Cognitive and Social Benefits Among Underrepresented First-Year Biology Students in a Field Course: A Case Study of Experiential Learning in the Galápagos

Nicholas A. Mason
Cornell University & University of California, Berkeley

Rebecca M. Brunner
Cornell University & University of California, Berkeley

Cissy J. Ballen
Cornell University & Auburn University

Irby J. Lovette
Cornell University

Abstract:
Student attrition is a persistent challenge in the life sciences, particularly among underrepresented minorities, first-generation students, and women. Experiential learning through short-term study abroad opportunities diversifies curricula by immersing students in nontraditional academic environments. However, most experiential learning and study abroad opportunities are primarily available to upper-division undergraduates. Here, we present a qualitative analysis of an experiential learning opportunity offered exclusively to first-year U.S. undergraduate students from underrepresented demographics. We performed ethnographic observations of a 10-day field component in the Galápagos Islands and analyzed self-reported survey results and field journals. Students consistently reported strong cognitive gains in their understanding of basic evolutionary concepts. Most students also benefited socially, although we observed higher variation in self-reported social gains. Our findings suggest that immersive field courses increase scientific literacy and promote social cohesion among students. We speculate that experiential learning opportunities may improve retention of underrepresented minorities in the life sciences, and we encourage future studies to further examine the short-term and long-term impacts of study abroad on student cognition and retention.

Introduction
Student attrition in science, technology, engineering, and mathematics (STEM) is a perennial concern of postsecondary institutions (Chen & Soldner, 2013). Occurring when students switch to a non-STEM major or leave secondary education altogether (Tinto, 2006), attrition is higher among underrepresented demographics such as ethnic and racial minorities (Matsui, Liu, & Kane, 2003;

Dirks & Cunningham, 2006; Allen-Ramdial & Campbell, 2014), women (Bebbington, 2002; Clark Blickenstaff, 2006; Griffith, 2010), and first-generation college students (Lam, Srivatsan, Doverspike, Vesalo, & Mawasha, 2005; Tate et al., 2015). Attrition in STEM occurs at higher rates among underrepresented students with weaker academic records (Mendez, Buskirk, & Lohr, 2008; Kokkelenberg & Sinha, 2010; Whalen & Shelley, 2010) and lower levels of reported self-efficacy, motivation, and confidence (Burtner, 2005; Beasley & Fischer, 2012). During the first two years of college, underrepresented students often have negative experiences with lecture-based introductory courses, which may offer limited personal interactions with instructors and peers (Seymour & Hewitt, 2000; Beasley & Fischer, 2012) and provide little exposure to the breadth of course structures and content offered by upper-division STEM curricula (Bettinger, 2010). Introductory STEM courses often receive poorer letter-grades on average across all students compared to non-STEM classes, which contributes to even higher attrition (Rask, 2010). The challenges of minority student retention in STEM fields are therefore multidimensional and complex.

One potential strategy for mitigating STEM attrition is to expose undergraduates to active learning techniques (Bonwell & Eison, 1991). A common form of active engagement involves experiential learning, which enhances more traditional learning processes through personal interactions with the material and subsequent reflection (Kolb, 1984; Kolb & Kolb, 2005). Experiential learning is designed to move students beyond simple recall of factual knowledge, and instead encourages higher-level thinking (sensu Bloom's taxonomy; Airasian et al., 2001) such as applying, analyzing, and synthesizing information (Krathwohl, 2002). In the biological sciences, experiential learning often takes the form of research internships, course-based undergraduate research experiences (Auchincloss et al., 2014), or field courses. Research internships have well-documented positive effects on students' comprehension and volition in the sciences (Hunter, Laursen, & Seymour, 2007; Russell, Hancock, & McCullough, 2007), particularly among underrepresented minorities (Lopatto, 2007). However, the cognitive and social benefits of other active learning opportunities, such as field courses, are not as well characterized—especially among underrepresented demographics.

Within the academic disciplines of ecology and evolutionary biology, field courses constitute a prominent form of experiential learning (Zervanos & McLaughlin, 2003; Smith, 2004; McLaughlin & Johnson, 2006). Field courses often occur through study abroad programs that foster discovery, exploration, and immersion into the course material and confer benefits beyond traditional classroom environments (Eisner, 1982; McLaughlin, 2005; Sanders, 2007). Various studies have documented positive effects of field experiences on students' knowledge and attitudes toward biology (Lisowski & Disinger, 1991; Magntorn & Helldén, 2005; Boyle et al., 2007; Easton & Gilburn, 2012; Prokop, Tuncer, & Kvasničák, 2007; Scott et al., 2012), geography (Marvell, 2008), and geology (Rathburn & Weinberg, 2011). Yet, field courses are disappearing from many curricula because of issues concerning risk management, funding, and faculty balancing other obligations (Barker, Slingsby, & Tilling, 2002; Smith, 2004; Lock, 2010; Scott, Boyd, Scott, & Derek, 2015). Therefore, assessments that address the social and cognitive outcomes of field courses in STEM disciplines—particularly for underrepresented minorities—are necessary to optimize and evaluate postsecondary curricula amid ongoing financial, social, and educational concerns.

Here, we examine the cognitive and social benefits of a 10-day field course in the Galápagos, offered as an experiential learning opportunity at the halfway point of paired semester-long classroom coursework. This curriculum was exclusively offered to individuals who self-identified as minorities, first-generation college students, and/or women. Through ethnographic observations of student behavior, assessments of student journals, and analyses of self-reported social and cognitive gains via post-curriculum surveys, we address both social and intellectual gains conferred through this type of international field course. We focus primarily on short-term effects of the field course, but encourage future studies to examine longitudinal data sets and long-term studies to assess how field courses affect student retention in the life sciences over longer time periods.

Materials and Methods

Galápagos Curriculum

The experiential learning opportunity considered in this case study is a major component of a themed curriculum that includes eight semester-long credits of coursework at Cornell University, where a typical first-year course-load is approximately 14–18 credits per semester. Our Galápagos Curriculum (GC) is offered via application to first-year students enrolled in the Biology Scholars Program (BSP), an academic community and support group that promotes underrepresented demographics in biology (Summers & Hrabowski, 2006; Tsui, 2007; Ballen & Mason, 2017). Because courses with a field component often involve high costs associated with travel and equipment, the GC travel component is heavily subsidized and entirely cost-free to participating students in order to grant access to students from different socioeconomic backgrounds. Twelve students have participated each year (except for 2012, the inaugural year, which had 8 students), bringing the total to 44 by the time of this study.

Students are selected via a written application and interviews with instructors. Accepted students are concurrently enrolled in two courses: a core biological sciences course entitled *Evolutionary Biology and Diversity* (BIOEE 1780) and a writing-focused seminar entitled *The Enchanted Isles: Human Observation and Impact in the Galápagos* (WRIT 1430). The structure of the GC divides the semester into three qualitatively different time periods: pre-trip, trip, and post-trip (Zervanos & McLaughlin, 2003). Prior to the trip, these courses teach background information about the ecology, evolutionary biology, human history, geography, conservation, and literature related to the Galápagos. Students then travel to the Galápagos for ten days during spring break, where they participate in observation-based discussions, write and sketch in field journals, and complete short assignments related to evening lectures. After the trip, the GC courses offer an opportunity for extended reflection and synthesis, in addition to the continuation of coursework related to evolution and conservation.

Although an in-depth description of each course's syllabus and structure is outside the purview of this paper, we provide a brief overview here. BIOEE 1780 is a large lecture-based course that covers basic concepts in evolutionary biology and introduces students to major biodiversity groups across the tree of life. It is a required course for all biology majors at Cornell University, and it is usually taken during the first or second year. In addition to taking BIOEE 1780, GC students are also required to enroll in a seminar-format *Writing in the Majors* (WIM) section of that course, which is Galápagos-themed and limited to GC students. Combined, the BIOEE 1780 course and the WIM section equal five credits and meet for a total of five times weekly. Through class discussions of

primary literature, homework assignments, and in-class activities, the WIM section reinforces BIOEE 1780 lecture material; GC students learn background information on evolutionary patterns and processes via past and ongoing research on Galápagos wildlife.

Taken at the same time, WRIT 1430 is a first-year writing seminar for GC students that focuses on human perspectives in the Galápagos, including the history, culture, literature, and conservation of the archipelago. The first-year writing seminar meets twice weekly and requires six graded essays in addition to various informal, low-stakes writing assignments used to assess and design future assignments based on the writing abilities of GC students. Course material focuses on the perspectives and experiences of different human groups who visited or lived in the Galápagos, such as early Spanish explorers, English and American whalers, evolutionary biologists from Darwin to the present day, prominent authors such as Melville and Vonnegut, and Ecuadorians who are current Galápagos residents. Taken together, the GC immerses students in an interdisciplinary study of the natural history and human history of one location over time.

Unlike most other places in the world, humans have been historically absent from the Galápagos prior to modern times. Therefore, Galápagos animals are generally unafraid of humans and are comfortable with very close observations and interactions. This unique feature of the islands facilitates experiential learning through immersive encounters with nature through hiking and snorkeling, expert-guided commentaries and discussions, and prompted (and unprompted) personal reflections in field journals. Students live, sleep, eat, and travel across the archipelago aboard a ship. While on the boat, students engage in guided discussions on primary literature relevant to the Galápagos, as well as student-led lectures on various assigned subjects. Many of the students speak Spanish and engage in discussions with the ship crew members, most of whom live in the Galápagos.

Assessment of Experiential Learning Gains

We assessed the cognitive and social gains of students in the GC in three ways: (1) observation of student behavior and interactions within an ethnographic framework; (2) evaluation of student entries in provided travel journals; (3) analysis of self-reported cognitive and social gains via an anonymous survey. Quantitative and qualitative approaches granted insight into different aspects of GC students' academic and personal experiences. We solicited student approval to undertake this project, anonymized student work, and performed all research in accordance with the Cornell University Institutional Review Board (IRB Protocol #1410005010).

Ethnographic Observations. Ethnography is a well-established framework in anthropology that involves descriptive observations of extended personal and social contact between researchers and their subjects (Clifford & Marcus, 1986; Willis & Trondman, 2000). Ethnographers assume a dualistic role of observer and facilitator, thereby seeking to describe and contextualize the idiosyncrasies and possible generalities that constitute an irreproducible human experience (Hammersley & Atkinson, 2007). In this case study, the instructor of WRIT 1430 observed and interacted with students in the classroom and during the 10-day excursion to the Galápagos.

Natural History Journals. Reflection is an integral component of experiential learning (Kolb, 1984), and observation is an essential skill in the life sciences (Magntorn & Helldén, 2005). Because natural history observations and reflections are often facilitated through the practice of keeping a

field journal (Herman, 1986), we required students to maintain field notebooks throughout the field component of the curriculum. While in nature, we required students to carry their notebooks at all times to record natural history observations; once per day, we also required personal reflections and responses to more formal writing prompts, at least once per day. Following completion of the Galápagos field trip, student journals were submitted for grading and evaluation of cognitive and social effects. For this component of the study, we only considered journals from the 2015 cohort because of the timing constraints of IRB approval.

Post-trip Survey Responses. We solicited anonymous, self-reported information regarding the effects of the Galápagos field experience through a post-trip survey of multiple cohorts of students. Using a five-option, Likert scale survey (1 = strongly disagree, 5 = strongly agree), we asked students to indicate how the experiential learning opportunity affected their cognitive and social gains (Supplementary Table S1). We also asked students open-ended questions to identify the greatest challenges and rewards associated with the Galápagos field course component (Supplementary Table S1). After we received survey responses, we treated each Likert response as interval data, calculating the mean and standard deviation associated with each question as a measure of central tendency. We also combined all social and cognitive responses into two respective groups and performed a two-tailed, nonparametric Mann-Whitney-Wilcoxon test (Bauer, 1972) and a Fligner-Killeen test (Conover, Johnson, & Johnson, 1981) to determine whether Likert scale responses differed between social and cognitive gains with regards to median scores and variance, respectively.

Results

Ethnographic Observations

The following observations were made by Nicholas A. Mason as instructor of WRIT 1430 during the spring 2015 semester. After discussion, other instructors, including Rebecca M. Brunner and Irby J. Lovette had similar general observations that corroborate the following ethnographic observations. At the beginning of the semester, GC students were eager about the course and visiting the Galápagos. However, students' incoming knowledge of the archipelago and its inhabitants was limited; most students' previous exposure to the islands was through brief excerpts in high school textbooks. For example, students generally knew very little about the geography of the archipelago; some students were uncertain whether the islands are in the Pacific or Atlantic Ocean or which country owned the Galápagos. Most students were also unaware that people live on some of the islands, in towns such as Puerto Ayora or Puerto Villamil (total population approximately 40,000). Many students initially conceptualized the Galápagos as lush, tropical landscapes. Prior to the spring break trip to the Galápagos, WRIT 1430 familiarized students with human experiences in the Galápagos and encouraged students to critically consider their own preconceptions of the archipelago. Students' conceptualizations changed quickly after reading various accounts of the islands, which transformed in their minds from a tropical paradise into a more foreboding setting of jagged lava rocks and little fresh water. Students were also surprised to learn that the Galápagos have been a sporadic hotbed of human activity during the past few centuries. Relevant to both the natural and human history of the islands, we devoted two weeks to reading about and discussing Charles Darwin's career and the formation of his ideas on evolution and biodiversity. Students realized that the Galápagos and its inhabitants played a different role in Darwin's career compared to the aggrandized and abridged descriptions in high school textbooks.

In the week before the trip to the Galápagos, students had individual interviews with the instructor of WRIT 1430. During these brief (approximately 15-minute) interviews, students expressed their feelings regarding the upcoming trip, including any sources of anxiety, excitement, or trepidation. All of the students were eager about the upcoming trip, although some were noticeably more excited than others. Some students were anxious about their first international travel experience; others harbored fears of the open ocean or close encounters with organisms that they perceived as dangerous. Despite their varying levels of exposure to nature and experience traveling, students were generally optimistic and excited about the field trip to the Galápagos.

Boarding the aircraft to the Galápagos facilitated a more concrete understanding of geography and human impacts in the Galápagos. Prior to departure, flight attendants fumigated the cabin to reduce the possibility of introducing foreign species and pathogens into the Galápagos. Students were startled and puzzled at first, but the experience reinforced the prominent role that humans play as agents of dispersal of invasive species. We observed students discussing the geography of Central and South America while paging through an in-flight magazine; one student was surprised to learn that Ecuador was almost directly south of New York. Although every student had looked at a world map before, the students seemed to gain an improved sense of Western Hemisphere geography through travel. Similarly, even though students were provided with flight itineraries well in advance, many were still surprised by the length of time it takes to reach the Galápagos from the mainland, an experiential measure of the archipelago's remote, offshore location. It proved easier for students to conceptualize distance through experience (i.e., air travel) than through lectures or readings.

After the aircraft landed on Baltra Island in the Galápagos, students immediately began to recognize organisms that they had discussed in class, such as land iguanas and *Opuntia* cacti. As the group moved through customs and travelled to our ship, students became visibly (and audibly) excited about each new organism that they saw as well as the upcoming itinerary. Prior to boarding our ship, we asked students to spread out along the coastline and spend approximately 30 minutes reflecting on their initial impressions of the Galápagos and whatever natural history was apparent in their immediate vicinity. As instructors, we found that this type of periodic reflection in isolation helped "center" students and encourage them to make mindful observations of their personal and shared experiences.

Although the hourly schedule during the Galápagos field course varied based on the trip itinerary, each day began at dawn, which conflicted with the sleeping schedule of almost every undergraduate on the trip. One student claimed that the only other sunrise they had seen that school year was after pulling an all-nighter to study for exams. In fact, early wake-up calls and conflicts with internal clocks were among the most common complaints from students during the trip. Once awake, however, students began to appreciate dawn as a time of peak animal activity and comfortable temperatures. We typically visited islands during the early morning and late afternoon to capitalize on the agreeable conditions for viewing wildlife and exploring the terrestrial ecosystems. Late mornings and early afternoons were typically reserved for snorkeling or on-boat academic activities as heat from the equatorial sun peaked in the middle of the day. Students entered the course with varying levels of experience and comfort with swimming and physical activity. Although we encouraged students to push themselves and participate as much as possible, water activities were generally optional and students occasionally chose to stay on the boat.

As a field course destination, the Galápagos provided an excellent environment for experiential learning. Travel itineraries are strictly regimented by the Galápagos National Park and many organisms are easily observable because of restricted habitat ranges, often fearless animal disposition, and an open landscape; therefore, GC instructors can successfully predict much of the phenomena participants will observe each day and we organized paper discussions and class activities accordingly. For example, every GC participant observed marine iguanas from only a few meters away. We therefore assigned primary literature related to these iguanas to be read directly before our encounters with them, which substantially enhanced student interest and understanding.

Compared to most field course settings, the Galápagos Islands provide a more controlled and logistically straightforward introduction to wildlife encounters and international travel—ideal for an exclusively first-year class. However, some animal encounters are unpredictable, even in the Galápagos; students on the 2015 trip, for instance, were disappointed that we did not encounter more dolphins. Moreover, students visiting the Galápagos during an El Niño year will have a very different impression compared to students who visit between El Niño events because these climate cycles dramatically influence the biology of the archipelago's most conspicuous animals. Although certain elements of the GC were impossible to predict and varied substantially from year to year, students learned that stochasticity, seasonality, and cyclical climatic effects are important components of any field course and nature itself.

The GC instructors remained ready to restructure activities and assignments to accommodate students' curiosity (assessed through constant instructor-student dialogue) as well as unpredictable learning opportunities. For example, in 2015, we were fortunate to interact with a group of college-age Ecuadorian student volunteers monitoring sea turtle nests. While we watched the students excavate a nest that should have finished hatching but still had many eggs, the GC students who spoke Spanish conversed with the volunteers. The students learned first-hand that a combination of larval flies and a fungal pathogen had attacked this particular brood of sea turtles. This serendipitous interaction with volunteers and aspiring wildlife biologists also exposed the GC students, who were almost entirely pre-medicine or pre-veterinarian, to additional career options in the life sciences.

Opportunities for experiential learning abounded while in the Galápagos—too many to comprehensively discuss here. After previously learning about sexual selection in their large lecture hall on campus, GC students observed blue-footed boobies perform their mating display. The immense size of giant tortoises and the observable size and color variation among different populations of lava lizards provided first-hand examples of island gigantism and biogeographic variation. Underwater observations of lateral tail movements by marine iguanas and the powerful thrusts of flightless cormorants' hind feet demonstrated adaptations to predominantly aquatic lifestyles. Lava gulls that scavenged the carcass of a sea lion pup reminded students of the eternal struggle for survival and the process of natural selection. These immersive experiences reinforced course material and provided lasting examples of evolutionary processes in nature.

The students were also excited to experience the landscapes and historical sites that inspired written works about the Galápagos. Students revisited descriptions of the islands from prominent writers such as Herman Melville and Charles Darwin. Students reflected on the similarity between their trip to the Galápagos and Darwin's famous voyage aboard the Beagle. Darwin was only a few

years older than the GC students during his visit to the Galápagos, and the Beagle was a similar size to our boat. We encouraged students to think critically about the similarities and differences between their experience and other human perspectives and histories in the Galápagos. By incorporating concepts and materials from literature and the humanities, we strove to create a more holistic, interdisciplinary academic experience. We created a video log that cataloged our daily activities and illustrates many of the encounters between students, instructors, wildlife, and historical sites in the Galápagos (Video S1).

In addition to gaining a deeper understanding of basic evolutionary concepts and human perspectives in the Galápagos, our time in the field offered students the opportunity to interact closely with their instructors. As first-year students, most of the participants had not previously formed strong bonds with any of their introductory-level course instructors. However, after protracted interactions with GC instructors in academic and non-academic settings, students began to feel more comfortable conversing with professors and graduate student instructors—perhaps for the first time appreciating the multidimensionality of college-level instructors as individuals, rather than solely authoritative figures in the classroom. After initial social boundaries had been broken down, students often conversed with instructors about their personal and professional lives. These interactions were not unidirectional; the instructors also learned more about undergraduate social and academic life. We felt that this mutual exchange of information increased appreciation for undergraduate, graduate, and faculty life and helped foster social networks that have persisted well beyond the Galápagos field experience.

Upon return from the Galápagos, the classroom dynamic transformed dramatically. After the field trip, students conversed freely with each other and the instructor before class; group activities were more fluid and inclusive. However, the students did feel that the climax of the semester had already passed; it was occasionally difficult to persuade students to continue reflecting and thinking about the Galápagos. Regardless, from our perspective as instructors, the field experience provided a strong platform to bolster core class concepts and strengthen social networks, both with peers and instructors.

Natural History Journals

At first, students were generally hesitant to engage in written reflection and required persistent prompts from instructors. Students also varied in their level of journaling skill: some students wrote minimalist entries, while others were more prolific and detailed (see Figure 1, Figure S1, Figure S2). Natural history entries toward the beginning of the trip consisted predominantly of information received from instructors rather than personal observations. Similarly, personal reflections began as mostly chronological records of daily activities rather than connections between their personal and shared experiences, core concepts of the course, or connections to ideas or concepts from other courses or background knowledge. Midway through the trip, we encouraged students to deepen their reflections and to use their notebooks to synthesize thoughts and forge cognitive connections beyond simply recording their daily activities in a diary. This intervention helped clarify what we expected as instructors, and, from our perspective, improved the overall quality and depth of the entries. In the future, we intend to emphasize these distinctions earlier in the field portion of the course.

Figure 1. Exemplary student entry in a field journal showing detailed observations of a close encounter with a giant tortoise and a land iguana.

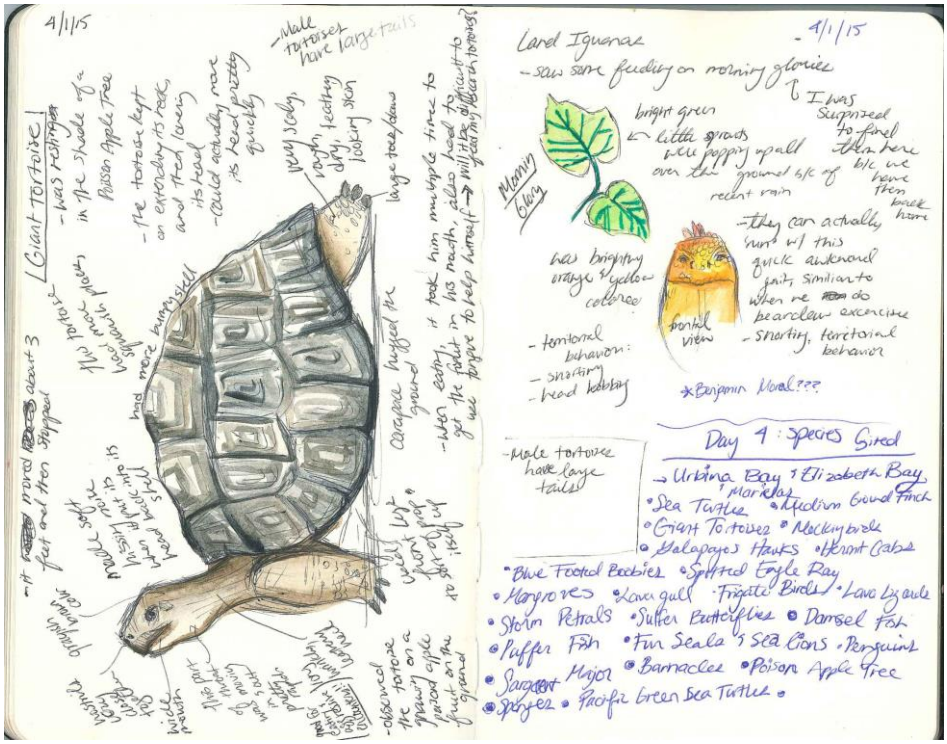


Figure S1. Example of student entry in the natural history section of their field journal.

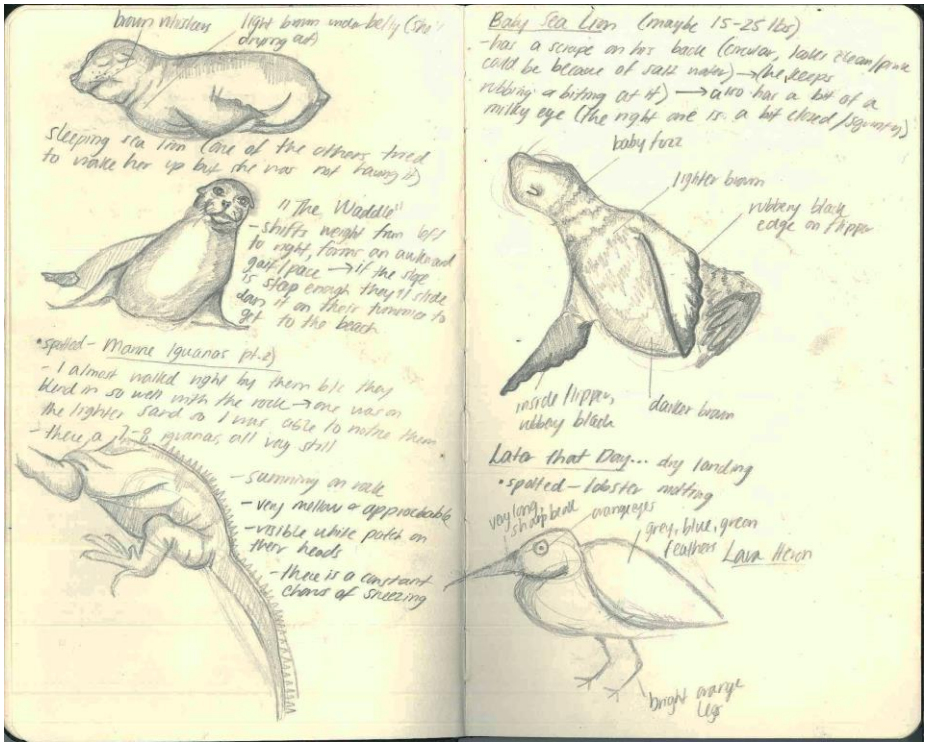
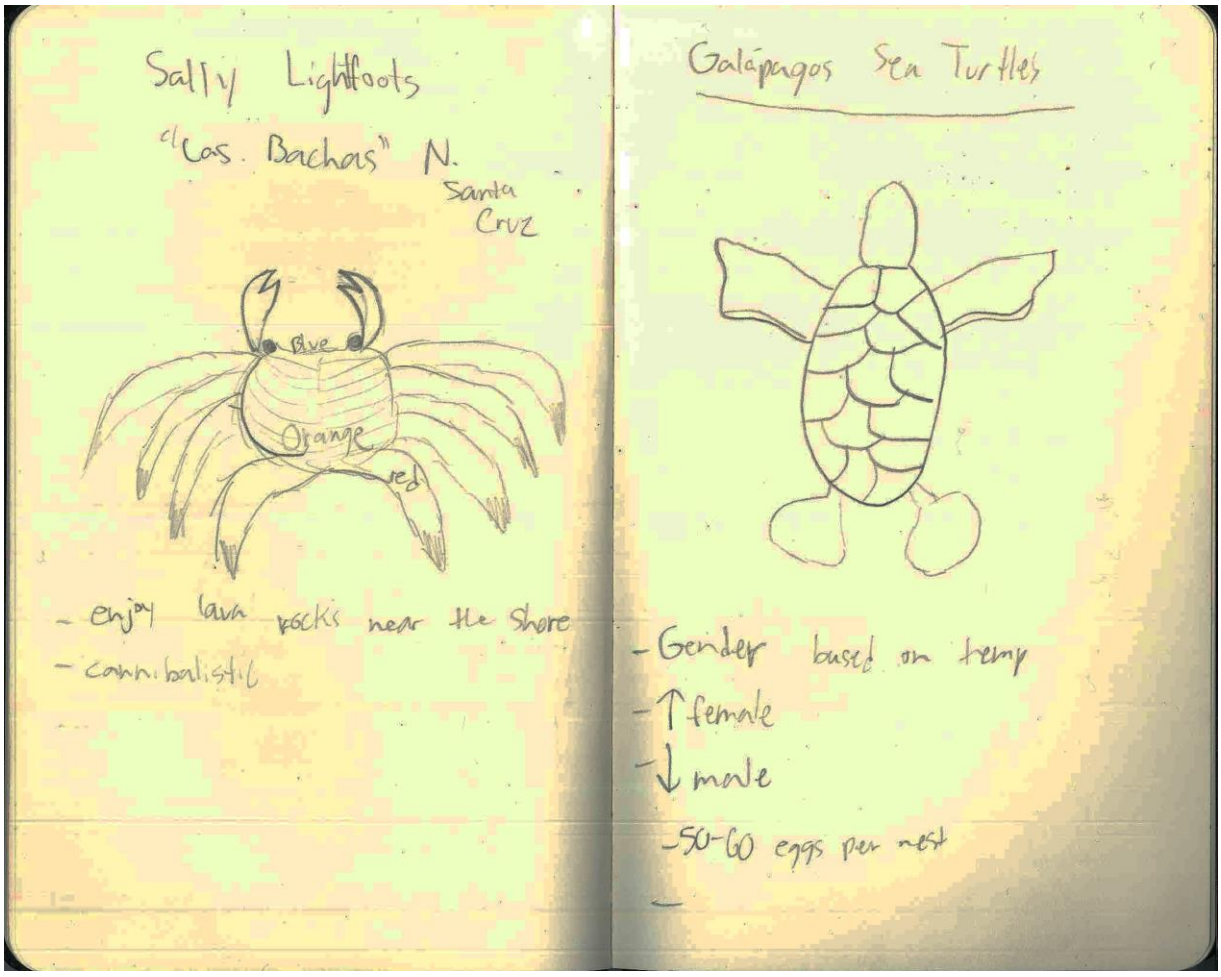
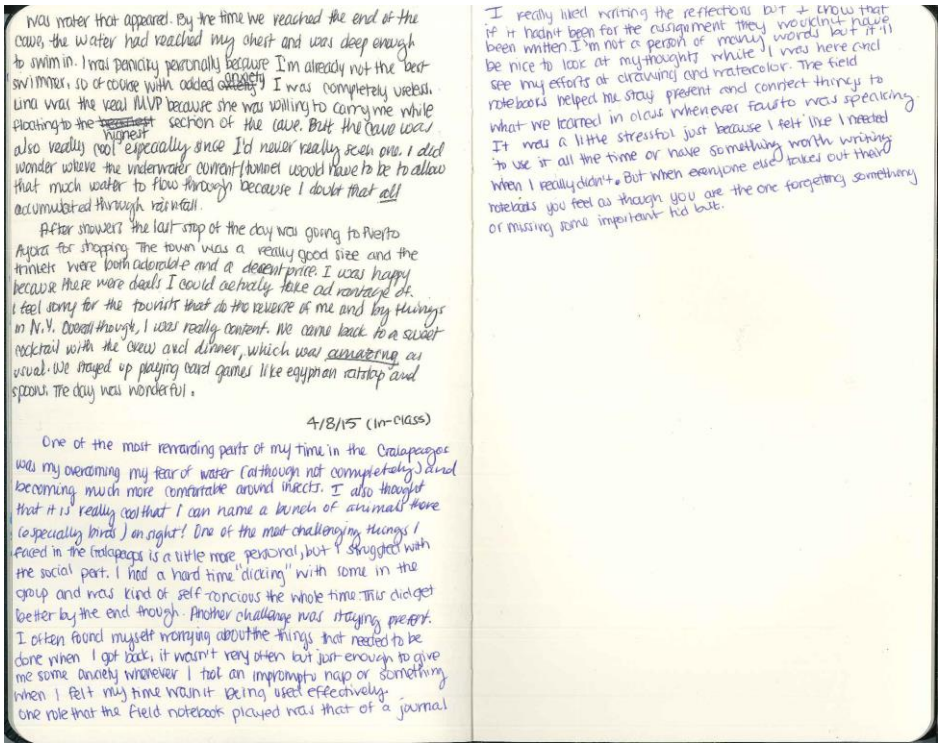


Figure S2. Example of student entry in the natural history section of their field journal.



As a final journal entry, we asked students to reflect on the role that their field notebooks played in their Galápagos experience. Student responses to field notebooks were positive overall. Many students felt that keeping personal observations helped them to appreciate the experience and were excited to have a personal account to remember it by. One student mentioned that their field notebook "helped them stay present." (Figure S3). Another student remarked that their field notebook "forced me to pay attention to details I may have otherwise overlooked" (Figure S4). In contrast, other students had reservations about their notebooks being graded by instructors and mentioned that the journal "[took] me out of the moment… but I am glad I have the knowledge recorded to look back on in the future" (Figure S5). Nonetheless, the field notebooks provided a means for reflection that facilitated a more immersive experience for many of the GC students during their time in the Galápagos.

Figure S3. Example of student entry in the personal reflections section of their field journal.



was water that appeared. By the time we reached the end of the cave, the water had reached my chest and was deep enough to swim in. I was panicky personally because I'm already not the best swimmer, so of course with added ~~anxiety~~ anxiety I was completely useless. Lina was the real MVP because she was willing to carry me while floating to the ~~beginning~~ highest section of the cave. But the cave was also really cool especially since I'd never really seen one. I did wonder where the underwater current/tunnel would have to be to allow that much water to flow through because I doubt that all accumulated through rainfall.

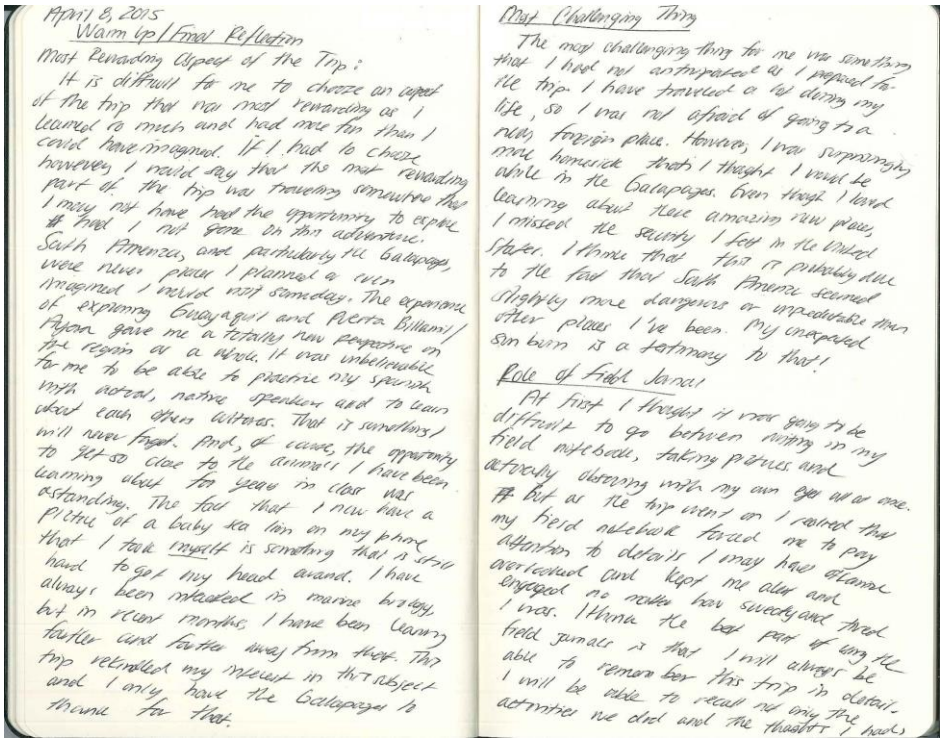
After showers the last stop of the day was going to Puerto Ayora for shopping. The town was a really good size and the trinkets were both adorable and a decent price. I was happy because there were deals I could actually take advantage of. I feel sorry for the tourists that do the reverse of me and buy things in N.Y. Overall though, I was really content. We came back to a sweet cocktail with the crew and dinner, which was ~~amazering~~ amazing as usual. We stayed up playing board games like egyptian ratslop and spoon. The day was wonderful.

4/8/15 (in-class)

One of the most rewarding parts of my time in the Galapagos was my overcoming my fear of water (although not completely) and becoming much more comfortable around insects. I also thought that it is really cool that I can name a bunch of animals there (especially birds) on sight! One of the most challenging things I faced in the Galapagos is a little more personal, but I struggled with the social part. I had a hard time "clicking" with some in the group and was kind of self conscious the whole time. This did get better by the end though. Another challenge was staying present. I often found myself worrying about the things that needed to be done when I got back, it wasn't very often but just enough to give me some anxiety whenever I had an impromptu nap or something when I felt my time wasn't being used effectively. One role that the field notebook played was that of a journal

I really liked writing the reflections but I know that if it hadn't been for the assignment they wouldn't have been written. I'm not a person of many words but it'll be nice to look at my thoughts while I was here and see my efforts at drawing and watercolor. The field notebooks helped me stay present and connect things to what we learned in class whenever I felt like I needed it was a little stressful just because I felt like I needed to use it all the time or have something worth writing when I really didn't. But when everyone else looked out their notebooks you feel as though you are the one forgetting something or missing some important bit bits.

Figure S4. Example of student entry in the personal reflections section of their field journal.



April 8, 2015

Warm Up / Final Reflection

Most Rewarding Aspect of the Trip:

It is difficult for me to choose an aspect of the trip that was most rewarding as I learned so much and had more fun than I could have imagined. If I had to choose however, I would say that the most rewarding part of the trip was traveling somewhere that I may not have had the opportunity to explore if I had not gone on this adventure. South America, and particularly the Galapagos, were never places I planned or even imagined I would visit someday. The experience of exploring Ecuador and Punta Billamil / Ayora gave me a totally new perspective on the region as a whole. It was unbelievable for me to be able to practice my spanish with actual, native speakers and to learn about each others cultures. That is something I will never forget. And, of course, the opportunity to get so close to the animals I have been learning about for years in class was astounding. The fact that I now have a picture of a baby sea lion on my phone that I took myself is something that is still hard to get my head around. I have always been interested in marine biology but in recent months I have been learning further and further away from that. This trip rekindled my interest in the subject and I only have the Galapagos to thank for that.

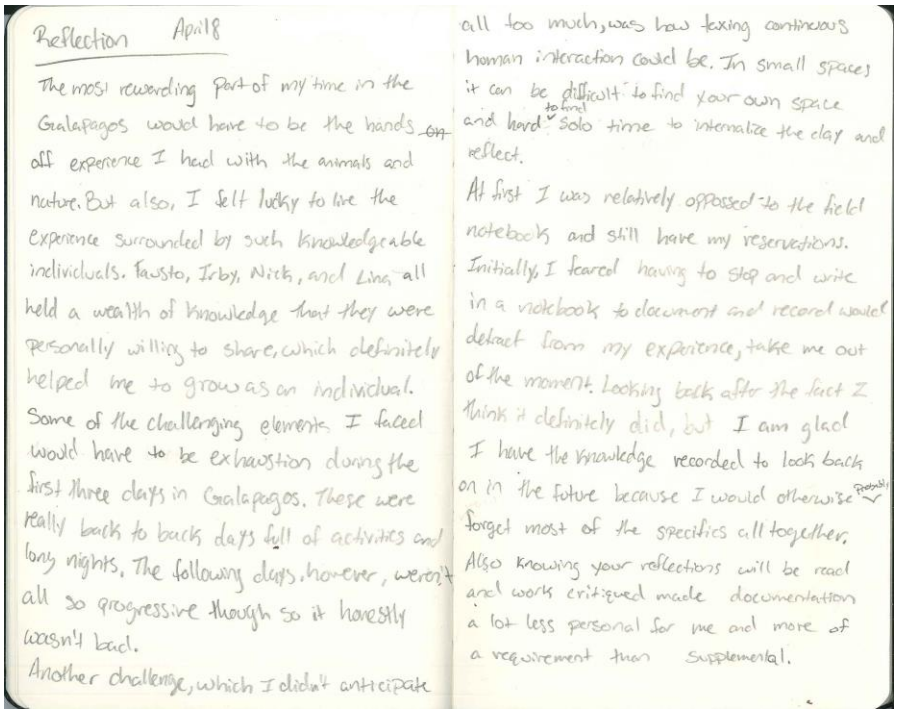
Most Challenging Thing

The most challenging thing for me was something that I had not anticipated as I prepared for the trip. I have traveled a lot during my life, so I was not afraid of going to a new, foreign place. However, I was surprisingly more homesick than I thought I would be while in the Galapagos. Even though I loved learning about these amazing new places, I missed the security I felt in the United States. I think that this is probably due to the fact that South America seemed slightly more dangerous or unpredictable than other places I've been. My unexpected sunburn is a testimony to that!

Role of Field Journal

At first I thought it was going to be difficult to go between writing in my field notebook, taking pictures and actually observing with my own eyes all at once. But as the trip went on I noticed that my field notebook forced me to pay attention to details I may have otherwise overlooked and kept me alert and engaged as never before. I love sketching and I was. I think the best part of using the field journal is that I will always be able to remember this trip in detail. I will be able to recall not only the activities we did and the thoughts I had,

Figure S5. Example of student entry in the personal reflections section of their field journal.



Reflection April 8

The most rewarding part of my time in the Galapagos would have to be the hands-on off experience I had with the animals and nature. But also, I felt lucky to live the experience surrounded by such knowledgeable individuals. Fausto, Irby, Nick, and Lina all held a wealth of knowledge that they were personally willing to share, which definitely helped me to grow as an individual. Some of the challenging elements I faced would have to be exhaustion during the first three days in Galapagos. These were really back to back days full of activities and long nights. The following days, however, weren't all so progressive though so it honestly wasn't bad.

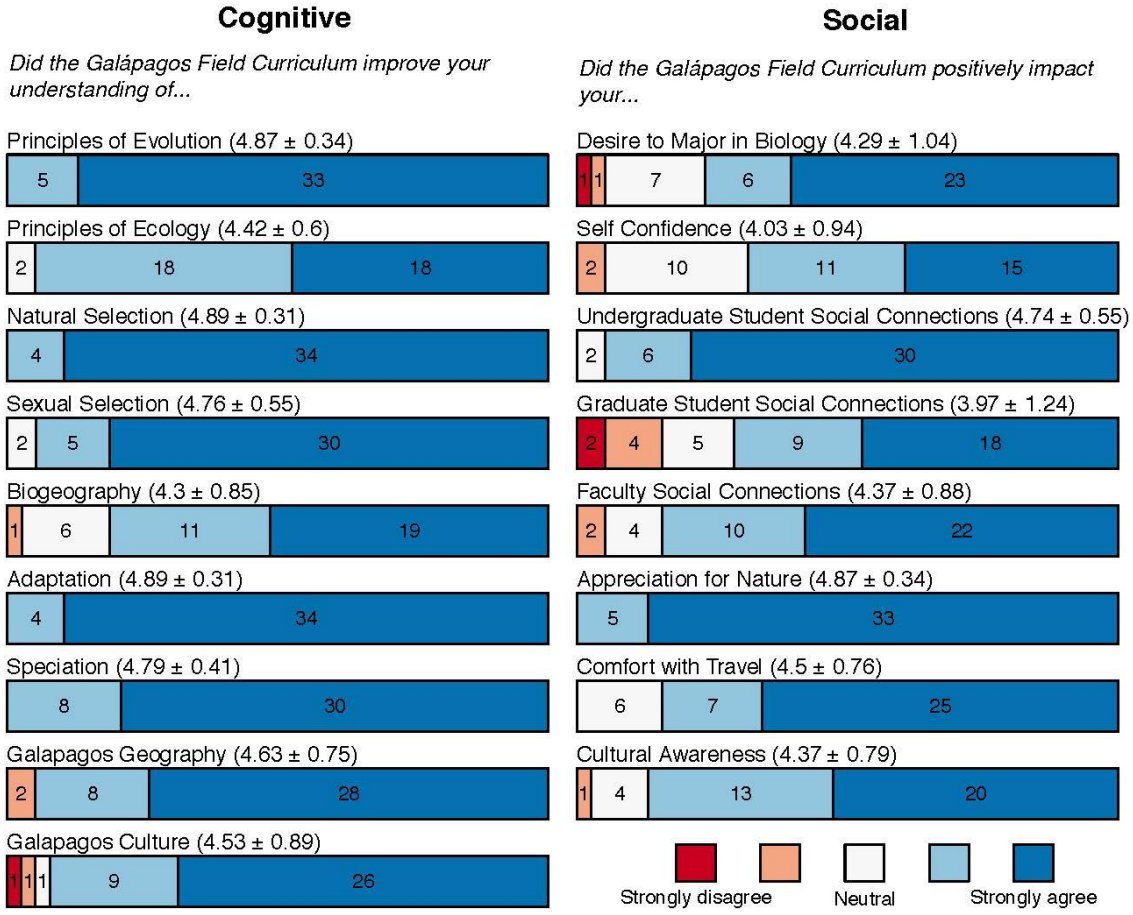
Another challenge, which I didn't anticipate all too much, was how taxing continuous human interaction could be. In small spaces it can be difficult to find your own space and hard to find solo time to internalize the day and reflect.

At first I was relatively opposed to the field notebooks and still have my reservations. Initially, I feared having to stop and write in a notebook to document and record would detract from my experience, take me out of the moment. Looking back after the fact I think it definitely did, but I am glad I have the knowledge recorded to look back on in the future because I would otherwise probably forget most of the specifics all together. Also knowing your reflections will be read and work critiqued made documentation a lot less personal for me and more of a requirement than supplemental.

Post-trip Survey Responses

We received survey responses from 38 out of 44 students (86.4%; Table S1). The distribution of Likert scale scores, as well as the mean and standard deviation, are reported in Figure 2. Assuming an interval scale, the average responses indicated positive effects for both cognitive (mean = 4.68 ± standard deviation = 0.62) and social gains (4.39 ± 0.9). We partitioned all question responses as either social or cognitive and used a Mann-Whitney test with the Likert scale data as ordinal to identify a lower median value for responses to social (n = 304) compared to cognitive (n = 342) questions (W = 59641.5, P = 3.9e-05). Using a Flinger-Killeen nonparametric test of homogeneity of variances, we also found that responses to social questions were more variable than cognitive questions (χ^2 = 20.57, df = 1, P = 5.75e-06).

Figure 2. Post-trip survey responses from 38 (out of 44) participants.



Participants responded to questions using a Likert scale, in which 1 corresponded to *strongly disagree*, 3 corresponded to *neutral*, and 5 corresponded to *strongly agree*. The number of responses for each Likert score is indicated above each bar. The mean and the standard deviation for each question are also displayed.

Student responses varied to the open-ended question about the most challenging and most rewarding aspects of the Galápagos curriculum. Many students said that the intense workload and the lack of sleep were the most challenging aspects of the course (Table S1). Seasickness, a particularly prevalent obstacle in this case study, and stomach illnesses were among the most common challenges for many students (Table S1). Certain students were critical of our role as "eco-tourists," feeling that "the trip [failed] to provide students with a practical portrayal of what it means to be a biologist." Overall, however, students were more forthcoming when asked to describe the most rewarding aspects of their time in the Galápagos. Multiple students cited close encounters with wildlife as the most rewarding aspect of the field component of the GC, in addition to a greater appreciation for nature (Table S1). Improved social connections with peers and instructors were also frequently mentioned as a positive aspect of the course (Table S1).

Discussion

Here we document evidence of cognitive and social gains associated with an experiential learning opportunity in the Galápagos for first-year students from underrepresented demographics in STEM fields. One distinct aspect of this particular case study is that the experiential learning opportunity was offered exclusively to first-year students of underrepresented demographics in the STEM fields. Because STEM attrition is even more pronounced among women, underrepresented minorities, and first-generation college students (Chen & Soldner, 2013; Allen-Ramdial & Campbell, 2014), providing diverse, affordable experiential learning opportunities specifically for these demographics may be an effective strategy to reduce attrition rates during the first two years of college education. Future longitudinal studies that track students who participate in field courses will be very useful in substantiating or refuting the long-term value of experiential learning opportunities for student retention in STEM.

Students who participated in the GC reported strong cognitive gains in their understanding of basic concepts in evolutionary biology and ecology, which corroborates previous findings on the efficacy of field courses for teaching content (Lisowski & Disinger, 1991; Magntorn & Helldén, 2005; Boyle et al., 2007; Prokop, Tuncer, & Kvasničák, 2007; Easton & Gilburn, 2012; Scott et al., 2012). Previous studies have found that certain underrepresented demographics tend to view evolution more negatively and have a weaker understanding of general evolutionary concepts, which may be related to a higher prevalence of religiosity among ethnic or racial minority groups (Bailey, Han, Wright, & Graves, 2011; Rissler, Duncan, & Caruso, 2014; Mead et al., 2015). Thus, experiential learning opportunities that emphasize evolutionary concepts through immersion beyond traditional classroom settings may improve scientific literacy and interest in evolution.

We found that self-reported social gains experienced by students in the GC were positive, albeit weaker and more variable than cognitive gains. The social benefits of an experiential learning opportunity for a specific individual are likely influenced by a number of interactive factors. For example, an individual's ability to form positive relationships with their peers and instructors will undoubtedly affect their self-reported social experience. Student and instructor dynamics vary from year to year, such that different individuals may feel more or less comfortable in any given academic group. Group dynamics will also be influenced by the unique set of previous experiences and beliefs of each student. Together, these factors contribute to the observed variation among self-reported social gains.

Based on our ethnographic observations, interactions with students, and assessment of field notebooks, we perceived an overall positive effect of field notebooks as facilitators of experiential learning. Students' reflective entries in field notebooks promoted connections of course material and personal experiences to their other academic interests and future aspirations. Among geography curricula, field journals have enhanced students' ability to critically reflect on their own learning experience and communicate their observations and ideas (McGuinness & Simm, 2005; Dummer, Cook, Parker, Barrett, & Hull, 2008). Therefore, reflective diaries and field journals appear to be an effective tool to facilitate experiential learning in the field across multiple STEM disciplines. However, we noticed that students initially treated the journal as more of a travel diary or activity log rather than a platform for deeper reflection; we recommend that instructors lay out clear guidelines

and provide examples of entries from previous years so that student entries meet the instructors' expectations.

As a case study, the GC discussed here involves a few nuances that are worth considering, especially in comparison to more traditional field course opportunities at most institutions. First, we were fortunate to be able to underwrite fully the cost of participation for students. Not every institution of higher education can offer heavily subsidized field courses given the scarcity of funding in the current economy. The Galápagos Islands provide excellent conditions for experiential learning in evolutionary biology; the approachability of endemic wildlife and the breadth (yet manageable time period) of human history in the archipelago creates an excellent opportunity for total immersion. However, the benefits documented here are also translatable to smaller-scale experiential learning opportunities, including shorter field courses or even day trips to local parks or other natural attractions (McLaughlin & Johnson, 2006; Prokop et al., 2007).

Through our collective experience as instructors for organismal biology curricula with prominent field components, we have amassed a selection of key insights and advice for instructors organizing similar courses. First, we feel it is important to allow ample time for student preparation and reflection both before and after the field component. Sufficient preparation before the field component promotes synthesis of each student's individual experience with background literature and perspectives of a given locality or ecosystem. This phenomenon is familiar to many: background knowledge enhances any intellectual experience, whether it be a visit to an art museum, a music or dance performance, or natural history immersion. Preparing these students via two half-semester courses before their trip to the Galápagos seemed to greatly enhance their contextual framing compared to an earlier pilot year in which the trip was not associated with semester-long courses. Designating time for reflection and continued coursework after the field component (in our case, during the second half of the regular semester classes, post-trip) allowed students to fully process their time in the field, and allowed their shared experience to improve classroom dynamics and student engagement.

Second, we find it useful to explicitly acknowledge the interdisciplinarity of these courses to the students. For example, students benefit when they realize that writing assignments not only help with articulation, but that good writing skills can help a student become a better scientist. Following in part from student suggestions, in more recent (post-2014) offerings, we have added a third 1-credit course taught by a professional artist who trains participating students in biological illustration techniques that they then deploy in their field journals. Many students have stated that they appreciated the interdisciplinarity of this science/humanities/art curriculum.

Third, for practical reasons, we found it important to ensure that these courses dovetailed with the academic requirements of the students' programs of study in their chosen major. Because both of the courses described here are part of the required curriculum for first-year biology majors, students could participate in the GC while simultaneously making expected progress toward their STEM degree.

As high attrition rates among historically underprivileged groups continue to plague the STEM disciplines, a central objective of colleges and universities has been to promote and maintain diversity in STEM fields. Experiential learning offers a powerful framework to diversify

undergraduate curricula and improve student undergraduate performance and volition (Kolb 1984; Freeman et al., 2014). Field courses are a longstanding form of experiential learning in ecology and evolutionary biology; however, many field courses are disappearing from course offerings, are prohibitively expensive, or are not available to first- or second-year students. Our study demonstrates that immersive field experiences confer important social and cognitive benefits to first-year undergraduate STEM students from underrepresented demographics. Study abroad experiences may very well translate to longer-term benefits related to retention and career advancement in the life sciences; however, these long-term benefits remain largely unquantified in the biological sciences. Nonetheless, we believe that higher education should support affordable, diverse learning opportunities to better educate students and strengthen social networks among individuals from different academic, socioeconomic, and ethnic backgrounds to promote and sustain diversity in the sciences.

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Supplementary Materials: Table S1, available at: https://frontiersjournal.org/wp-content/uploads/2018/11/Mason-et-al-Supplementary-Table.pdf

