawals, typical of gateway courses, have a negative impact on transfer and degree completion (Adelman 2005; Cabrea et al., 2005).

These results are unsurprising, as these early courses provide foundational learning in scientific literacy, including an introduction to the working vocabulary of the discipline. While scientific literacy has a greater scope than the ability to engage with scientific texts (Benjamin et al., 2017), it is becoming increasingly recognised that this fundamental definition of literacy is critical to success (Richardson and Lock 1993; Francis and Simpson, 2009; Harriet et al., 2018). Unfortunately, it is becoming increasingly common to remove vocabulary from courses as more topics are added to the syllabus (Stahl and Gerard Shiel 1992). Further, studies have shown that vocabulary necessary for STEM literacy is learned only by the students who then integrate the vocabulary into their daily language as opposed to treating it as only useful within the classroom (Moje 2008). An obvious solution is to provide students with assignments that link classroom vocabulary to topics that are both familiar and interesting to them (Lesaux, Harris, and Sloane 2012). There is evidence that project-based approaches could be effective in helping students consolidate vocabulary and increase success metrics (Anderson, 2010).

Project-based learning has been used to enhance learning since the early 20^{th} century (Kilpatrick 1918). The main goal of project-based learning is to motivate active learning by linking new material to prior knowledge and interests to enhance cognitive integration (Cognition and Technology Group at Vanderbilt, 1990; Neo and Neo 2009). Project-based learning has been shown to be effective in stimulating students' problem-solving skills and interest in science (Han, Capraro, and Capraro 2016). A vital component of such projects is the need for them to pique the interest and curiosity of the students (Tamim and Grant 2013). Ideally, these projects can also be used to increase technological literacy.

Technology has become an integral component of modern society and is absolutely required for success in STEM fields (Mapotse, 2018). The reliance on technology courses is insufficient (Buss et al. 2015); strengthening students' technological literacy through supplemental training in other courses should be a priority. Low technological literacy rates are exacerbated in the community college student demographic, where socio-economic factors limit access to technology at home (Attewell 2001; Hesseldahl 2008; Ritzhaupt et al. 2013). Technological literacy is enhanced at <college identifiers removed> through the integration of the ePortfolio system (Arcario et al. 2013), which has been integrated into most courses. All students are required to create a personalised, or 'core' ePortfolio during their first-year seminar course. The core ePortfolio acts as a repository for work and reflection that students add during their time at LaGCC (Eynon et al., 2014). Students are trained on the ePortfolio system in their first-year seminar courses, which are supplemented with campus-wide training events. In addition to its impact on technological literacy, the use of ePortfolio has been linked to an increase in various student success metrics, such as integrative learning, inquiry-based learning and technology-based learning (Eynon et al., 2014). However, there is much work to be done on how to integrate ePortfolio effectively within individual courses.

In order to address these challenges, we developed a semester-long ePortfolio project for the General Biology I (SCB201) course for majors, which is a key gateway course in STEM. This course serves as a critical foundation for students' future success in higher-level science courses, such as General Biology II, Microbiology, and Cell Biology. Students enrolling in this course commonly have little background in biology and its vocabulary, as well as low technological literacy. The course has both high withdrawal rates and low passing rates. According to our 2019 institutional research data, 250 students attempted the General Biology I course, but nearly a quarter of the enrolled students withdrew and approximately 40% of those that remained received a grade lower than C. A preliminary vocabulary survey conducted for General Biology I students showed that most struggled with fundamental terminology. The main objectives of this project were to improve vocabulary and technological literacy for students in this course.

Overall, this project achieved its goals of addressing the unique challenges that Community college students have when taking an introductory STEM course. The project provides a simple and modular approach to addressing vocabulary, making connections of the subject matter to their lives, and scientific literacy. This project can be adapted to any STEM course and can provide a simple yet powerful way to increase STEM retention and learning.

Methods

Participants: Students were recruited from the General Biology I (SCB201) courses in Spring 2017, Fall 2017 and Spring 2018 at <college identifiers removed>. A total of 164 participants were used in this study.

Projects: The project was implemented in the laboratory portion of the course and composed of four units, with each unit linked to an important concept taught in the lectures. These concepts were water and its properties, cellular respiration and energy, mitosis and meiosis, reproduction and evolution. At the beginning of the project, each student chose an animal, plant, or fungus from the Arkive website (www.Arkive.org) that would serve as the basis for their project. Students created four short videos covering suggested topics in Biology that mirrored concepts learned in the course.

Students were required to make four short videos throughout the semester, each covering a specific lecture topic and due not long after the topic was covered (see Appendix 1 for guidelines and dates). In the first video, students analysed the water and air resources in their organism's habitat, including a full atomic and bonding profile for important molecules. In the second video, students linked their organism's food and macronutrients to the production of ATP through cellular respiration. In the third video, students created a model karyotype for their organism and described its life cycle, focusing on reproduction and growth. The video included meiosis, the developmental patterns of gene expression, and mitosis. In the fourth and final video, students used the Tree of Life website (www.tolweb.org) to classify their organism, assemble its basic phylogenetic tree, and generate a hypothesis for when it last shared a common ancestor with *Homo sapiens*. All videos were submitted on the ePortfolio site created by the instructor, where students could review each other's videos and provide comments.

Training of the ePortfolio system: All instructors teaching the experimental groups were trained in the use of the ePortfolio system through several institutional professional development seminars. All student participants took, or were taking, the required First Year Seminar course in which training to use the ePortfolio system was provided. All participants had established their own core ePortfolio page prior to conducting the project. In addition, students were able to obtain additional support from ePortfolio consultants and studios that are open college-wide at LaGCC. Students uploaded the assigned videos to designated ePortfolio folders prior to evaluation and analysis.

Video analysis: All student videos were assessed in three performance criteria: (1) use of vocabulary, (2) depth of understanding, and (3) digital proficiency. The rubric for assessing vocabulary and depth of understanding were adapted from Massachusetts Digital Literacy and Computer Science standard. The digital proficiency rubric was adapted from <college identifiers removed> Digital Communications Ability, which is used to assess video artefacts across the college as part of college-wide assessment efforts. All criteria were ranked using scores from 0–5, with 0–1 indicating a low level of competency, 2–3 indicating an intermediate level of competency, and 4–5 indicating the highest level of competency. For criterion 1, the use of vocabulary, low rankings were given to videos that incorporated little or incorrect biological vocabulary, while high rankings were given to videos that correctly and effectively incorporated biological vocabulary. For criterion 2, depth of understanding, low rankings were given to videos that showed limited comprehension of underlying biological concepts, while high rankings were given to videos that showed mastery of underlying biological concepts. For criterion 3, digital proficiency, low rankings were given to

Table 1. Survey questions 1–5 assessed student attitudes towards the ePortfolio project and their ability to relate it to relevant topics. Chi square analysis was used to compare the distribution of responses to a null distribution of equal responses. Possible responses were: strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD).

	Question/Statement	**SA (%)**	**A (%)**	**D (%)**	**SD (%)**	χ^2	**df**	*p*
Q1	What type of organisms did you choose for your ePortfolio project?	92.2	6.96	0.87	0	278	3	**<0.001**
Q2	Has the ePortfolio project been fun so far?	29.6	46.1	17.4	6.95	39.1	3	**<0.001**
Q3	Has the ePortfolio project increased your interest in biology?	23.5	37.4	33.0	6.09	26.6	3	**<0.001**
Q4	To understand biology, I sometimes think about my ePortfolio project and relate it to the topic being analysed.	18.7	44.3	25.5	11.3	25.4	3	**<0.001**
Q5	I related the important lecture information to the ePortfolio project.	25.2	51.4	16.8	6.54	42.6	3	**<0.001**

Table 2. Survey questions 6–8 assessed student facility with the ePortfolio software. Chi square analysis was used to compare the distribution of responses in the treatment group that was assigned the ePortfolio project to a control group. Possible responses to Q6 and Q7 were: strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD). Possible responses to Q8 were: ePortfolio office (O), peers (P), instructor (I), classmates (C), multiple resources (M), none of the above (N).

Question/Statement	**Group**			**SA (%)**	**A (%)**	**D (%)**	**SD (%)**	χ^2	**df**	*p*
I find the ePortfolio system easy to understand.	Treatment			19.3	43.0	28.9	8.77	7.80	3	**0.028**
	Control			11.6	41.9	34.9	11.6			
I had problems using the ePortfolio system.	Treatment			22.4	32.7	31.0	13.8	2.28	3	0.515
	Control			18.2	38.6	29.5	13.6			
Question/Statement	**Group**	**O (%)**	**P (%)**	**I (%)**	**C (%)**	**M (%)**	**N (%)**			
When using the ePortfolio system, I received support mainly from:	Treatment	23.9	1.77	28.3	22.1	15.0	8.84	37.3	3	**<0.001**
	Control	19.6	23.9	21.7	8.69	21.7	4.34			

Table 3. Survey questions 9–17 assessed student interest and enthusiasm for biology. Chi square analysis was used to compare the distribution of responses in the treatment group that was assigned the ePortfolio project to a control group. Possible responses were: strongly agree (SA), agree (A), disagree (D), and strongly disagree (SD).

	Question/Statement	Group	SA (%)	A (%)	D (%)	SD (%)	χ^2	df	*p*
Q9	The subject of biology has little relation to what I experience in the real world.	Treatment	9.35	20.5	54.2	15.9	6.69	3	0.082
		Control	10.4	31.3	45.8	12.5			
Q10	This course has increased my curiosity about the living world.	Treatment	52.3	41.1	6.54	0	6.72	2	**0.035**
		Control	41.8	53.1	4.08	0			
Q11	I find biology more interesting than when I started this course.	Treatment	48.6	41.1	7.48	2.80	8.13	2	**0.017**
		Control	36.7	55.1	8.16	0			
Q12	Biology consists of many disconnected topics.	Treatment	10.4	33.0	44.3	12.3	4.65	3	0.200
		Control	8.33	41.7	41.7	8.33			
Q13	I can apply what I have learned in biology to many other problems.	Treatment	31.8	57.9	9.35	0.934	0.145	2	0.929
		Control	30.6	59.2	10.2	0			
Q14	I enjoy figuring out answers to biology questions.	Treatment	39.3	47.7	10.3	2.80	1.20	2	0.548
		Control	38.8	53.1	8.16	0			
Q15	This course has changed my ideas about how the natural world works.	Treatment	39.3	50.5	9.35	0.935	11.5	2	**0.003**
		Control	32.7	63.3	4.08	0			
Q16	To learn biology, I only need to memorise facts and definitions.	Treatment	16.0	17.9	50.0	16.3	12.1	3	**0.007**
		Control	22.4	26.5	24.7	16.3			
Q17	If I had plenty of time, I would take a biology class outside of my major requirements just for fun.	Treatment	33.6	41.1	18.7	6.5	19.0	3	**<0.001**
		Control	18.4	57.1	16.3	8.16			

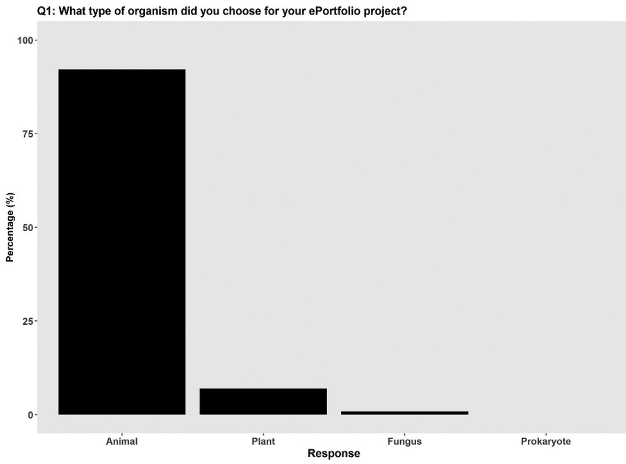

Figure 1. Students' choice of organism for their semester-long project. The distribution was significantly different from the null distribution ($\chi^2 = 278.08$, df = 3, $p < 0.001$).

videos that demonstrated minimal or no use of digital capacities, while high rankings were given to videos that demonstrated consistent and effective use of digital capacities.

Statistical analysis: All data analyses were done in the R statistical software platform (R Core Team, 2016). All responses were numerically coded prior to analysis. As questions Q1 – Q5 assessed students' perceptions of the ePortfolio project, they were not surveyed in the control sections. We analysed questions Q1–Q5 by applying a chi-square goodness of fit test to compare the frequency of the students' responses with a null category frequency that assumed an equal distribution of responses among all response categories. As there were four responses, the null category frequency was 0.125. For questions Q6–Q17, which were surveyed in both the treatment and control sections, we also applied a chi square test of independence by assigning the distribution of the control group responses to the expected frequencies before comparing them to the number of responses per bin in the treatment group. For questions Q10, Q11, Q13–Q15, the category of 'strongly disagree' was removed prior to analysis because it had zero responses from the control group and less than 3%

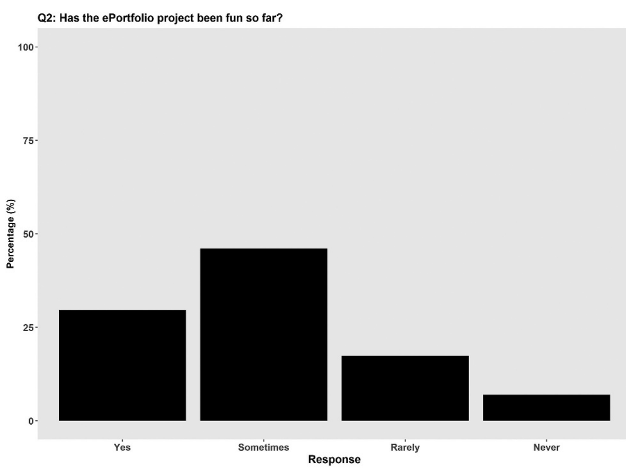

Figure 2. Student enjoyment of project. The distribution was significantly different from the null distribution ($\chi^2 = 39.05$, df = 3, $p < 0.001$).

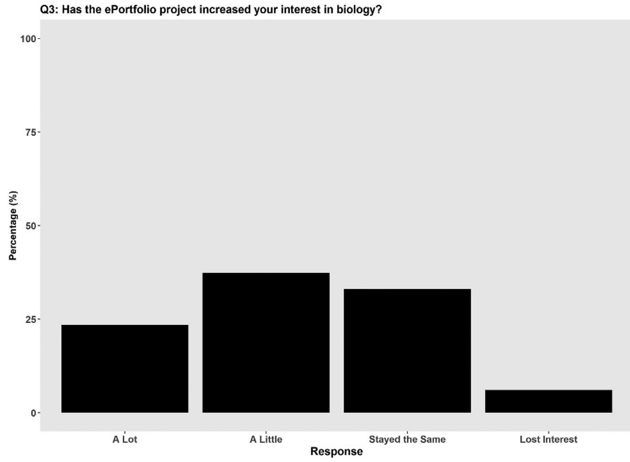

Figure 3. Student interest in biology related to project. The distribution was significantly different from the null distribution (χ^2 = 26.60, df = 3, p < 0.001).

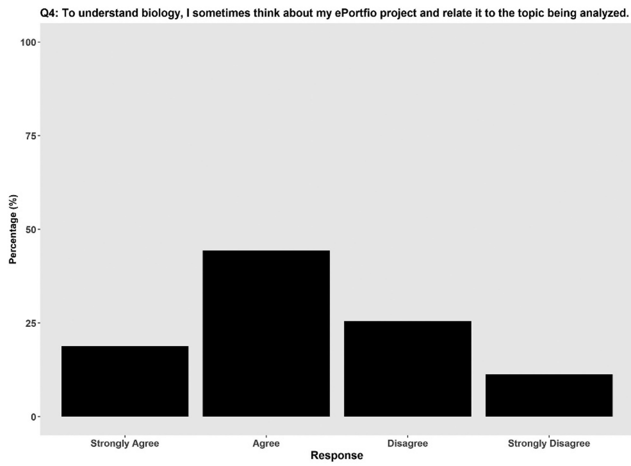

Figure 4. Student utilisation of project to aid understanding. The distribution was significantly different from the null distribution (χ^2 = 25.40, df = 3, p < 0.001).

response from the treatment group, and chi square analysis has a high probability of reporting false positives when there are less than five responses in a category. For each category used to the score the video artefacts, a t-test was used to compare the mean difference between the start of the semester to the end of the semester.

IRB: Protocols of conducting this study comply with the CUNY Human Research Protection Program (HRPP) and were approved by CUNY's Integrated Institutional Review Boards (IRB). The HRPP file number for this project is 2017–0192.

Results

We delivered surveys to 164 students over three semesters (Spring 2017–Spring 2018) and 12 sections of General Biology I (SCB201) at <college identifiers removed>. The survey questions were broken into three categories: student attitudes towards the ePortfolio project (Q1–Q5; Table 1),

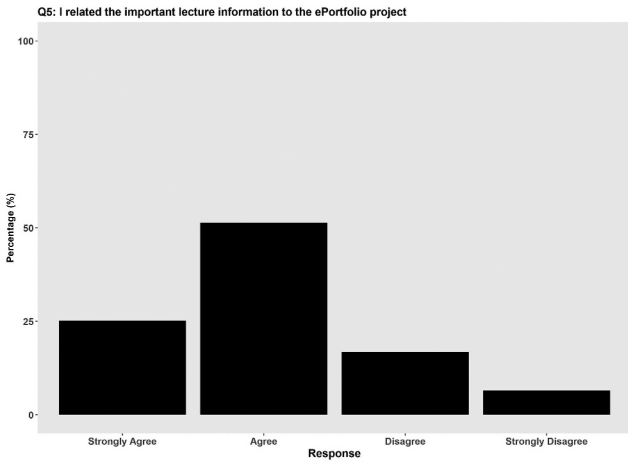

Figure 5. Student ability to relate lecture material to project. The distribution was significantly different from the null distribution ($\chi^2 = 47.28$, df = 3, $p < 0.001$).

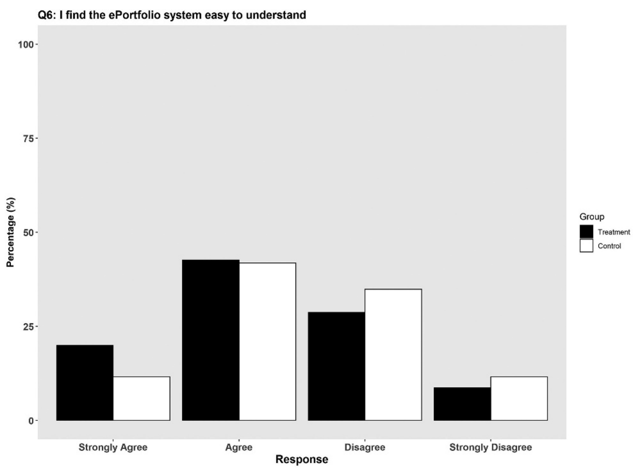

Figure 6. Impact of project on student understanding of the ePortfolio system compared to control group. The distribution was significantly different from the null distribution ($\chi^2 = 9.11$, df = 3, $p = 0.028$).

student attitudes to the ePortfolio system as compared to a control section (Q6–Q8; Table 2), and student interest in biology as compared to a control group (Q9–Q17; Table 3).

Questions 1–5 were delivered only to students in the treatment group and measured student attitudes towards the ePortfolio project. The distribution of student attitudes towards the ePortfolio project were all significantly different than the null distribution. A majority of students (92.2%) chose an animal as their project topic (Q1: $\chi^2 = 278.08$, df = 3, p < 0.001; Table 1, Figure 1). Approximately 76% of students agreed that the project was fun at least sometimes (Q2: $\chi^2 = 39.05$, df = 3, p < 0.001; Table 1, Figure 2). Most students (~61%) also responded that the project had increased their interest in biology at least a little (Q3: $\chi^2 = 26.60$, df = 3, p < 0.001; Table 1; Figure 3). A majority (~62%) of students agreed that they thought about the ePortfolio project when trying to understand biology (Q4: $\chi^2 = 25.39$, df = 3, p < 0.001; Table 1; Figure 4). Similarly, approximately

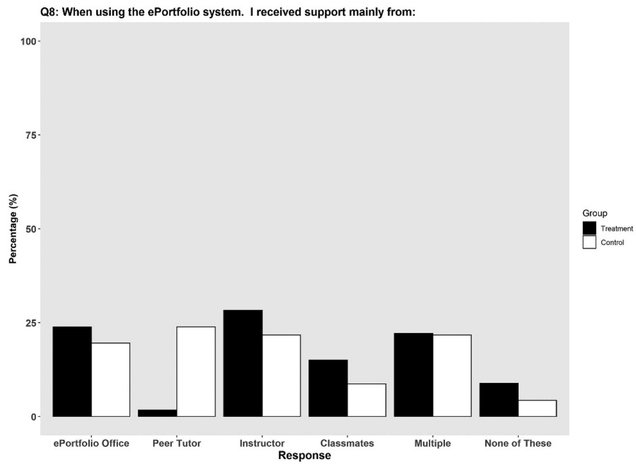

Figure 7. Student utilisation of support resources for the ePortfolio system compared to control group. The distribution was significantly different from the null distribution ($\chi^2 = 37.3$, df = 5, $p < 0.001$).

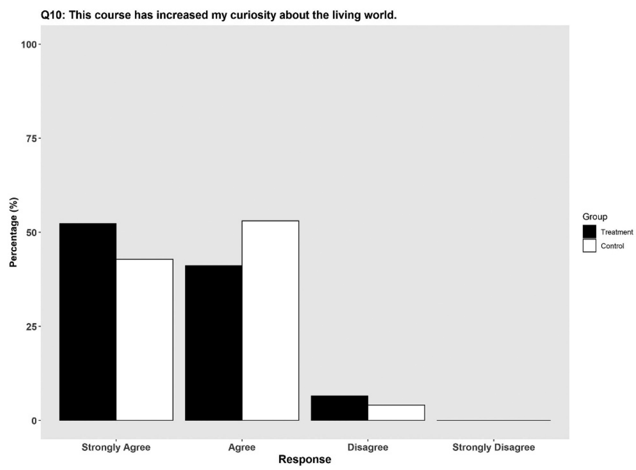

Figure 8. Effect of project on student curiosity about the world compared to control group. The distribution was significantly different from the null distribution ($\chi^2 = 11.3$, df = 5, $p < 0.01$).

76% of students related the lecture material to the ePortfolio project (Q5: $\chi^2 = 42.56$, df = 3, $p < 0.001$; Table 1; Figure 5).

Questions 6–8 assessed student facility with the ePortfolio system. There was a significant difference between treatment and control groups in understanding of the ePortfolio system (Q6: $\chi^2 = 9.11$, df = 3, $p = 0.028$; Table 2; Figure 6), with ~62% of treatment group students agreeing that the ePortfolio system was easy to understand compared to ~54% of students in the control group. However, there was no significant difference between the two groups in their response to the question about having problems with the ePortfolio system (Q7: $\chi^2 = 2.28$, df = 3, $p = 0.515$; Table 2), with ~55% of treatment group students and ~57% of control group students agreeing with the statement. There was a significant difference between treatment and control student groups in how they received support when using the ePortfolio system (Q8: $\chi^2 = 37.3$, df = 3, $p < 0.001$; Table 2; Figure 7), the biggest differences being that the treatment group relied more on their classmates for

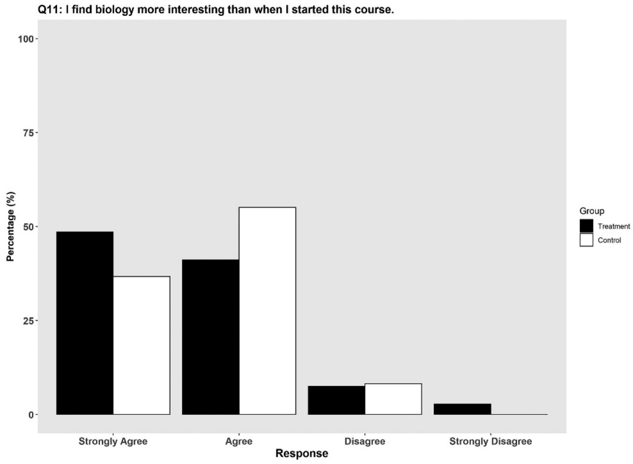

Figure 9. Effect of project on student interest in biology compared to control group. The distribution was significantly different from the null distribution (χ^2 = 86.1, df = 3, p < 0.001).

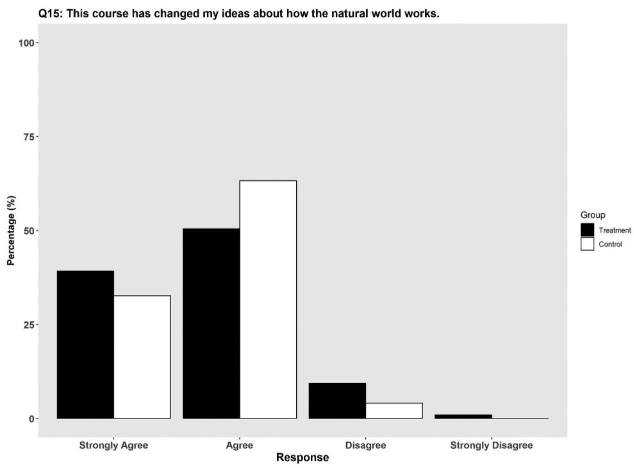

Figure 10. Effect of project on student ideas about how the natural world works as compared to control group. The distribution was significantly different from the null distribution (χ^2 = 11.5, df = 2, p = 0.003).

support (treatment 22.1%, control 8.69%), while the control groups relied more on the peer instructors (treatment 1.77%, control 23.9%).

Questions 9–17 assessed student interest and enthusiasm for biology. Although more students in the treatment group disagreed with the statement that biology has little relation to the real world (treatment 70.1%, control 58.3%), there was no difference between the distributions of the treatment and control groups (Q9: χ^2 = 6.69, df = 3, p = 0.082; Table 3). However, students in the treatment groups more strongly agreed (treatment 52.3%, 41.8%) with the statement that biology had increased their curiosity about the living world (Q10: χ^2 = 6.72, df = 2, p = 0.035; Table 3; Figure 8). They also more strongly agreed (treatment 48.6%, 36.7%) that they found biology more interesting than when they began the course (Q11: χ^2 = 8.13, df = 2, p = 0.017; Table 3; Figure 9). While treatment groups disagreed more with the statement that biology consists of many disconnected topics (treatment 56.6%, control 50.3%), there was not a significant difference between the distributions (Q12: χ^2 = 4.65, df = 3, p = 0.200; Table 3). Students from both groups had similar responses when asked about

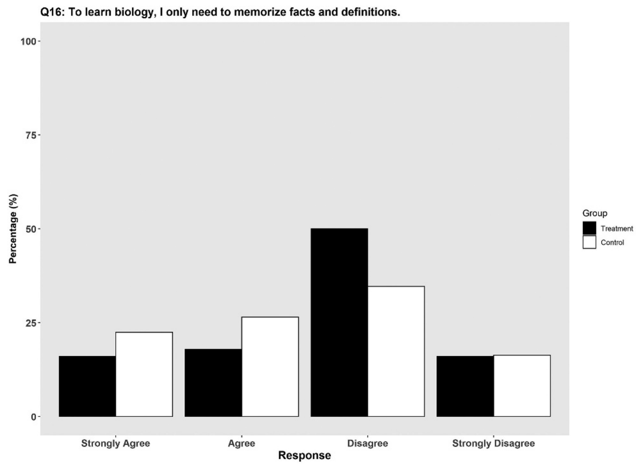

Figure 11. Effect of project on student conceptualisation of biology as consisting mainly of memorising facts as compared to control group. The distribution was significantly different from the null distribution ($\chi^2 = 12.0$, df = 3, $p = 0.007$).

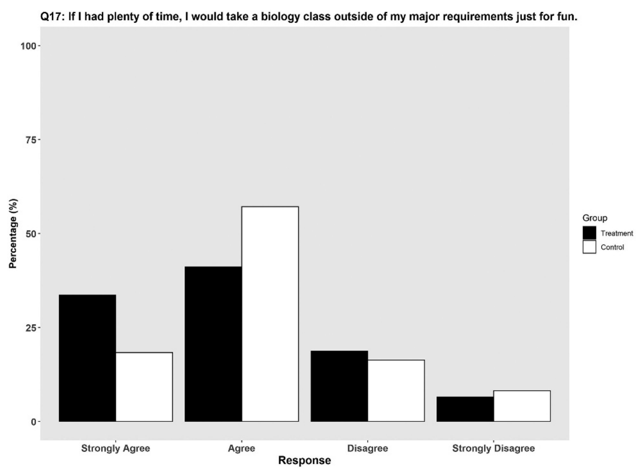

Figure 12. Effect of project on student interest in taking extracurricular biology courses. The distribution was significantly different from the null distribution ($\chi^2 = 19.0$, df = 3, $p = 0.001$).

applying biological concepts to other problems (Q13: $\chi^2 = 0.145$, df = 2, p = 0.929; Table 3) and whether they enjoy figuring out answers to biology questions (Q14: $\chi^2 = 1.20$, df = 2, p = 0.548; Table 3). Students in the treatment group more strongly agreed (treatment 39.3%, control 32.7%) that the course had changed their ideas about how the natural world works, and the distributions were significantly different between groups (Q15: $\chi^2 = 11.5$, df = 2, p = 0.003; Table 3; Figure 10). A higher percentage of students in the treatment group (treatment 56.5%, control 41%) also disagreed with the statement that learning biology is mainly about memorisation (Q16: $\chi^2 = 12.1$, df = 3, p = 0.007; Table 3; Figure 11). A much higher percentage of students (treatment 33.6%, control 18.4%) strongly agreed that they would take a biology course for fun (Q17: $\chi^2 = 19.0$, df = 3, p < 0.001; Table 3; Figure 12).

Video artefact analyses from the students in the treatment group showed significant gains in use of vocabulary (criterion 1: $t_{118} = 5.29$, p < 0.001) and depth of understanding (criterion 2: $t_{115} = 3.98$, p < 0.001), but not in digital proficiency (criterion 3: $t_{109} = 0.81$, p = 0.419) (Figure 13).

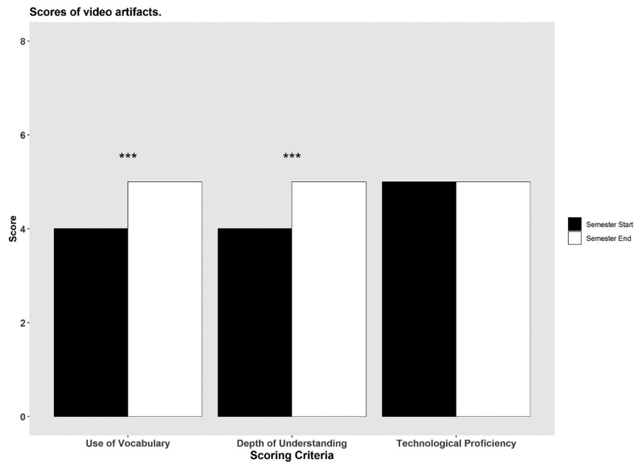

Figure 13. Scores of video artefacts using three different criteria. Scores were compared between first videos created by students and final videos created by students. Asterisks indicate significant results of *t*-tests at the probability of $p < 0.001$.

Discussion

We created an ePortfolio project for our General Biology I, a gateway course for majors, that connected the vocabulary they learned in lectures with the biology of an organism of their choice. Our objective was to help students increase scientific literacy by integrating the vocabulary from the lectures with real-world examples, thus increasing their depth of understanding and enthusiasm for biology. We also aimed to increase technological literacy regarding the ePortfolio platform, which has been integral to our college's assessment efforts. Overall, we found that students who participated in the project responded favourably to it along multiple dimensions, and compared to their peers, who did not participate in the project, they found the ePortfolio system easier to understand and expressed more curiosity and enthusiasm for biology.

A key component of the project was that it allowed students to pick an organism, usually an animal (Q1: Table 1), as a way to integrate the concepts and vocabulary they were learning in class. This was designed to increase their interest and enthusiasm for the subject matter, which often feels disconnected from their experiences. It would also give students a central organising topic around which to anchor these concepts. The results showed that the project was successful in meeting these aims, as students perceived that the project had been fun (Q2: Table 1) and that it increased their interest in biology (Q3: Table 1, Figure 2). Students also spent time thinking about their project and were able to relate it to the topics of analysis (Q4: Table 1, Figure 4) and lecture information (Q5: Table 1, Figure 5). While this was not true of all students, it was true of a majority for each question (Table 1). This result strongly suggests that, at least within their self-reported attitudes, students found value in the project and that it was able to effectively generate interest in biology and help students integrate lecture vocabulary.

Technological literacy is vital for the success of all STEM students, yet enrolled students are often deficient. Although students are trained in the ePortfolio system during their first-year seminar course, many have difficulty learning the new software. Learning new software systems is a continuing aspect of STEM careers, and one of the aims of this project was to increase student technological literacy with the ePortfolio system. Interestingly, students in the treatment group expressed having as many problems with the ePortfolio system as students in the control group (Q7: Table 2), but a higher percentage also found the system easier to understand (Q6: Table 2, Figure 6). These results suggest that there was little extra burden in terms of technical difficulties that came from implementing the ePortfolio project, but that, unsurprisingly, working with the software regularly improved their understanding of it. Although these were individual projects, students in the treatment group also used their peers and instructors much more as resources than the control group (Q8: Table 2, Figure 7). This is likely simply due to normal levels of cooperation among peer groups when working on classwork, but it suggests that projects of this type could be useful in attaining widespread understanding of a technology without increasing the role of support offices.

Ideally, this project would also generate a deeper understanding of the connections between the biology material and their lives, as well as enthusiasm for biology. The results were mixed in terms of these aims. While a higher percentage of students in the treatment group claimed that the course had changed their ideas about the natural world (Q15: Table 3, Figure 10), they did not learn to relate biology to their experience in the real world (Q9: Table 3), unify concepts around a central theme (Q12: Table 3), nor apply what they learned in biology to other concepts (Q13: Table 3). These results suggest that the project was unable to stimulate students to these high levels of learning (e.g., transfer). However, these concepts were not explicit components of the project, which was focused on integrating vocabulary, so it is perhaps unsurprising. The higher disagreement of treatment group students with the idea that biology is just about memorising facts (Q16: Figure 11) suggests that the project did stimulate students beyond the level of memorisation. One of the most successful aspects of the project appear to be in generating enthusiasm and curiosity for biology, with students in the treatment group reporting increased curiosity (Q10: Table 3, Figure 8), more interest than when they started (Q11: Table 3, Figure 9), and interest in taking extracurricular biology courses (Q17: Table 3, Figure 12). This suggests that these types of projects are effective in attaining their explicit learning objective but do not necessarily help students with broader learning goals such as transfer.

Analysis of these video artefacts supported these conclusions, as students showed modest gains in both their use of vocabulary and depth of understanding by the end of the semester (Figure 13). However, it is likely that our scoring rubrics underestimated the gains made by students. Early video artefacts generated relatively high scores because students were technically correct in their use of vocabulary and concept statements; however, early attempts by students to integrate the vocabulary and concepts were absent or perfunctory. Students at the beginning of the semester often simply listed and defined the vocabulary terms before discussing the characteristics of the organism, without further referencing the vocabulary. Integration improved in later video artefacts. In these, students often wove the vocabulary and concepts into their descriptions of the organism and its environment. Most students thought that the project was fun (Figure 2), and this also became more apparent in their demeanours as the semester progressed. Students initially rushed through the vocabulary and descriptions, but they relaxed and appeared more enthusiastic as the semester progressed.

Students did not show greater gains in technological literacy (Figure 13), despite the increase in their understanding of the ePortfolio system (Q6: Table 2, Figure 6). That is, they did not exhibit greater skill in incorporating digital elements into their videos, mainly relying on PowerPoints to make their videos throughout the semester. There was an implicit assumption in our model that students would improve in their technological literacy through creating video artefacts; however, this suggests that students will not increase in proficiency without explicit guidelines and support.

Overall, the ePortfolio project was successful in its goals. Students responded positively to the project and showed gains in their understanding of the topics, integration of the vocabulary, enthusiasm for biology, and understanding of the technical platform.

Acknowledgments

We thank Dr. Charles Keller and Dr. Chaogu Zheng for their participation as instructors. The funding for this research was provided by a grant from The City University of New York (CUNY) through the Accelerated Study in Associate Programs (ASAP) to Drs. Brashears, Porter-Morgan, and Xu.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the The City University of New York (CUNY) through the Accelerated Study in Associate Programs (ASAP).

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