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SYMPOSIUM

How an Early, Inclusive Field Course can Build Persistence in Ecology and Evolutionary Biology

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Synopsis Field courses have been identified as powerful tools for student success in science, but the potential for field courses to address demographic disparities and the mechanisms behind these benefits are not well understood. To address these knowledge gaps, we studied students in a nonmajors Ecology and Evolutionary Biology course, Introduction to Field Research and Conservation, at the University of California Santa Cruz, a large Hispanic-Serving Institution. We examined (a) the effects of participation on students' perception of their scientific competencies and (b) how the field course shaped student experiences and built their sense of community, confidence and belonging in science. Our mixed-methods approach included the Persistence in the Sciences (PITS) survey with field course students and a control group; interviews, focus groups, and prompted student journal entries with a subset of field course students; and participant-observation. We found that field course participants scored higher on all science identity items of the PITS instrument than students in the control (lecture course) group. Field course students from underrepresented minority groups also scored similarly to or higher than their well-represented peers on each of the six PITS survey components. From our qualitative data, themes of growth in peer community, relationships with mentors, confidence living and working outdoors, team-based science experiences, and a sense of contributing to knowledge and discovery interacted throughout the course—especially from the initial overnight field trip to the final one—to assist these gains and strengthen interest in science and support persistence. These findings highlight the importance of holistic support and community building as necessary driving factors in inclusive course design, especially as a way to begin to dismantle structures of exclusion in the sciences.

Introduction

Increased retention of students—especially those who have been historically underrepresented in the biological sciences—is an imperative goal for educators and institutions of learning. An important means to achieve this goal is by supporting persistence of students who enter with interest in biology majors. In higher education, active, problem-based, and inquiry-driven learning approaches in the classroom, lab, and field support short- and long-term persistence of students in the biological sciences (Beck and Blumer 2012; Graham et al. 2013; Allen-Ramdial and Campbell 2014; Beltran et al. 2020; Harris et al. 2020; Theobald et al. 2020). Programs that recognize the challenges of negotiating undergraduate education and provide mentorship, research experience, and tutoring are also important contributors to students' persistence, especially for people excluded by ethnicity or race (PEER; Asai 2020) or those who are the first in their family to attend college (Mina et al. 2004; Crisp and Cruz 2009; Feldman et al. 2013; Tovar 2015; Garriott and Nisle 2018). However, these approaches often continue to operate under individualistic, neoliberal, and exclusive structures and ideologies that maintain a noninclusive culture for many students in the sciences, especially those who are Black, Indigenous, and people of color (BIPOC) (Stephens et al. 2012; Marín-

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Spiotta et al. 2020; Morales et al. 2020; O'Brien et al. 2020).

To disrupt this pattern, we argue that in addition to the above-mentioned approaches, inclusive biology courses need to incorporate a holistic, community-building focus. A holistic approach recognizes the whole student with their lived experiences and histories, and meets students where they are (Orion 2007; Mahmoudi et al. 2012). It moves away from a deficit-oriented perspective of student knowledge and towards an asset-based approach (Renkly and Bertolini 2018). A focus on community-building is important for creating a sense of belonging in the sciences, which in turn is an important contributor to student success and retention in the sciences (Trujillo and Tanner 2014; Strayhorn 2019; O'Brien et al. 2020; Turetsky et al. 2020). We believe an intentional holistic and community-building approach can lead to increases retention of students from all backgrounds in biology. However, in most biological sciences majors, exclusive, competitive "weed out" courses still create barriers to student success and persistence, overwhelmingly affecting students underrepresented in science. Our research aims to identify and understand a foundation that courses can build on to center inclusion and community, recognizing the education debt owed to students who have far too long been excluded (Ladson-Billings 2006).

We hypothesize that field-based courses can be an ideal format for this model of science education. Traditional field courses are often still spaces of exclusion (Morales et al. 2020), by which we mean spaces where people face barriers to participation, in this case barriers including course fees, course requirements, access, historic whiteness and lack of representation of BIPOC members (Hall et al. 2002; Abbott 2006; Fleischner et al. 2017). Much work has been done to move these to spaces of inclusion including scholarships, intentional centering of student concerns, and reduced course requirements (Zavaleta et al. 2020). At the University of California (UC) Santa Cruz, the Ecology and Evolutionary Biology (EEB) Department offers a two-unit introductory field course, *Introduction to Field Research and Conservation* that centers inquiry-driven, holistic, community building features to support student success. Previously, we found participation in this and other subsequent field courses to be associated with higher self-efficacy gains, college graduation rates, EEB major retention, and GPAs at graduation for all students, but especially for PEER in the sciences (Beltran et al. 2020). Here, we incorporate student voice to guide our understanding of the full impact of field courses on students and the course design elements that undergird successful experiences. We hypothesized that the larger self-reported gains in specific ecological research skills by PEERs in *Intro to Field Research* reported previously (Beltran et al. 2020) would be associated with higher scores on assessments of six psychosocial outcomes linked to Persistence in the Sciences (PITS; Hanauer et al. 2017). In this paper, we report on these psychosocial outcomes for PEER and well-represent (WR) students and identify the features of *Intro to Field Research* that led to gains in self-efficacy, science identity, and belonging for students from all backgrounds.

Methods

Setting

Intro to Field Research is a course taught at UC Santa Cruz and created to address a shortage of lower-division, low commitment field courses for undergraduate students. The quarter-long (10-week) course is two units, the equivalent time commitment of a lab attached to a typical five-unit lecture course and includes weekly lectures and four field trips (two day trips, two overnight trips) (see Table A1). The course supports frosh and transfer students' transition to college by providing opportunities to explore and learn about local natural history through visits to local UC Reserves, engage in group field-based research projects, and develop skills and awareness of resources for pursuing future research.

Participants

There are no prerequisites for *Intro to Field Research,* and students from all majors are eligible to take the course. The demographics of this course vary across quarters but are generally reflective of the University, which enrolls approximately 30% Latinx, Black, American Indian, and Pacific Islander (categorized as PEERs in this research), 42% First Generation Students and has 30% Educational Opportunity Programs (EOP) participation, which is based on family income, undocumented, and foster care status (see Table A2).

Data collection and analysis

This work was approved by University of California Santa Cruz (UCSC) IRB protocol #HS3230. Data were collected using a mixed-methods, case study approach. Students 18 years and older were invited to participate in the study. Data for this study came from four quarters of in-person instruction (Winter 2019 [W19], Spring 2019 [S19], Fall 2019 [F19], and Winter 2020 [W20]). Data collected include reflective journal prompts, end of class focus groups, pre/post surveys (PITS post survey data reported here), individual student interviews, instructor/TA interviews, and an ethnographic case study (see Table A3). Demographic data were collected only from the participants who took the survey. No identifying data were collected for the qualitative data due to required anonymity.

Qualitative data

Reflective journal prompts were collected S19, F19, and W20 to capture changes in student self-efficacy, community, and science identity (see Appendix). The number of responses varied given the format collected (through online form [S19, W20] or written in field notebooks [F19]) (see Table A4). Focus groups were conducted W19, S19, and F19, with the number of students varying per quarter (see Table A5). Student interviews ($N = 4$) were conducted in Spring 2019. Students were recruited through email and announcement in the course, and anyone who was interested was invited to participate. These approaches explored student motivations, aspirations, experiences and barriers (see Supplementary Material). Course instructors ($N = 5$) and an undergraduate teaching assistant (TA) were also interviewed, with a focus on how they approached teaching the course, their perceptions on the strengths and weaknesses of the course, and anecdotal examples of student outcomes (see Supplementary Material). A case study of a section of the course ($n = 23$) was conducted in F19. Data were collected using ethnographic methods including participant observation and field notes. This case study provided insights into the context and experience of the participants. It also provided data on student discussion, connections, and experience that might not be captured in the reflective prompts.

To analyze our data, we first created a codebook using inductive and deductive approaches (Saldana 2016). We drew from the literature to identify codes for science identity (Carlone and Johnson 2007), self-efficacy (Chemers et al. 2011), and sense of belonging (Freeman et al. 2007). Two members of the research team collaboratively developed the codebook through multiple iterations and narrowing to ensure consistency and to increase validity. We used the qualitative software Dedoose to facilitate our coding of the journal entries, interviews, and focus groups. Dedoose tracked our coding and aided in the quantitative analysis of the application of the codes (i.e., co-occurrences or percentage of application). From this process, we were able to identity the major themes across the data sources. These themes emerged from the code frequency as well as literature supporting our quantitative analysis (Hanauer et al. 2017). Due to the lack of demographic links to the individual qualitative data, we recognize the limitations of our qualitative findings to make claims about the experience of any specific demographic group.

Quantitative data

The quantitative data reported come from the post-course survey, which included the PITS instrument (Hanauer et al. 2017). The PITS Survey has 36 Likert-scale questions organized around six components related to persistence: (1) Project Ownership-Content; (2) Project Ownership-Emotion; (3) Science Self-Efficacy; (4) Science Identity; (5) Science Community Values; and (6) Networking (Hanauer et al. 2017). The survey has been validated by Hanauer et al. (2017). They found a high degree of internal consistency (Cronbach's $\alpha = 0.96$) with Cronbach's α values being 0.96, 0.96, 0.92, 0.87, 0.88, and 0.85 for Project Ownership-Content, Project Ownership-Emotion, Self-Efficacy, Science Identity, Scientific Community Values, and Networking, respectively (Hanauer et al. 2017). PITS survey data for two components, Science Identity and Science Community Values, were also collected from students at the end of BIOE 20C (Ecology and Evolution, a five-unit introductory ecology lecture course required for the EEB major, as a control. Data comparison between the two courses focuses on these two PITS measures, which are the two that could be assessed for a nonresearch-based course. We used unpaired, one-tailed Wilcoxon Signed-Rank Tests to compare numerical PITS scores by item on the Science Identity and Science Community Values components between the field and lecture classes (specifically, to test the hypothesis that field courses would be associated with higher PITS scores for each component). Additionally, we used unpaired, one-tailed pairwise Wilcoxon signed-rank tests to compare mean PITS scores by component between PEER and WR students (specifically, to test the hypothesis that PEERs would have higher PITS scores for each component). Numerical PITS scores treat "Strongly Agree" as 5, "Agree" as 4, "Neither Agree Nor Disagree" as 3, "Disagree" as 2, and "Strongly Disagree" as 1. We visually inspected data for concordance with the assumption of normally distributed values and conducted analyses in R version 4.0.2.

Findings

Measures of Persistence in the Sciences

At the end of *Intro to Field Research,* PEER students reported persistence outcomes higher than their WR peers on the Project Ownership-Content component ($t_{101} = -2.44$, $P = 0.008$) and on the Science Identity component of the PITS survey ($t_{98} = -1.95$, $P = 0.027$) (Fig. 1). PEER students reported outcomes similar to their WR peers on the four other PITS components (Networking, Science Community Values, Project Ownership-Emotion, and Self-Efficacy, $P > 0.15$).

Scores on all five Science Identity items were significantly higher on the field course than in the lecture class (Fig. 2A). Three of the four Science Community Values items differed significantly between the courses, with mean scores higher in each case for the field course

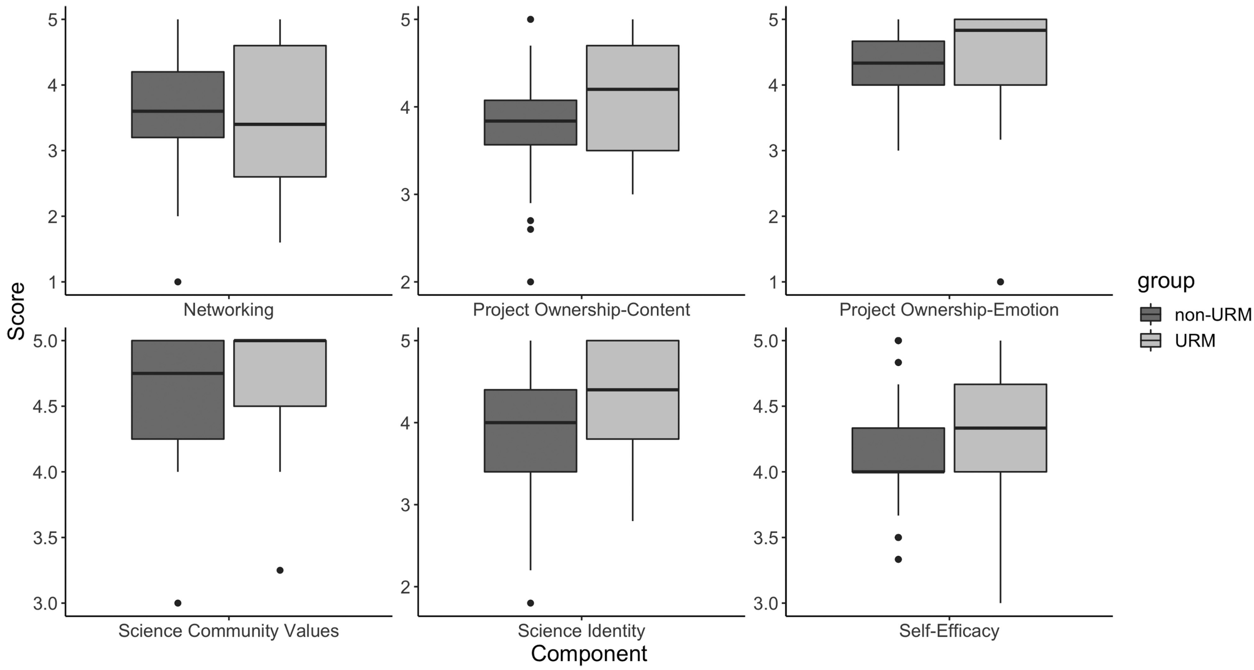


Fig. 1 Student end-course scores on each of the six PITS survey categories (Hanauer et al. 2017), comparing PEER ($n = 21$) and well-represented (WR) ($n = 79$) participants in the field course *Introduction to Field Research*. Plus sign denotes the level of significance: $^{+}P < 0.05$.

as compared to the lecture course (Fig. 2B). PEER students in the field course reported significantly stronger science identities and sense of belonging than WR students in the field course and all students in the lecture course (Fig. 2).

Course components supporting persistence

We found three central field course components that students linked to their experiences and that provide explanations for the course's positive effects on key factors—self-efficacy, science identity, and sense of belonging—that can lead to persistence in the biological sciences: (1) Designed for Inclusion; (2) Community and Peer Network Building; (3) Inquiry-driven Group Research Experiences.

Designed for inclusion

Intentional course design to support inclusion is important to reduce barriers that might limit participation and to support students during the course. Holistic support before, during and after taking *Intro to Field Research*, played an important role in supporting all students.

Minimized barriers to participation: At many universities, field courses are offered only as upper-division courses, once a year, with prerequisites, an application, and a large associated course fee. *Intro to Field Research* was designed to minimize these barriers in order to create an accessible pathway to field experiences for all interested students. The course has no prerequisites, and instructors do active outreach to recruit students from all majors. While there is still an application process, which some students in the focus groups mentioned was slightly intimidating, the course is offered every quarter, often with multiple sections (see Table A2). Priority is given to students with no previous field experience, and students who are not accepted are encouraged to apply again. Course fees can be prohibitive to all students, especially those from lower socioeconomic backgrounds (Garland 1993). In our focus groups, at least one student per quarter mentioned the financial barrier of field course fees. *Intro to Field Research* provides scholarships to minimize this barrier.

Holistic support: For about 12% of students, this course was their first opportunity to camp, hike or spend an extended amount of time in nature. This can create both material and mental barriers for students. Materially, students may not have access to the gear needed for field experiences, including camping equipment, proper activewear, or warm clothes. To remove the material barrier, all camping equipment (tents, sleeping bags, and sleeping pads) and food for overnight trips were provided throughout the course. We saw the effect of this on one student we interviewed who had never camped before:

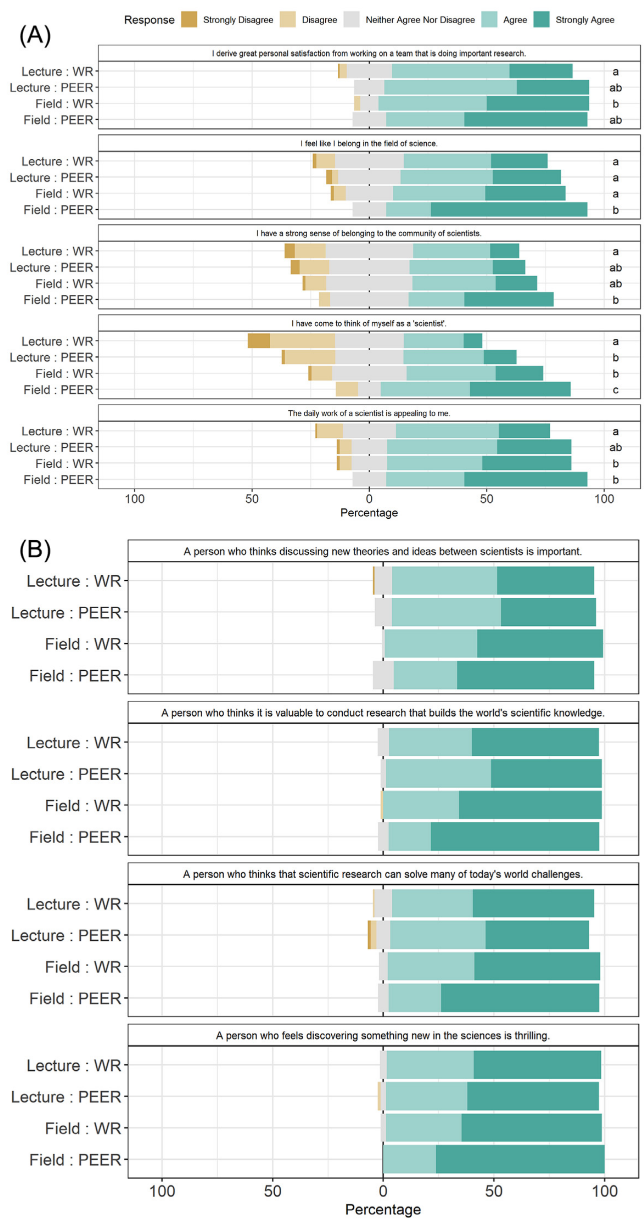


Fig. 2 Student scores on each of the PITS: (**A**) Science Identity and (**B**) Science Community Value items (Hanauer et al. 2017), comparing students completing the required major lecture course (5 units) and the field course *Introduction to Field Research and Conservation* (2 units) from well-represented (WR) groups and PEER. For the Science Identity section, students responded to the prompt: "Please rate the degree you agree or disagree with the following statements concerning your sense of yourself as a scientist who undertakes research activities." For the Science Community Values section, students responded to the prompt: "Please read each description and think about how much each person is or is not like you. Check the answer that best reflects how much the person in the description is like you." Letters denote a significant difference between courses and/or student groups.

> I really enjoyed the experience and I'm not really scared of it anymore. I was a little nervous going camping because I didn't think that I'd be ready for it or equipped for it because I never really had done it before…So the fears of like, what if I run out of food or what if something happens? That's completely gone.

As this student related, the impact of removing material barriers helped minimize certain mental barriers, like fear, which sets students up for success in future outdoor experiences (Carlone et al. 2015).

Mentorship opportunities: This course provides former students the opportunity to become undergraduate assistants for the class. In this paid position, undergraduate TAs support students on the field trips by acting as peer mentors. One undergraduate TA reflected on the most successful aspect of the experience for them:

> It's nice to see that I actually learned something. I'm far from being like a PhD professor, but I kinda like that it was nice to see that I could hold my ground…I was in these student's shoes not too

> long ago, just looking at the trees for example, and being like, oh that's a nice tree, but not being able to correlate it with anything. Now I could just go to them and be like, well, why is that tree so curved? Or why is it on this slope, not on that slope? And then be able to push them into thinking more critically.

In traditional lecture courses undergraduate students are required to show their learning through stressful assessments such as exams. Having the opportunity to apply knowledge in the field, while facilitating learning opportunities for peers, creates spaces for content and skills mastery and identity development as a person who does science. The undergraduate TAs can also serve as more approachable, near-peer mentors, as one instructor mentioned:

> I feel like the undergraduate TAs can really [support] the students who are struggling, like, you know, I was here, I can do this, you can do this is, it gets better.

Holistic support from peers changes the power dynamics that may prevent some students getting the support they need (Apple 1995).

Community and peer network building

In a course designed for inclusion, community and peer network building are central components of enhancing belonging and sustaining students after the course ends. In *Intro to Field Research*, we found that small class size and shared first-time experiences were central in supporting peer network-building, leading to community building and increased sense of belonging.

Small class size: In journal prompts asking about connection to classmates, 10% of students explicitly mention small class size as an important factor for creating connections to classmates and beyond. The majority of classes that new undergraduates take are large lecture courses, often with well over 100 students. This can create challenges to making connections, especially for frosh students acclimated to smaller high school class sizes. In *Intro to Field Research,* the average class size is 23 students. This small class size, combined with the hands-on experiences of the field course, facilitate student connection and community building. One student reflected in a focus group:

> From this class, I think I gained a better sense of community with other fellow EEB majors because, as someone I think earlier mentioned, the class size was so small you're actually able to connect with your classmates instead of like in the big lectures. So I feel like now I have more friends who are studying similar stuff to me and it has given me more connections to find out about more programs and more research opportunities. And that's been very exciting and comforting.

While this class is offered to nonmajors, it is often largely taken by intended biological sciences majors who wish to learn more about field research. Having a small class to help facilitate connection to classmates and the broader biological sciences community is important for students to develop a sense of belonging in the major. In response to the journal prompt "Has your relationship with your classmates changed?," we found that 92% of students reported a changed relationship, including deeper connections, friendships, found shared interests and shared new experiences (Fig. 3). Deep connections and community building facilitated by small class size can have long-term impacts on student retention (Booker 2016).

Shared first-time experiences: Of those who responded to the journal prompt about first time experiences ($N = 71$), 89% reported they had a first-time experience in the course. These first-time experiences included research ($N = 27$), learning a new skill like field journaling, small mammal trapping or pattern recognition ($N = 22$), camping ($N = 7$), kayaking ($N = 5$), and engaging with classmates ($N = 2$). In our data, the code "first time experience" co-occurred with "classmates" and "appreciation" in 35% of the responses. Having a particular memorable experience with classmates seemed to be an important catalyst to strengthen peer-network development, as one student reflected:

> Since Fort Ord, I have become much closer with my classmates from BIO 82. On this trip, we all jumped into the ocean together and swam through a cave to some more tidepools. It was totally wack and totally awesome. I love these people so much and I am so glad to get to share these experiences with them.

Having an experience that creates a bond can lead to friendships and peer networks in the sciences. These strong positive emotions and having a space where your classmates feel like friends can also lead to other positive psychological outcomes, like reduced fear and anxiety and feeling like you can be yourself. This is particularly important for students who may normally not feel like they belong or are processing additional fears that can accompany first-time outdoor experiences (Dillon et al. 2006).

Inquiry-driven group research experiences

Providing students with the opportunity to conduct research was a central component that led to student gains in science self-efficacy, or the confidence that one can successfully complete the behavior required to produce a result around a scientific task (Bandura 1977), and science identity, or who one thinks one must be to engage in sciences (Calabrese Barton 1998).

Our data highlighted the importance of students being able to collaboratively design and carry out their own experiments, more than once, all while being able to connect the process to a potential career in science.

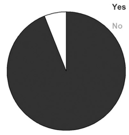
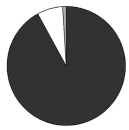
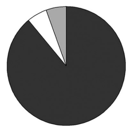
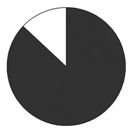
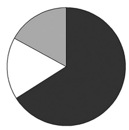
Question	Responses	Sample Quotes
Has the way you engage with the “field” changed over the course of this program?	 N=58	*"I definitely view nature in a completely different way. I find myself identifying birds and asking questions about patterns I discover in my day to day. What I have learned can be applied to my future career and hopefully other classes I enroll in."*
Have your connections with your classmates changed?	 N=71	*"Yes, I realized field research is a beautiful way to get to know people. Camping makes for a great environment to loosen up and really get to know people in a profound way."*
Did you do anything in this class for the first time?	 N=60	*"I feel like this trip really broadened my view on the possibilities of education in college. I have never before done field research and discovering that this is possible as an undergrad is eye-opening. Being in the field with other students who are interested in similar things was exciting as well. Even though this was just a 2-day trip, I feel like it gave us a really good taste of future possibilities. Talking to people like Joe, who manages this reserve, gave me an idea of what it looks like to have a career in this field!"*
Do you feel this class has prepared you to succeed as a student at UCSC?	 N=36	*"Yes, it prepared and motivated me to follow environmental studies at UCSC. Thanks to this class I'm gonna work for an internship based on ecology restoration for a UCSC lab."*
Has this trip changed the way that you view the UCSC campus?	 N=23	*"All of this has made me feel a lot more comfortable and at home at UCSC. It's been a little strange moving to a small college town from a place like San Francisco- I was worried about getting bored of this place, but after visiting upper campus I feel like I could spend a lot of time just exploring."*

Fig. 3 Responses to (Yes = black, Maybe = light gray, No = dark gray) and sample quotes from selected journal prompts.

Working in a group: For about 40% of students, this course provided their first opportunity to conduct scientific research. As with any first-time experience, students can feel nervous or unsure about their abilities and maybe feel, like one student mentioned, “like an amateur.” To minimize this, students worked in groups to support collaborative learning. Students really valued the group environment, one student reflecting:

> Working in a group was beneficial in a variety of ways. The very beginning, the entire process we went through to find a topic went very smoothly as we were able to organize our thoughts in a very effective way. Instead of simple ideas being lost and undeveloped, as a group we could combine our knowledge to build on predictions. Additionally, we were able to speed up data collection in a grand way given the different roles we would each take. This was incredibly beneficial in the final presentation of our poster.

As this student reflects, by working collaboratively they are able to build knowledge, collect more data and more effectively communicate their results. While not all groups worked perfectly together, one student reflected, “it was also difficult because we all had different ideas of how we should measure [spider]webs,” scientific argumentation is an important skill to develop. By having to defend their research decisions, students had to be confident in their ideas. Many students reported increased confidence, like this one:

> After this experience I feel a lot more confident in myself. I learned that when I’ genuinely passionate about something I can carry it out effectively and skillfully and give a confident presentation. I’m very excited to hone my field research skills and become a better scientist.

Increased confidence in the ability to complete scientific tasks is the definition of science self-efficacy. In this student’s response, we see how self-efficacy can also act as a mediator for science identity as the student referred to themself as a scientist.

Two research projects: An important component of building self-efficacy is the opportunity to gain confidence through multiple opportunities to practice skills. *Intro to Field Research* allows students the ability to conduct two research projects in two different ecosystems. Students reported that the opportunity to conduct two research projects was highly beneficial, like this student:

> The research project that we did the second time around was much better than the first. We were able to gather data without bias, graph our information in a more scientific manner, and ask questions that a scientist would’ve asked. I felt much more pre-

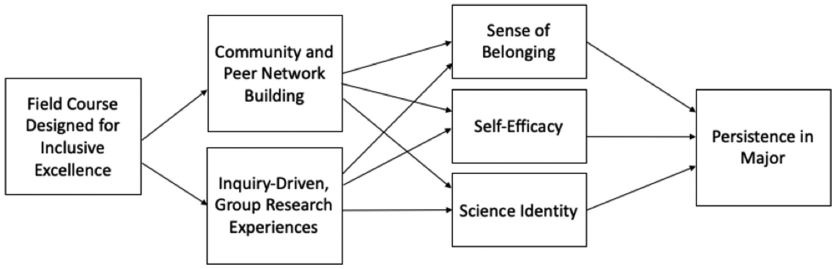


Fig. 4 Model of the key factors and psychological outcomes that impact persistence in a biological science major.

> pared to answer questions after our presentation because I was asking those questions myself as we were putting together our project.

For this student, the opportunity to practice and improve skills resulted in greater confidence in ability, and increased sense of science identity, as we see the student feeling the questions asked were those that a scientist would ask. 88% ($N = 25$) of students said their experience improved between the first and second research project, mentioning increased confidence, ability and feeling "clearer" about what to do.

Own research questions: Conducting research can help students see themselves as scientists (Robnett et al. 2015). They can develop important scientific skills, like hypothesis development, data collection, data analysis, collaboration, and scientific communication (Seymour et al. 2004). While some students had conducted research before, this was the first time that many got to answer their own research question. One student reflected on the process of answering their own questions:

> I collected data for a research project I got to design myself for the first time this trip! In the past although I've done data collection inside and outside it was always for someone else's research project with someone else's methods. I was so much more excited about the data collection process and the project itself because I got to study what I wanted to study and decide how I wanted to study it.

Answering their own questions appeared to strengthen science identity as students participated in the entire scientific research process, though in a condensed format (Weaver et al. 2008). As this student mentioned excitement for the scientific process is heightened with increased project ownership.

Seeing a career in science: Instructors of the field course provided students with information about careers in field biology and conservation by introducing them to research opportunities and field scientists. As one transfer student, who was now participating in a field-based research internship, reflected:

> I'm just so happy that it was one of my first classes because I feel like that it really sparked more of an interest in the possibility that I could do field stuff, that it was an option. Coming from community college they tell you certain career paths, but I didn't even know that fieldwork was a thing. I wasn't aware that you can actually do work like that. So that was my first exposure. Then just learning how scientists work outside and do all that was really cool. I feel like that just totally sparked a whole new thing for me, which was awesome.

This feeling of connection to field research was common for students. This connection often led to students pursuing field-based research opportunities after the course. This was supported by one of the course assignments in which students developed a curriculum vita and a cover letter. During interviews, all the instructors mentioned that this activity was important for supporting students to apply for internships. Early exposure to opportunities can open pathways to a career in science (Rodenbusch et al. 2016). As this course enters its fifth year, while we do not yet have sufficient longitudinal data, we have anecdotally seen many past *Intro to Field Research* students pursuing a career or graduate degree in the biological sciences. During interviews, all instructors mentioned that many students had reached out for letters of recommendation for jobs or graduate programs.

Discussion/conclusion

We found that course features including minimized barriers, group research projects, multiple field trips, and mentored holistic support created spaces for student gains in self-efficacy, science identity and sense of belonging. These gains were evident across both PEER and WR students and were stronger in some respects for PEERs than WR students, indicating that the course narrowed rather than expanded experience and outcome gaps underrepresented students. Drawing from the model of Hanauer et al. (2017) for PITS, we propose that in addition to course research experiences, courses must foster community and peer network building to support the psychological impacts that can increase persistence (Fig. 4). This is particularly important for fostering a sense of belonging, which can be a major factor leading to attrition, especially for students from marginalized groups (O'Keeffe 2013; O'Brien et

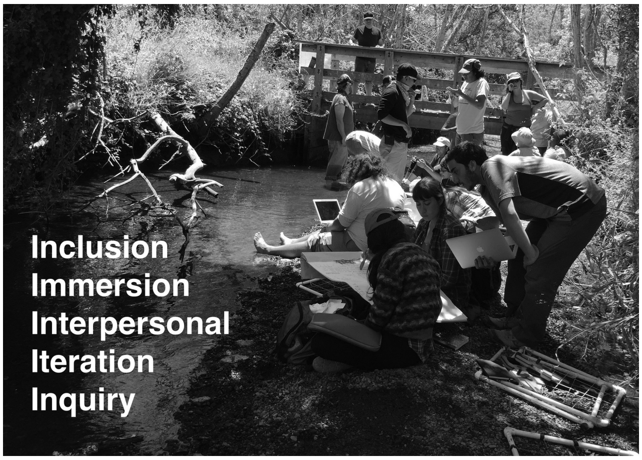


Fig. 5 Five I's model to support psychological outcomes to increase persistence in the biological sciences.

al. 2020). We observe that networking is more than just an outcome of research experience. It comes from intentional and explicit discussion of links among peers and the larger science community, and from shared experiences outside of formal class time. The field is an ideal setting for these collective, flexible experiences among students and their instructors and mentors. This model helps us better understand which features in field courses contributed to gains in associated factors related to PITS for both PEER and WR students.

To help translate our research findings into practice, we propose a "5 I's" model for field course components to support psychological outcomes associated with PITS: **Inclusion, Immersion, Interpersonal, Iteration**, and **Inquiry-driven** (Fig. 5). To reduce experience gaps, course features that support *inclusion* and *immersion* are central. An example of this is holistic support for overnight field trips through providing and demystifying supplies, food, and outdoor skills. Emphasizing development of *interpersonal* relationships can support peer-network development and challenge individualistic, competitive approaches to teaching science. Building these connections includes both an emphasis on collaboration in research experiences and working collaboratively in the outdoor living space. *Iteration* of both research projects and field trips is important for building confidence in science skills because repeated research efforts and outdoor experiences allow students to see their gains from one attempt to the next. Finally, for students to see themselves as practicing scientists, research projects should include student-driven *inquiry*, with research questions and study designs emerging from the students themselves.

As courses adopt these elements, we emphasize the importance of collaboration, not competition. For too long, the competitive nature of research, a product of the neoliberal, individualistic model of knowledge production, has created a culture of exclusion and isolation. Collaborative spirit will strengthen the scientific community by increasing the diversity of ideas and students attracted to science. Finally, science majors are frequently structured around an assumption that students must master extensive science content before they can participate in the research process. We found that students just arriving at college, from many majors, were able to successfully co-create research in *Intro to Field Research* and to become scientists in the process, without prior content mastery. This makes clear that a flipped curricular structure in biology majors—one that puts research at the front of the major experience, to motivate and give meaning to subsequent content learning—could be a powerful tool to improve retention in and diversify EEB.

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Data availability statement

The data underlying this article are available upon request from authors.

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Appendix A

Table A1 Intro to field research course structure

	BIOE 82 intro to field research
Number of Field trips and/or time spent in field	Four weekend field trips (two day trips, two overnight trips) and four individual observations
Course assignments	Field journal, reading summaries, CV/cover letter
research project description	Two rapid research projects done in groups of 3–4 at Reserves during field trips; students given aprox. 3 h to develop hypothesis, gather data, create poster and then present to group
Lectures: time and topics	Eight lectures/2 h each. Focus on natural history, preparation for field trips, addressing inequity and sexism in the field and careers in science (guest presenters)

Table A2 Demographics of intro to field research

Quarter	**Total number of students**	**Number of sections**	**FirstGen%**	**EOP%**	**%PEER**
Winter 2019	42	2	26%	30%	28%
Spring 2019	45	2	47%	36%	38%
Fall 2019	71	3	27%	39%	38%
Winter 2020	44	2	32%	30%	26%

Table A3 Summary of data collected

	Pre/post surveys	**Reflective journal prompts**	**Focus group**	**Instructor interviews**	**Case study**
Winter 2019	✓		✓		
Spring 2019	✓	✓	✓		
Fall 2019	✓	✓	✓		✓
Winter 2020	✓	✓		✓	

Table A4 Count of responses to reflective journal prompts each quarter

Quarter	Total number of students	P1	P2	P3	P4	Total	Average response rate	Handwritten or online?
Spring 2019	45		4	4	6	14	10%	Online
Fall 2019	71	53	49	42	34	178	65%	Handwritten
Winter 2020	44	11	7	2	7	27	16%	Online

Table A5 Summary of data response rates from BIO 82 participants

	Winter 2019	Spring 2019	Fall 2019	Winter 2020
Total number of students	42	45	71	44
Post-surveys collected (number/response rate)	25 (60%)	26 (58%)	43 (61%)	12 (27%)
%PEER response	12.5%	23%	25%	25%
Focus group # of participants	7	9	5	0
Case study	—	—	23	—