Understanding the Benefits of Residential Field Courses: The Importance of Class Learning Goal Orientation and Class Belonging

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ABSTRACT

While previous literature finds many benefits to participation in undergraduate field courses, the mechanisms for how these benefits develop is still unknown. This study explores these mechanisms and any unique benefits of field courses by examining results from pre and post surveys about scientific literacy, future science plans, and motivation and belonging for undergraduate students who took courses in one field station setting (n = 249) and one traditional on-campus setting (n = 118). We found positive associations between the field station setting and scientific literacy as well as future science plans. In addition, this study finds support for the serial and multiple mediation of class learning goal orientation and class belonging in explaining the relationships between the field station setting and scientific literacy as well as future science plans. The results of this study have implications for enhancing field course design and increasing access and inclusion.

INTRODUCTION

Hands-on learning in the natural world is considered an essential experience for academic development of undergraduates in science, technology, engineering, and mathematics (STEM) disciplines with a field component (Petcovic *et al.*, 2014; Fleischner *et al.*, 2017; Klemow *et al.*, 2019; Mead *et al.*, 2019; Giles *et al.*, 2020). Undergraduate field courses immerse students within their object of study (nature) and a community of inquiry (e.g., Lonergan and Andresen, 1988; Harland *et al.*, 2006; Mogk and Goodwin, 2012; O'Connell *et al.*, 2020; Petcovic *et al.*, 2020). Common field course designs provide opportunities for students to be engaged in many high-impact educational practices (e.g., collaborative assignments and projects, undergraduate research, community-based learning, and capstone courses and projects; Kuh, 2008; see also Lonergan and Andresen, 1988; O'Connell *et al.*, 2020). In addition, field courses have been shown to facilitate strong connections between students and other individuals and the academic discipline (e.g., Boyle *et al.* 2007; Stokes and Boyle, 2009; Mogk and Goodwin, 2012; Streule and Craig, 2016; Petcovic *et al.*, 2020).

Previous work has identified a number of positive student outcomes from undergraduate field courses. Outcomes from undergraduate field courses have included gains in field-specific skills (e.g., Riggs *et al.*, 2009; Petcovic *et al.*, 2014; Hannula *et al.*, 2019), improved understanding of the process of science (e.g., Patrick, 2010), development of self-awareness and identity (e.g., Boyle *et al.*, 2007; Stokes and Boyle, 2009; Petcovic *et al.*, 2014; Kortz *et al.*, 2020), and increased interest in the field course topic (Dayton and Sala, 2001). During field courses, students share learning experiences with peers, faculty, and other experts, developing knowledge and skills through prolonged participation and reflection, connecting them to the

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wider field science community of practice (Mogk and Goodwin, 2012; Streule and Craig, 2016; Petcovic *et al.*, 2020). Additionally and importantly, field courses have also been shown to reduce educational equity gaps, promote retention of students from groups historically excluded from field disciplines, and support self-efficacy gains for all students (Beltran *et al.*, 2020).

Residential field courses, in which students live at/near the field station/marine lab/field site (s) and stay in shared accommodation, potentially even traveling to multiple sites, are a common approach used in biology and geosciences field education (e.g., Lonergan and Andresen, 1988; Gold *et al.*, 1991; Whitmeyer *et al.*, 2009; Petcovic *et al.*, 2014; Jolley *et al.*, 2018; O'Connell *et al.*, 2020). In residential field courses, students are not only immersed in the context of what they are learning, but they are also immersed with a community of peers, faculty, and researchers with shared goals, providing the opportunity for social benefits such as building a professional network (Mogk and Goodwin, 2012; Thompson *et al.*, 2016; Mason *et al.*, 2018), acquiring social skills for collaborative research (Hanauer *et al.*, 2012; Mogk and Goodwin, 2012; Jolley *et al.*, 2018), and developing a scientific identity (Streule and Craig, 2016).

Though previous work has identified benefits of field courses, we still have much to learn about mechanisms driving these benefits (Beltran *et al.*, 2020). In addition, while many of these studies give specific insights into the benefits of field courses, few compare these insights to work in other settings. To address this gap, we investigated the links between outcomes associated with the type of course work students engage with in field settings, including scientific literacy or familiarization with the process of science (e.g., Kardash, 2000; Lopatto, 2004; Beltran *et al.*, 2020), as well as future science plans, including continued interest in engaging in science course work/having a career in science (e.g., van der Hoever Kraft *et al.*, 2011; Carpi *et al.*, 2017), motivation, and sense of belonging. This study examines courses at one field station and one institution by comparing courses at the field station with on-campus courses. We refer to this binary variable in our model and the research questions below as "the field setting."

We sought to answer the following research questions:

1. What is the relationship between the field setting and perceived scientific literacy (including scientific understanding, scientific communication, and scientific skills)?
2. What is the relationship between the field setting and future science plans (including motivation to take more science courses, motivation to be a science major, and interest in pursuing a scientific career)?
3. Is there a moderating effect of race/ethnicity and generation status on the relationship between the field station setting and perceived scientific literacy and future science plans? In other words, does race/ethnicity and/or generation status affect the strength of the relationship between the field station setting and perceived scientific literacy and future science plans?
4. To what extent do perceptions about the course (class learning goal orientation and class belonging) mediate these relationships between the field station setting and perceived scientific literacy and future science plans?

LITERATURE CONTEXT

In this study, we are concerned about four major variables and how they relate to student outcomes in the field setting: scientific literacy, future science plans, learning goal orientation, and sense of belonging. These variables are driven not only by the hypothesized outcomes of high-impact educational practices (Kuh, 2008) that occur in residential field courses, but also by the rich groundwork that has been laid by other scholars studying undergraduate field education. The following sections highlight key advances in the literature that form the foundation for this study.

Scientific Literacy

The concept of scientific literacy generally refers to familiarization with the process of science, often regarded as the essential knowledge that the public should have about science (for a discussion, see Laugksch, 2000). We have operationalized scientific literacy using prior research conducted on undergraduate research experiences and scientific communication and application. Many of the courses involved in our study had a significant research component and emphasized the ability to communicate about and apply scientific content.

Previous research found that field courses are associated with larger increases in student confidence in their ability to conduct research and design experiments than in similar lecture courses (Beltran *et al.*, 2020). In addition, studies of undergraduate research experiences demonstrated that students gained specific research skills (e.g., "formulate a research hypothesis based on a specific question") over the course of their experiences (Kardash, 2000; Lopatto, 2004). The Survey of Undergraduate Research Experiences found that students who participated in undergraduate research experiences had the highest gains on items related to the research process (e.g., "Understanding of the research process"), scientific problems (e.g., "Understanding how scientists work on real problems"), and lab techniques (e.g., "Ability to analyze data"; Lopatto, 2004). Similarly, studies of course-based undergraduate research experiences (CUREs), report student gains in research skills, self-efficacy, and intent to persist in science (Lopatto, 2004; Shaffer *et al.*, 2010; Harrison *et al.*, 2011; Auchincloss *et al.*, 2014; Jordan *et al.*, 2014; Rowland *et al.*, 2016). It follows that field courses with a research component should produce similar student outcomes.

In addition to involving students in research projects, courses involved in our study focused on broadening students' ability to communicate and apply scientific concepts. Studies demonstrate that students gain communication skills through participation in CUREs (Corwin *et al.*, 2015) and in particular when students present work done in their class outside their class, such as at a research symposium (e.g., Caruso *et al.*, 2009). In their study of Taiwanese university biology courses, Lin *et al.* (2015, p. 452) found positive associations between students' self-efficacy for biology (including using science in their daily lives and communication) and an *understanding* conception of learning ("building personal comprehension of the learning context") as opposed to a *memorizing* conception of learning ("memorization of scientific contents"). As students are immersed within a community as well as the context of what they are learning (Mogk and Goodwin, 2012; Giamellaro, 2017; Jolley *et al.*, 2018), field courses may naturally encourage more conversations about research as well as consideration of the application of course topics. A recent study supports this point, finding that students had larger gains on confidence in oral presentation skills in field courses compared with on-campus lecture courses (Beltran *et al.*, 2020). Thus, the field setting should provide more opportunity to communicate and consider the application of science.

Though the term "scientific literacy" has not been widely used in field education research, many investigations describe the importance of building science process skills and an awareness of how science is conducted. In addition, field education is often explicitly centered around conducting research (e.g., Lonergan and Andresen, 1988; Gold *et al.*, 1991), and opportunities for students to take ownership of their learning through authentic experiences of scientific practice feature heavily in field pedagogy (e.g., Jolley *et al.*, 2019; Kortz *et al.*, 2020; Petcovic *et al.*, 2020). In a recent survey of undergraduate field experiences predominantly in ecology and the geosciences (n = 162), respondents indicated that more than half include some form of small-group research (O'Connell *et al.*, 2020). Furthermore, 141 of the 162 field experiences indicated that "increased understanding and proficiency with research practices" was a desired student outcome of their program (O'Connell *et al.*, 2020). As students embody the procedures and practices of authentic science in the field, they develop scientific literacy.

Future Science Plans

The social cognitive career theory (SCCT) suggests that person inputs (e.g., gender, race, or ethnicity; predispositions), background influences (supports and barriers), and self-efficacy and outcome expectations (beliefs about response outcomes) help form career interests, goals, and actions (Lent *et al.*, 1994). Haynes *et al.* (2015) present a modified Framework for Career Influences, based on the SCCT, that identifies personal and contextual influences, such as students' perceptions of nature and exposure to nature during childhood as important variables that contribute to students pursuing careers in the natural resources. They found that these influences were particularly salient for students from historically excluded backgrounds. These influences can then affect the student's self-efficacy and outcome expectations, which may encourage or discourage the student to seek out the learning experiences, such as a residential field course, important for pursuing a career in the field-based sciences. The significance of fieldwork, and outdoor experiences more broadly, for supporting student interest and career choices in science has been explored widely in the field of education and broader disciplinary interest literature (e.g., Levine *et al.*, 2007; Prokop *et al.*, 2007; Stokes and Boyle, 2009; Houlton, 2010; LaDue and Pacheco, 2013; Petcovic *et al.*, 2014; Hecht *et al.*, 2019; Kortz *et al.*, 2020).

Science identity refers to how a person develops a professional identity within the scientific culture (Carlone and Johnson, 2007; Seymour *et al.*, 2010; Williams and George-Jackson, 2014), and it is a predictor of the persistence and educational success of students from groups underrepresented in science (Hernandez *et al.*, 2013; Estrada *et al.*, 2016; Stets *et al.*, 2017). Because they provide opportunities for students to create working communities that closely mimic professional communities, ones in which they are working with other students and faculty doing work similar to professionals, field experiences offer a unique environment for students to develop their professional identities (Streule and Craig, 2016; Petcovic *et al.*, 2020).

Learning Goal Orientation

Within achievement goal theory, learning goal orientation has been an important component of understanding student behavior and engagement relating to learning (Midgley, 2002). There are different kinds of goal orientations within achievement goal theory, including mastery or learning goal orientation (referring to a focus on developing mastery of content and trying to understand content to gain new skills, with a focus on improving oneself), as well as performance goal orientation (referring to learning content based on the intention of doing better than others or judging one's performance against others; Meece *et al.*, 2006). Learning goal orientation is generally considered an adaptive motivational approach (Kaplan *et al.*, 2002), and extensive research has linked learning goal orientation to academic performance (for a review, see Urdan, 1997).

Goal orientation can be described as an individuals' perception of personal goals in a course (Velayutham *et al.*, 2011) or goals promoted in the class by the teacher (Walker, 2012), and these perceptions are often congruent. For example, Wolters (2004) found positive associations between the students' view of instructional practices as learning goal oriented (e.g., the teacher emphasizes effort) and student's perceptions of their own learning goal orientation in that class. In science courses specifically, learning goal orientation is associated with achievement (Tuan *et al.*, 2005; (Velayutham *et al.*, 2011; Hong *et al.*, 2020). Learning goal orientation has also been linked to continued interest and enrollment in further courses in the subject of study in college (Harackiewicz *et al.*, 2002) and to affective outcomes, including well-being (Kaplan and Maehr, 1999), perceptions of liking or enjoying school (Midgley and Urdan, 2001), as well as class belonging (Walker, 2012). In an observational study of high school teachers who promoted a strong learning goal orientation, Anderman *et al.* (2011) found that instructors encouraged collaboration and positive peer interactions and teacher–student relationships. Taken together, these studies suggest many positive outcomes associated with learning goal orientation and also point to possible links between learning goal orientation and perceptions of belonging. While we are not aware of any studies that examine goal orientation in the field setting, other studies have linked experiences in the field setting to intrinsic motivation and other adaptive motivational perspectives (e.g., Jolley *et al.*, 2018; Scott *et al.*, 2019), and we expect that a learning goal orientation would be fostered in the field setting.

Sense of Belonging

Though no single accepted theory of belonging exists, scholars have focused on belonging as a basic human need (Deci *et al.*, 1991; Baumeister and Leary, 1995) and as a component of identification (Finn, 1989). Across these different theories, belonging generally represents the perception of being accepted, included, and valued (Goodenow, 1992). Belonging has been linked to many positive outcomes, including well-being, health outcomes, and cognitive outcomes (Baumeister and Leary, 1995). In higher education, belonging plays an important role in students' mental health and well-being

(Pittman and Richmond, 2008; Kennedy and Tuckman, 2013; Gummadam *et al.*, 2016), academic achievement and motivation (Freeman *et al.*, 2007; Zumbrunn *et al.*, 2014; Wilson *et al.*, 2015), and institution-level retention (Tinto, 1993, 2017; Hausmann *et al.*, 2009), and it is particularly pivotal in promoting the success of students from backgrounds underrepresented in STEM disciplines (e.g., Hernandez *et al.*, 2013; Estrada *et al.*, 2016; Rainey *et al.*, 2018; Marshall and Thatcher, 2020; O'Brien *et al.*, 2020). Perceptions of belonging also have strong links to perceptions of competence, or the feeling that students understand content and can perform well, in STEM fields (Rainey *et al.*, 2018).

According to Goodenow (1992), "Learning, development, and education are so fundamentally embedded in a social matrix that they cannot be truly understood apart from that context" (p. 178). For example, group membership and group norms play a crucial role in our understanding of how specific contexts can shape perceptions of feeling accepted (as opposed to just focusing on individual perception; Goodenow, 1992). The idea of belonging as inextricably linked to a social context has much in common with recent work in field education. This work emphasizes the importance of social learning and communities of practice to understand how students learn in the field, an environment that is physically and culturally distinct from a traditional classroom (e.g., Mogk and Goodwin, 2012; Streule and Craig, 2016; Atchison *et al.*, 2019; Kortz *et al.*, 2020; Petcovic *et al.*, 2020).

There has been little direct exploration of the role of sense of belonging in field courses. One exception is a recent study of first-year geoscience students that found that an early introduction into immersive fieldwork could provide a powerful feeling of belonging with the discipline (Malm *et al.*, 2020). Atchison *et al.* (2019) highlighted the significance of fostering a sense of belonging for students with disabilities in the field. Based on time spent together, the kind of course work students conduct in field experiences, and shared living and dining in residential field experiences in particular, perceptions of belonging may be especially fostered in a field setting.

HYPOTHESES

By making comparisons between the field setting and on-campus courses, this study seeks to examine any unique outcomes associated with the field setting. Based on our literature review, we hypothesize that the field station setting will lead to higher levels of perceived scientific literacy and higher levels of future science plans. We predict that these relationships will be mediated by perceptions about the course, including class learning goal orientation and class belonging. Figure 1 and Figure 2 depict the serial multiple mediation models that were developed to test these hypotheses.

METHODS

This study investigates the links between outcomes of scientific literacy and future science plans and the field setting. In addition, we explore the extent to which perceptions about the course (class learning goal orientation and class belonging) mediate these relationships.

To operationalize these research questions, we used the context of field station and on-campus courses associated with a large midwestern university.

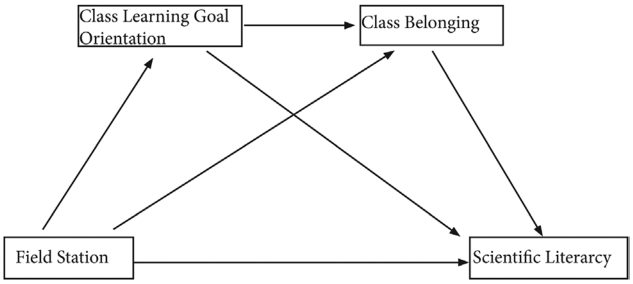

FIGURE 1. We hypothesize the serial multiple mediation of class learning goal orientation and class belonging on the relationship between field station setting and perceived scientific understanding (A) and the relationship between field station setting and future science plans (B).

Setting and Study Population

Sample. The participants for this analysis included 388 students, including students in the field station courses across two Spring/Summer terms (2018 and 2019; $n = 271$) and on-campus courses across Fall/Winter terms across 2 years (2018–2019 and 2019–2020; $n = 117$; demographics are available in Table 1).

Field Station. The field station associated with the large midwestern university is residential, with students living together in cabins. Faculty and researchers also live on-site. All students eat meals together in the dining hall. In addition, all courses at the field station had small class sizes (fewer than 25 students). During Spring and Summer terms, students were encouraged to attend guest lectures with scientists from across the country. Students interacted informally and formally with researchers, other faculty, and students, and within the field station setting, and created final projects and/or papers based on their field station experiences. Students involved in courses at the field station often collected their own data in the field as part of a course research project. Students generally worked on independent research projects in small groups under the guidance of instructors. Students typically participated in courses for the full day (9 am–5 pm), either every day or week or twice a week, depending on the length of the course.

Field station courses were only offered during the Spring and Summer terms and ranged from 10 days to 7 weeks. The majority of courses (78%) were longer than 3 weeks; those that were 2 weeks or fewer were considered extension courses, which meant that they were an extension of a course taught on campus

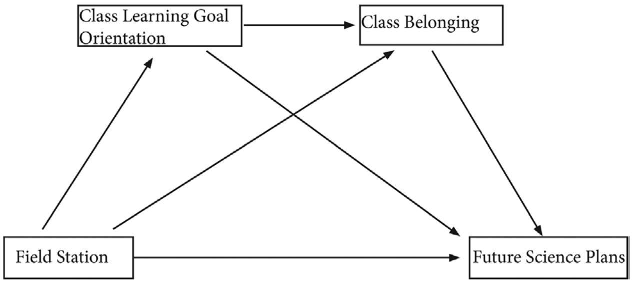

FIGURE 2. The final contextual model for research design and process skills.

TABLE 1. Demographics of on-campus and field station courses

	On campus		Field station	
	n	Percent	*n*	Percent
Race/ethnicity				
HBN	8	6.8%	21	7.7%
Non-HBN	109	93.2%	250	92.3%
Gender				
Male	35	29.9%	68	25.1%
Female	82	70.1%	203	74.9%
Generation status				
First-generation	23	19.7%	54	19.9%
Continuing generation	94	80.3%	217	80.1%
Academic year				
First/second-year student	21	17.9%	73	26.9%
Third/fourth/fifth+- year student	96	82.1%	198	73.1%
Course type at field station				
New course			104	38.4%
Traditional course			167	61.6%

and could either precede or follow that course. All extension courses, as well as the introductory lab courses, were part of a larger grant awarded to the field station to create a program that brought students from new disciplines and historically excluded backgrounds in STEM to the field station. Students who participated in extension courses were provided with scholarships to cover room and board, and tuition costs were added to block tuition for these courses, so students would typically not need to pay additional tuition or housing costs. While courses spanned a variety of topics, most courses were from the Ecology and Evolutionary Biology Department, and all courses offered a field component. See Table 2 for a full list of course details.

On Campus. On-campus courses were taught as traditional courses on campus, that is, students attended lectures and/or discussions in classrooms several days a week. Course size ranged from 19 students to 79 students. Campus courses were offered during Fall and Winter terms, and all courses except one ran for the 14-week term (see Table 2). Course requirements varied for on-campus courses, including final exams and presentations/final projects; some courses on campus did require students to participate in at least one field trip. Students attended a lecture for ~1–1.5 hours 2–3 days a week, and labs ran for approximately 3–4 hours once a week. Many of the on-campus courses incorporated lecture and lab components, although General Ecology on campus had a separate lab course, which students were advised but not required to take concurrently. Within the General Ecology lab on campus, students generally worked on independent research projects, and in other lab courses, students participated in a variety of field trips, specimen identification work, and/or class presentations.

Faculty whose courses are included in this sample have taught courses at both the field station and on campus. All except one faculty member who taught on campus also taught at the field station or were heavily involved in the field station programming (e.g., leading student research experiences). Faculty demographic data were not collected.

Design and Data Collection

Our research questions examined whether the field station setting was positively associated with perceived scientific literacy and future science plans. To address this, we conducted quantitative analyses including linear regression and mediation analysis. Data were collected with pre and post surveys using measures that addressed our four outcomes of interest: scientific literacy, scientific interest, learning goal orientation, and sense of belonging. The study received an exempt determination under the Institutional Review Board office associated with the institution. Validity and reliability for these measures are addressed in the following subsections. We used both linear regression analysis and serial multiple mediation analysis to investigate the relationships between these outcomes of interest, guided by our research questions. Using a linear regression analysis allowed us to control for pre scores, demographics, and course types. Serial multiple mediation analysis (Hayes, 2013) allowed us to control for these same variables and also test different series of relationships in examining relationships between the field setting and perceived scientific literacy as well as future science plans.

Procedures

Pre surveys were sent online via Qualtrics to all students during the first 2 days of the class, and post surveys were sent during the last 2 days of class. Instructors in most, but not all, courses offered a 1% extra credit for completion of both the pre and post surveys. In courses where extra credit was not offered, students who completed both surveys were entered into a raffle for several gift cards.

The overall response rate for the study for on-campus and field station students who completed both pre and post surveys was 42.8%. Of the total students on campus, 23.1% responded to the survey. Response rates varied across courses. In the on-campus courses, response rates ranged from 5% to 83.9%. Of the total students who enrolled at the field station, 75% responded to the survey. In field station courses, response rates ranged from 42.1% to 100% for each course.

Survey Design

Pre and post surveys were created with input from faculty, staff, and students. After discussions of an initial program evaluation proposed to examine specific student learning outcomes, faculty and staff suggested additional outcomes to investigate. We found measures in the literature that matched these proposed outcomes. In addition, we conducted a literature review of field-based and science course–based student outcomes, and selected survey measures that were supported by staff input as well as theory. Survey items were refined based on feedback from staff at the field station, including the director, associate director, and program staff, as well as cognitive interviews with students who did and did not attend the field station ($N = 5$) to ensure construct validity. Responses were similar across all students when asked about specific items as well as the meaning of measures, such as class belonging (Karabenick *et al.*, 2007). No major changes were made to the survey based on student feedback.

Measures and Model Variables

Demographics. All demographics, including race/ethnicity, gender, academic year, and generation status came from student records. Self-reported survey data were used when student record data were unavailable (15.3% of students). We used the demographic categories from the institutional records.

Because we used institutional records for the majority of participants, we followed the definitions from the institution at which these data were collected to code student data. This institution uses the term "underrepresented minority" (URM) to describe students from racial/ethnic backgrounds that have historically been present in the institution at lower numbers than in the general population. We acknowledge that scholars have proposed alternate terms to URM that more explicitly recognize the systems that have created and sustained educational inequities (e.g., "historically excluded," Dodson *et al.*, 2009, p. 185; "PEERS—persons excluded due to ethnicity and race," Asai, 2020, p. 745). To maintain consistency with the institutional records, we followed the definitions from the institution at which these data were collected. However, to avoid deficit-framed language and more clearly define which racial/ethnic groups are in which categories, we created a new acronym for Hispanic, Black, and Native American students (HBN), which we compared with non-Hispanic, Black, and Native American students. Thus, HBN status was coded if student records indicated that the student identified as Hispanic, Black, or Native American; non-HBN status was coded if students were classified as White, 2 or More, or Asian (Table 1). As we could not discern if any of the categories in 2 or More were consistent with the institutional definition of HBN, all students coded as 2 or More were excluded from the HBN category. We acknowledge that there are limitations to grouping Hispanic, Black, and Native American students together and interpret with caution and awareness that all students have differing needs and experiences.

If generation status was not available in student records, students were coded as first generation if they selected that neither parent completed a bachelor's degree on self-report survey data, which is the same definition used by the institution where this study takes place.

Course Topic. We included all courses in our model (see Table 2). Arts and Humanities courses were identified based on the department offering the course, course content, and syllabi, and included courses taught in the Art, Anthropology, American Culture, and English Departments. Discussions with faculty and review of the course content and syllabi indicated that these courses had intended outcomes and assignments that varied from other courses taught on campus and at the field station (e.g., students created projects that consisted of illustrations, videos, maps, reflections, or essays). To account for these variations, we included Arts/Humanities as a control variable in our models.

Class Learning Goal Orientation. Six items that focused on learning orientation were adapted from Velayutham *et al.*'s (2011) science learning instrument (e.g., "It is important to me that I learned a lot of new concepts in this class"). Students responded to each item on a scale of 1–5, with 1 being "strongly disagree" to 5 being "strongly agree." An exploratory factor analysis was performed to explore the factor structure of these items with this survey population, using a principal components analysis with an oblique rotation, as was used in Velayutham *et al.* (2011). This analysis produced similar reliability estimates ($\alpha = 0.91$) as in other studies using this measure, including the original scale development ($\alpha = 0.91$).

Class Belonging. We measured class belonging using a modified Psychological Sense of School Membership scale (Goodenow, 1993). Students were asked to address their sense of belonging to a specific course (e.g., "I felt like a real part of this class"). An exploratory factor analysis was performed with the 10 items to explore the factor structure with this survey population, using a principal components analysis with varimax rotation as was used in the original measure (Goodenow, 1993). The scale included seven items. Students responded to each item on a scale of 1–5, with 1 being "not at all true" to 5 being "completely true." We found similar reliability estimates in our study ($\alpha = 0.91$), as in other studies that used these items with college students (e.g., Freeman *et al.*, 2007).

Perceived Scientific Literacy. The scientific literacy measure was created based on items from Kardash (2000) and Lopatto (2004) reports about student outcomes from undergraduate research experiences. Eleven items were selected upon review of their findings that most closely matched discussions with faculty and staff. In addition, three items about scientific communication were adapted from the Biology Learning Self-Efficacy measure (Lin *et al.*, 2015) that most closely matched student outcomes perceived by faculty and staff. Language was modified to use the word "science" instead of "biology." Students responded to each item on a scale of 1–5 concerning their degree of confidence in being able to do each of the items, with 1 being "strongly disagree" to 5 being "strongly agree." Though these items were independently created and tested with college populations, we wanted to explore these items together in our study population. Thus, an exploratory factor analysis was done with all items to explore the factor structure. Principal components analysis was selected, along with an oblique rotation (direct oblimin). These items loaded on three factors, which upon review of the items, we termed "research design and process skills" (e.g., "understanding how scientists work on real problems"), "scientific application" (e.g., "examining everyday life using scientific theories"), and "synthesis skills" (e.g., "statistically analyzing data"). See Table 3 for items, the eigenvalues of each factor, and the factor structure. Research design and process skills included eight items (pre score, $\alpha = 0.88$; post score $\alpha = 0.92$), scientific application included three items (pre score, $\alpha = 0.86$; post score $\alpha = 0.86$), and synthesis skills had three items (pre score, $\alpha = 0.70$; post score $\alpha = 0.73$). Each factor was included as a covariate (pre score) and as a dependent variable (post score).

Future Science Plans

This measure included three items written by the lead researcher (author S.S.) that asked students about their future science-related plans, including "I am motivated to take more science classes," "I am motivated to be a science major," and "I would be interested in a career in environmental research and problem solving." This measure was included as a covariate (pre score) and as a dependent variable (post score). Students responded to each item on a scale of 1–5, with 1 being "strongly disagree" to 5 being "strongly agree."

TABLE 2. Details of courses included in study

Course topic	Course level	Term[a]	Number of students	Setting	Years surveyed
Ecology	200 Campus; 300 Field station	SP, SU, F/W	16, 17, 18, 19, 19, 20, 21, 24 Field station, 78, 79 Campus	Field station, campus	2018, 2019, 2020
Evolution	300	SU, F/W	10, 11 Field station, 68, 79 Campus	Field station, Campus	2018, 2019, 2020
Ethnobotany	400	SP	5, 11	Field station	2018, 2019
Ethnobotany	200	F/W	40	Campus	2020
Ornithology	300	SP	7, 8	Field station	2018, 2019
Ornithology	400	F/W	19	Campus	2019
Mammalogy	400	SU	12	Field station	2018
Mammalogy	400	F/W	34	Campus	2020
Fishes	400	F/W, EXT	5, 9 Field station, 28, 36, 36 Campus	Field station, Campus	2018, 2019, 2020
Algae	400	SU	3, 6, 13	Field station	2018, 2019
Insects/Parasites	400	SU	3, 5	Field station	2018, 2019
Agroecology	400	SU	10	Field station	2018
Geology	200	SU	5	Field station	2019
Forest Ecosystems	300	SU	6, 7	Field station	2018, 2019
Limnology	400	SU	10	Field station	2019
Introductory Lab (Chemistry)	100	SP	12, 20	Field station	2018, 2019
Introductory Lab (Biology)	100	SP	9, 12	Field station	2018, 2019
Humanities (Arts, Culture, Environment)	200–300	SP[b]	8	Field station	2019
Land, Water, Culture at field station/field station region	100	F/W[c]	31	Campus	2019
Microbiology	400	EXT	7, 11	Field station	2018, 2019
Law and Policy	300	EXT	3	Field station	2018
Statistics	400	EXT	4	Field station	
Art/Plants	300	EXT	7, 8	Field station	2018, 2019
Sustainability	300	EXT	4, 8	Field station	2018, 2019

[a] SP, Spring term courses which ran for 4 weeks; SU, Summer term courses which ran for 8 weeks; EXT, Extension course which ran for 10 days-2 weeks; F/W, Fall/winter term course which ran for 14 weeks.

[b] This course began in Spring term but lasted 6 weeks.

[c] This course ran during a regular F/W term but lasted 7 weeks.

ANALYSIS

To examine the proportions of different demographic groups across settings, we used chi-square statistics to compare our student samples in the field station setting and on-campus setting.

Because we used both multilevel regression analysis and serial multiple mediation in our analysis, we created dichotomous codes for many of our variables. First, we used a dichotomous code for our independent variable, learning setting (Field Station = 1, On Campus = 0). We also created dichotomous codes for our control variables, including course type (Arts/Humanities = 1, All Other Courses = 0), as well as demographics (Male = 1, Female = 0, HBN = 1, Non-HBN = 0, First-Generation = 1, Non-First Generation = 0, and First/Second Year = 1, Third/Fourth/Fifth+ = 0).

We also created a dichotomous code for students participating in newly developed courses at the field station (New Course = 1, Others = 0). These newly developed courses were all part of the field station effort to increase participation and thus were generally shorter than other courses. As part of our understanding of who participates in these new courses, we examined student perceptions about their future science plans as they began the program using *t* tests to compare mean scores of students who enrolled in a new course compared with students who enrolled in a traditional course at the field station.

Due to the fact that the structure of our study is students nested within classes, we needed to consider the use of multilevel regression analysis. Within our analysis, class sizes ranged from two to 29 across 51 unique classes. We first ran ordinary least-squares (OLS) regression with scientific literacy and future science courses variables as our outcomes to determine the best predictors for our models. For models in which a significant relationship existed between the field station setting and outcome variables, we further explored this by including a random effect for class, using SPSS mixed models linear function under the restricted maximum likelihood estimation. Within these models, we examined the intraclass correlation coefficient (ICC) to determine whether including a multilevel analysis would affect the estimates in a meaningful way. For models with an ICC above 0.05, we determined that it would be advantageous to include a random effect of class.

Within the models that included a random effect of class, we first ran a null model to determine the initial ICC. Next, we ran a random intercepts model including student-level predictors, specifically, pre scores, HBN, First-Generation, Male, and First/

TABLE 3. Factor analysis of perceived scientific literacy items[a]

Item	1	2	3
Research process and design skills			
Understanding the research process	0.89		
Understanding how scientists work on real problems	0.86		
Observing and collecting data	0.68		
Understanding how scientists think	0.58	0.41	
Designing an experiment or theoretical test of the hypothesis	0.53		
Making use of primary scientific research literature in your field (e.g., journal articles)	0.49		
Formulating a research hypothesis based on a specific question	0.46		
Scientific application			
Explaining everyday life using scientific theories		0.85	
Proposing solutions to everyday problems using science		0.76	
Using what I have learned in classes to have a scientific discussion with others		0.67	
Synthesis skills			
Orally communicating the results of research projects			0.75
Statistically analyzing data			0.68
Commenting on presentations made by my classmates		0.42	0.60
Writing a research paper for publication			0.53
Eigenvalue	6.87	1.16	1.01
% Variance accounted for	49.04	8.28	7.24

[a]Only factor loadings of above 0.40 are included in the table.

Second Year. The final model included level 2 predictors, including Field Station, New Course, and Arts/Humanities. Missing data were handled using listwise deletion in each regression model.

To examine possible moderation effects of underrepresented status on the relationships between the field station setting and scientific literacy as well as future science plans, we mean centered predictors (Dalal and Zickar, 2012) and then created interaction terms between First-Generation and Field Station and HBN status and Field Station (e.g., Field Station*HBN). We added the interaction term as an additional step in each model so we could examine any ΔR^2 within each model. Each interaction term was added in the model separately. These models were examined under OLS regression initially, followed by multilevel modeling for any models with significant interaction terms.

To examine mediation, we used the PROCESS macro in SPSS, which uses a bootstrapping method (Hayes, 2013). Bootstrapping allows for any irregularities in the sample distribution, providing higher power compared with normal linear models (Hayes, 2013). While the PROCESS bootstrapping program does not allow for multilevel data, the results of our multilevel regression analyses indicated that we had accounted for important predictors within our models at both the individual and class levels. Mediation was only tested on models in which the field station was significantly associated with scientific literacy and future science plans. Following the direction of Hayes (2013), 10,000 bootstrap samples were used for a serial-multiple mediation model 6. This model allows us to examine how multiple mediators are associated with our independent and dependent variables as well as each other. In this study, the significance level was set at 0.05. Missing data were handled using listwise deletion in each model.

RESULTS

No significant differences were found among proportions of demographic groups in the field station compared with on-campus setting for first-generation students χ^2 (1, $N = 388$, $p = 0.95$), first/second year students χ^2 (1, $N = 388$, $p = 0.06$), male students χ^2 (1, $N = 388$, $p = 0.32$), and HBN students χ^2 (1, $N = 388$, $p = 0.75$). Correlations, means, and SDs of all measures are presented in Table 4.

Additionally, when we examined the mean pre scores of students in the new courses compared with students taking traditional courses at the field station, there were no significant differences between the two groups (Table 5).

What Is the Relationship between Field Station Setting and Perceived Scientific Literacy? (Research Question 1)

The results of the analysis of the relationship among all variables and perceived scientific literacy using OLS regression are displayed in Table 6. Based on these results, we examined the results of the research design and process skills and synthesis skills with the random effect of class.

For research design and process skills, the ICC was 0.287, indicating that 28.7% of the variance in research design and process skills occurs between classes. The results of this null model are presented in Table 7. Next, we ran a student-level random intercepts model including student-level predictors to explore whether these predictors were associated with research design and process skills, also presented in Table 7. γ_{00} is 2.222, which is the overall research design and process skills score for all students, and is significantly different than zero ($t = 11.668$, $p < 0.001$). γ_{10} is 0.493, meaning that for every one-unit increase in pre scores, research design and process skills increased by 0.493, controlling for demographic variables. This is significant ($t = 10.182$, $p < 0.001$). Within this model, there was still significant variability in the intercepts, $\tau_{00} = 0.250$, Wald $Z = 11.758$, $p < 0.001$). There was also significant variability within classes $\sigma^2 = 0.078$, Wald $Z = 2.859$, $p = 0.004$. We used Raudenbush and Bryk's (2002) convention to estimate proportional reduction in variance within classes, indicating that 35.5% of the within-class variance was

TABLE 4. Means, standard deviations, and correlations among main variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. First-generation		0.20**	0.05	0.05	–0.06	0.05	0.06	0.08	0.07	0.06	0.07	0.10	0.03	0.06	0.04	0.02	0.02	–0.01	0.05	0.00	0.00
2. HBN			0.01	0.16**	–0.07	0.07	–0.01	0.01	–0.04	0.02	0.03	–0.03	0.01	–0.01	0.04	–0.02	–0.04	–0.02	–0.08	–0.03	0.02
3. Male				0.01	–0.11*	–0.07	0.02	0.04	–0.03	0.06	0.05	0.08	0.06	0.06	0.12*	0.04	0.087	0.00	–0.09	–0.02	–0.05
4. First/Second year					–0.05	0.35**	0.06	0.09	0.03	0.08	0.11*	0.03	–0.04	0.03	–0.06	0.01	0.01	0.03	0.06	0.10*	0.10
5. Arts/Humanities						0.39**	–0.04	–0.06	–0.03	0.01	–0.08	–0.10	–0.23**	–0.18**	–0.14**	–0.40**	–0.30**	–0.19**	–0.01	0.15**	0.15**
6. New Course							0.05	0.05	–0.02	0.10	0.04	–0.09	–0.08	–0.07	–0.03	–0.16*	–0.12*	–0.10	0.11*	0.23**	0.40**
7. Pre score: Motivation to take more science courses								0.76**	0.57**	0.63**	0.66**	0.44**	0.31**	0.35**	0.13*	0.26**	0.24**	0.18**	0.34**	0.34**	0.14**
8. Pre score: Interest in science major									0.58**	0.53**	0.73**	0.43**	0.28**	0.31**	0.18*	0.20**	0.24**	0.12*	0.33**	0.31**	0.16**
9. Pre score: Interest in career in environmental research/problem solving										0.46**	0.55**	0.65**	0.31**	0.24**	0.11*	0.18**	0.18**	0.12*	0.26**	0.21**	0.12*
10. Post score: Motivation to take more science courses											0.73**	0.55**	0.20**	0.25**	0.12*	0.24**	0.23**	0.18**	0.42**	0.38**	0.19**
11. Post score: Interest in science major												0.58**	0.24**	0.24**	0.09	0.22**	0.23**	0.10	0.37**	0.27**	0.09
12. Post score: Interest in career in environmental research/problem solving													0.30**	0.24**	0.12*	0.28**	0.26**	0.25**	0.32**	0.23**	0.01
13. Pre score: Research process and design skills														0.64**	0.72**	0.51**	0.41**	0.41**	0.16**	0.11*	–0.11*
14. Pre score: Scientific application															0.53**	0.36**	0.41**	0.29**	0.20**	0.07	–0.00
15. Pre score: Synthesis skills																0.36**	28**	0.39**	0.10	0.04	–0.14**
16. Post score: Research process and design skills																	0.72**	0.82**	0.30**	0.32**	0.00
17. Post score: Scientific application																		0.62**	0.32**	0.36**	0.00
18. Post score: Perceived synthesis skills																			0.26**	0.35**	0.00
19. Class learning goal orientation																				0.39**	0.25**
20. Class belonging																					0.44**
21. Station																					
Mean	0.20	0.07	0.27	0.24	0.05	0.27	4.17	4.09	3.96	4.28	4.14	3.98	3.72	3.91	3.57	4.07	4.20	3.87	4.40	4.32	0.70
SD	0.40	0.26	0.44	0.43	0.22	0.44	0.92	1.12	1.09	0.86	1.07	1.13	0.62	0.68	0.70	0.65	0.67	0.70	0.61	0.72	0.46

*$p < 0.05$.
**$p < 0.01$.

TABLE 5. Mean comparisons of future science plans for new courses and traditional courses at field station

	Mean (SD)	
	New course	Traditional course
Pre score: Motivation to take more sciences classes	4.24 (0.78)	4.26 (0.82)
Pre score: Motivation to be a science major	4.18 (1.02)	4.23 (0.97)
Pre score: Interest in a career in environmental research/problem solving	3.93 (0.99)	4.13 (1.00)

explained by student-level predictors ($\sigma^2_{\text{null model}} = 0.121$ and $\sigma^2_{\text{student-level model}} = 0.078$).

The final model included all of the demographic variables and pre scores at level 1 and also included Field Station setting, New Course and Arts/Humanities at level 2 (see Table 8). γ_{00} is 2.02, which is significantly different than zero ($t = 10.934$, $p < 0.001$). γ_{10} is 0.483, indicating that for every one-unit increase in pre scores, research design and process skills increases by 0.483, controlling for all demographics and level 2 predictors. This effect is significant ($t = 10.073$, $p < 0.001$). In addition, γ_{60} was 0.208, indicating that courses at the field station will have a 0.208 increase in research design and process skills, controlling for all other student-level and class level predictors ($t = 2.419$, $p = 0.020$). In addition, Arts/Humanities was −0.863, indicating that Arts/Humanities courses would have a 0.863 decrease in research design and process skills, controlling for all other student-level and class-level predictors ($t = -5.055$, $p < 0.001$). Within this model, there still exists variability within the intercepts $\tau_{00} = 0.291$ (Wald $Z = 11.810$, $p < 0.001$); however, the intercept parameter indicates that the intercepts do not vary significantly across classes (Wald $Z = 1.469$, one-tailed $p = 0.071$). Proportional reduction in classroom-level variance was estimated using Raudenbush and Bryk's (2002) convention by comparing the final contextual model to the student-level model. The results explain that 14.1% of the between-classroom variance in the intercepts was explained by including level 2 predictors ($\tau_{00\text{ student-level model}} = 0.291$ and $\tau_{00\text{ final model}} = 0.250$) after controlling for student-level variables. The results of this model are presented in Table 8. The final model presented in Figure 3.

TABLE 6. Regression analyses predicting scientific literacy

	Research process and design skills	Scientific application	Synthesis skills
First-generation	−0.01	−0.01	−0.03
HBN	−0.04	−0.05	−0.04
Male	−0.01	0.04	−0.04
First/Second year	0.04	0.01	0.09
Arts/Humanities	−0.30***	−0.23***	−0.12*
Pre score	0.46***	0.37***	0.40***
New Course	−0.09	−0.04	−0.13*
Field Station	0.16**	0.07	0.13*
R^2	0.37***	0.23***	0.20***

[a]HBN = 1, Non-HBN = 0; First-Generation = 1, Continuing Generation = 0; Male = 1, Female = 0; First/Second Year = 1, Third/Fourth/Fifth+ = 0; Arts/Humanities = 1, Non-Arts/Humanities = 0; New Course = 1, Traditional Course = 0; Field Station = 1, On Campus = 0.

*$p < 0.05$.

**$p < 0.01$.

***$p < 0.001$.

For synthesis skills, the ICC was 0.078, indicating that 7.8% of the variance in synthesis skills exists between classes. The results of this null model are presented in Table 9. Next, we ran a student-level random intercepts model including student-level predictors to explore whether these predictors were associated with synthesis skills, also presented in Table 9. γ_{00} is 2.477, which is the overall synthesis score for all students, and is significantly different than zero ($t = 13.422$, $p < 0.001$). γ_{10} is 0.396, meaning that for every one-unit increase in pre scores, synthesis skills increased by 0.493, controlling for demographic variables. This is significant ($t = 7.923$, $p < 0.001$). Within this model, there was still significant variability in the intercepts, $\tau_{00} = 0.394$, Wald $Z = 12.019$, $p < 0.001$). There was also significant variability within classes ($\sigma^2 = 0.033$, Wald $Z = 1.611$, one-tailed $p = 0.049$). We used Raudenbush and Bryk's (2002) convention to estimate proportional reduction in variance within classes, indicating that 15.4% of the within-class variance was explained by student-level predictors ($\sigma^2_{\text{null model}} = 0.039$ and $\sigma^2_{\text{student-level model}} = 0.033$).

The final model included all of the demographic variables and pre scores at level 1 and also included Field Station setting, New Course, and Arts/Humanities at level 2 (see Table 10). γ_{00} is 2.43, which is significantly different than zero ($t = 12.138$, $p < 0.001$). γ_{10} is 0.397, indicating that for every one-unit increase in pre scores, synthesis skills increases by 0.397, controlling for all demographics and level 2 predictors. This effect is significant ($t = 7.895$, $p < 0.001$). In addition, γ_{80} was −0.392, indicating that Arts/Humanities courses would have a 0.392 decrease in synthesis skills, controlling for all other student-level and class-level predictors ($t = -2.032$, $p < 0.001$). However, the effect of Field Station (γ_{60}) was not significant ($t = 0.165$, $p = 0.085$). Within this model, there still exists variability within the intercepts $\tau_{00} = 0.396$ (Wald $Z = 12.174$, $p < 0.001$); however, the intercept parameter indicates that the intercepts do not vary significantly across classes (Wald $Z = 0.973$, one-tailed $p = 0.165$). Proportional reduction in classroom-level variance was estimated using Raudenbush and Bryk's (2002) convention by comparing the final contextual model to the student-level model. The results explain that 0.05% of the between-classroom variance in the intercepts was explained by including level 2 predictors ($\tau_{00\text{ student-level model}} = 0.394$ and $\tau_{00\text{ final model}} = 0.396$) after controlling for student-level variables. The results

Mixed Model

$$\text{Research Process and Design Skills}_{ij} = \gamma_{00} + \gamma_{10}{*}\text{Pre-Score}_{ij} + \gamma_{20}{*}\text{HBN}_{ij} + \gamma_{30}{*}\text{First-Generation}_{ij} + \gamma_{40}{*}\text{Malei}_{j} + \gamma_{50}{*}\text{First/Second Year}_{ij} + \gamma_{60}{*}\text{Field Station}_{ij} + \gamma_{70}{*}\text{New Course}_{ij} + \gamma_{80}{*}\text{Arts/Humanities}_{ij} + u_{0j} + r_{ij}$$

FIGURE 3. The final contextual model for synthesis skills.

TABLE 7. Null model and model with student-level predictors for research design and process skills

	Model 1 Null model			Model 2 Student-level model		
Fixed effects	**Estimate (SE)**	***t* (*df*)**	***p***	**Estimate (SE)**	***t* (*df*)**	***p***
Model for intercept, research design and process skills (β_0)						
Intercept (γ_{00})	4.076 (0.061)	66.700 (44.042)	<0.001	2.222 (0.190)	11.668 (322.409)	<0.001
Model for pre score slopes (β_1)						
Intercept (γ_{10})				0.493 (0.048)	10.182 (315.650)	<0.001
Model for HBN slopes (β_2)						
Intercept (γ_{20})				−0.081 (0.112)	−0.726 (301.671)	0.468
Model for First-Generation slopes (β_3)						
Intercept (γ_{30})				−0.044 (0.187)	0.074 (312.275)	0.551
Model for Male slope (β_4)						
Intercept (γ_{40})				0.011 (0.067)	0.174 (304.097)	0.862
Model for First/Second Year slope (β_5)						
Intercept (γ_{50})				0.084 (0.074)	1.135 (323.378)	0.257
Random effects (variance components)	**Estimate (SE)**	**Wald *Z***	***p***	**Estimate (SE)**	**Wald *Z***	***p***
Variance in intercepts (τ_{00})	0.322 (0.021)	1265.59	<0.001	0.250 (0.021)	11.758	<0.001
Variance within classes (σ^2)	0.121 (0.025)	3.157	0.002	0.078 (0.027)	2.859	0.004

of this model are presented in Table 10. The final model is presented in Figure 3.

What Is the Relationship between Field Station Setting and Future Science Plans? (Research Question 2)

The results of the analysis of the relationship among all variables and future science plans using OLS regression are displayed in Table 11. Based on these results, we examined the results of motivation to take more science classes with the random effect of class.

For motivation to take more science classes, the ICC was 0.172, indicating that 17.2% of the variance in motivation to take more science classes exists between classes. The results of this null model are presented in Table 11. Next, we ran a student-level random intercepts model including student-level predictors to examine whether these predictors were associated with synthesis skills, also presented in Table 11. γ_{00} is 1.90, which is the overall synthesis score for all students, and is significantly different than zero ($t = 10.759$, $p < 0.001$). γ_{10} is 0.564, meaning that for every one-unit increase in pre

TABLE 8. Mixed model with pre scores, HBN, First-Generation, Male, and First/Second Year at level 1 and with Station, New Course, and Arts/Humanities at level 2 for research design and process skills

Fixed effects	**Estimate (SE)**	***t* (*df*)**	***p***
Model for intercept, research design and process skills (β_0)			
Intercept (γ_{00})	2.202 (0.201)	10.934 (248.874)	<0.001
Model for pre score slopes (β_1)			
Intercept (γ_{10})	0.483 (0.048)	10.073 (320.564)	<0.001
Model for HBN slopes (β_2)			
Intercept (γ_{20})	−0.097 (0.110)	−0.879 (301.671)	0.380
Model for First-Generation slopes (β_3)			
Intercept (γ_{30})	−0.037 (0.072)	−0.517 (320.393)	0.606
Model for Male slope (β_4)			
Intercept (γ_{40})	−0.013 (0.066)	0.969 (316.267)	0.843
Model for First/Second Year slope (β_5)			
Intercept (γ_{50})	0.070 (0.073)	0.969 (312.233)	0.333
Model for Field Station (β_6)			
Intercept (γ_{60})	0.208 (0.086)	2.419 (43.557)	0.020
Model for New Course (β_7)			
Intercept (γ_{70})	−0.121 (0.095)	−1.279 (46.041)	0.207
Model for Arts/Humanities (β_8)			
Intercept (γ_{80})	−0.863 (0.170)	−5.055 (46.815)	<0.001
Random effects (Variance components)	**Estimate (SE)**	**Wald *Z***	***p***
Variance in intercepts (τ_{00})	0.251 (0.021)	11.810	<0.001
Variance within classes (σ^2)	0.021 (0.014)	1.469	0.142

TABLE 9. Null model and model with student-level predictors for research design and process skills

	Model 1 Null model			Model 2 Student-level model		
Fixed effects	**Estimate (SE)**	***t (df)***	***p***	**Estimate (SE)**	***t (df)***	***p***
Model for intercept, research design and process skills (β_0)						
Intercept (γ_{00})	3.873 (0.049)	79.184 (33.006)	<0.001	2.477 (0.185)	13.422 (322.409)	<0.001
Model for pre score slopes (β_1)						
Intercept (γ_{10})				0.396 (0.050)	7.923 (328.765)	<0.001
Model for HBN slopes (β_2)						
Intercept (γ_{20})				–0.11 (0.138)	–0.769 (325.690)	0.442
Model for First-Generation slopes (β_3)						
Intercept (γ_{30})				–0.070 (0.089)	–0.782 (333.018)	0.435
Model for Male slope (β_4)						
Intercept (γ_{40})				–0.030 (0.086)	0.174 (329.377)	0.715
Model for First/Second Year slope (β_5)						
Intercept (γ_{50})				0.111 (0.086)	1.285 (290.567)	0.200
Random effects (Variance components)	**Estimate (SE)**	**Wald *Z***	***p***	**Estimate (SE)**	**Wald *Z***	***p***
Variance in intercepts (τ_{00})	0.461 (0.038)	12.112	<0.001	0.394 (0.033)	12.019	<0.001
Variance within classes (σ^2)	0.039 (0.025)	1.529	0.126	0.078 (0.027)	2.859	0.004

scores, synthesis skills increased by 0.564, controlling for demographic variables. This is significant ($t = 13.937$, $p < 0.001$). Within this model, there was still significant variability in the intercepts ($\gamma_{00} = 0.414$, Wald $Z = 12.050$, one-tailed $p < 0.001$). There was also significant variability within classes ($\sigma^2 = 0.036$, Wald $Z = 1.795$, one-tailed $p = 0.037$). We used Raudenbush and Bryk's (2002) convention to estimate proportional reduction in variance within classes, indicating that 72.1% of the within-class variance was explained by student-level predictors ($\sigma^2_{\text{null model}} = 0.129$ and $\sigma^2_{\text{student-level model}} = 0.036$).

The final model included all of the demographic variables and pre scores at level 1 and also included Field Station setting, New Course, and Arts/Humanities at level 2 (see Table 12). γ_{00} is 1.76, which is significantly different than zero ($t = 9.606$, $p < 0.001$). γ_{10} is 0.559, indicating that for every one-unit increase in pre scores, motivation to take science classes increases by 0.559, controlling for all demographics and level

TABLE 10. Mixed model with pre scores, HBN, First-Generation, Male, and First/Second Year at level 1 and with Station, New Course, and Arts/Humanities at level 2 for synthesis skills

Fixed Effects	**Estimate (SE)**	***t (df)***	***p***
Model for intercept, synthesis skills (β_0)			
Intercept (γ_{00})	2.43 (0.200)	12.138 (301.874)	<0.001
Model for pre score slopes (β_1)			
Intercept (γ_{10})	0.397 (0.050)	7.895 (320.564)	<0.001
Model for HBN slopes (β_2)			
Intercept (γ_{20})	–0.114 (0.137)	–0.831 (327.580)	0.407
Model for First-Generation slopes (β_3)			
Intercept (γ_{30})	–0.068 (0.088)	–0.764 (330.924)	0.446
Model for Male slope (β_4)			
Intercept (γ_{40})	–0.050 (0.081)	–0.619 (330.356)	0.536
Model for First/Second Year slope (β_5)			
Intercept (γ_{50})	0.136 (0.088)	1.545 (314.081)	0.123
Model for Field Station (β_6)			
Intercept (γ_{60})	0.165 (0.094)	1.760 (45.521)	0.085
Model for New Course (β_7)			
Intercept (γ_{70})	–0.186 (0.108)	–1.727 (56.746)	0.090
Model for Arts/Humanities (β_8)			
Intercept (γ_{80})	–0.392 (0.193)	–2.032 (62.008)	0.046
Random effects (Variance components)	**Estimate (SE)**	**Wald *Z***	***p***
Variance in intercepts (τ_{00})	0.396 (0.032)	12.174	<0.001
Variance within classes (σ^2)	0.015 (0.016)	0.973	0.330

TABLE 11. Null model and model with student-level predictors for motivation to take more science classes

	Model 1 Null model			Model 2 Student-level model		
Fixed Effects	**Estimate (SE)**	***t* (*df*)**	***p***	**Estimate (SE)**	***t* (*df*)**	***p***
Model for intercept, research design and process skills (β_0)						
Intercept (γ_{00})	4.32 (0.070)	61.230 (50.119)	<0.001	1.90 (0.177)	10.759 (284.786)	<0.001
Model for pre score slopes (β_1)						
Intercept (γ_{10})				0.564 (0.040)	13.937 (321.197)	<0.001
Model for HBN slopes (β_2)						
Intercept (γ_{20})				0.068 (0.145)	0.470 (322.062)	0.639
Model for First-Generation slopes (β_3)						
Intercept (γ_{30})				0.005 (0.095)	0.053 (325.329)	0.958
Model for Male slope (β_4)						
Intercept (γ_{40})				–0.014 (0.084)	0.171 (324.657)	0.865
Model for First/Second Year slope (β_5)						
Intercept (γ_{50})				0.127 (0.093)	1.362 (292.161)	0.174
Random effects (Variance components)	**Estimate (SE)**	**Wald *Z***	***p***	**Estimate (SE)**	**Wald *Z***	***p***
Variance in intercepts (τ_{00})	0.619 (0.051)	12.241	<0.001	0.414 (0.034)	12.050	<0.001
Variance within classes (σ^2)	0.129 (0.046)	2.814	0.005	0.036 (0.020)	1.795	0.073

2 predictors. This effect is significant ($t = 13.815$, $p < 0.001$). In addition, γ_{60} was 0.221, indicating that courses at the field station will have a 0.221 increase in motivation to take more science classes controlling for all other student-level and class-level predictors ($t = 2.515$, $p = 0.036$). Within this model, there still exists variability within the intercepts ($\tau_{00} = 0.396$, Wald $Z = 12.065$, $p < 0.001$); however, the intercept parameter indicates that the intercepts do not vary significantly across classes (Wald $Z = 1.510$, one-tailed $p = 0.066$).

Proportional reduction in classroom-level variance was estimated using Raudenbush and Bryk's (2002) convention by comparing the final contextual model to the student-level model. The results explain that 0.05% of the between-classroom variance in the intercepts was explained by level 2 predictors ($\tau_{00\text{ student-level model}} = 0.414$ and $\tau_{00\text{ final model}} = 0.416$) after controlling for student-level variables. The results of this model are presented in Table 12. The final model is presented in Figure 4.

TABLE 12. Mixed model with pre scores, HBN, First-Generation, Male, and First/Second Year at level 1 and with Station, New Course, and Arts/Humanities at level 2 for motivation to take more science classes

Fixed effects	**Estimate (SE)**	***t* (*df*)**	***p***
Model for intercept, Motivation to take more science classes (β_0)			
Intercept (γ_{00})	1.76 (0.183)	9.606 (196.533)	0 < 0.001
Model for pre score slopes (β_1)			
Intercept (γ_{10})	0.559 (0.040)	13.815 (315.077)	0 < 0.001
Model for HBN slopes (β_2)			
Intercept (γ_{20})	0.059 (0.145)	0.409 (320.889)	0.683
Model for First-Generation slopes (β_3)			
Intercept (γ_{30})	0.009 (0.095)	0.103 (322.955)	0.918
Model for Male slope (β_4)			
Intercept (γ_{40})	0.028 (0.084)	0.327 (322.390)	0.744
Model for First/Second Year slope (β_5)			
Intercept (γ_{50})	0.127 (0.096)	1.318 (313.926)	0.189
Model for Field Station (β_6)			
Intercept (γ_{60})	0.221 (0.10)	2.151 (58.422)	0.036
Model for New Course (β_7)			
Intercept (γ_{70})	–0.034 (0.121)	–0.277 (66.349)	0.782
Model for Arts/Humanities (β_8)			
Intercept (γ_{80})	–0.101 (0.215)	0.469 (67.540)	0.641
Random effects (Variance components)	**Estimate (SE)**	**Wald *Z***	***p***
Variance in intercepts (τ_{00})	0.416 (0.034)	12.065	0 < 0.001
Variance within classes (σ^2)	0.028 (0.016)	1.510	0.131

Mixed Model

$$\text{Synthesis Skills}_{ij} = \gamma_{00} + \gamma_{10}\text{*Pre-Score}_{ij} + \gamma_{20}\text{*HBN}_{ij} + \gamma_{30}\text{*First-Generation}_{ij} + \gamma_{40}\text{*Malei}_{j} + \gamma_{50}\text{*First/Second Year}_{ij} + \gamma_{60}\text{*Field Station}_{ij} + \gamma_{70}\text{*New Course}_{ij} + \gamma_{80}\text{*Arts/Humanities}_{ij} + u_{0j} + r_{ij}$$

FIGURE 4. The final contextual model for motivation to take more science classes.

To review, for research design and process skills, synthesis skills, and motivation to take more science classes, we examined multilevel models. The results suggest that the field station setting is associated with higher levels of research design and process skill as well as higher levels of motivation to take more science courses, after controlling for demographics, course-type, and pre scores. Including a random effect of class in each of these analyses demonstrated that this relationship is robust even as we account for differences between classes for research design and process skills as well as motivation to take more science classes; however, not for synthesis skills. In addition, arts/humanities courses were associated with lower levels of research design and process skills, whereas there was no relationship between arts/humanities courses and interest in taking more science courses. There were no significant associations between the field station setting and the scientific application or other measures for future science plans.

Is There a Moderating Effect of Underrepresented Status on the Relationship between the Field Station Setting and Perceived Scientific Literacy and Future Science Plans? (Research Question 3)

The results of the added interaction terms are displayed in Table 13 (predicting scientific literacy) and Table 14 (predicting future science plans), under OLS regression. As the βs and ΔR^2 demonstrate, the majority of the interaction terms was not significant, and the ΔR^2 was not significantly in the majority of these models. The one exception was for the model predicting interest in a career in environmental research and problem solving. Including the HBN*Field Station interaction term in the model was associated with ΔR^2 of 0.02 (F-change = 9.50, $p < 0.01$).

We examined this relationship with a multilevel model in order to include the random effect of class. The final model included all of the demographic variables and pre scores at level 1 and also included Field Station setting, New Course, and Arts/Humanities at level 2 (see Table 15). This final mode presented in Figure 5. γ_{10} is 0.683, indicating that for every one-unit increase in pre scores, motivation to take science classes increases by 0.683, controlling for all demographics and level 2 predictors. This effect is significant ($t = 15.339$, $p < 0.001$). In addition, γ_{60} was –0.121; indicating the effect of Field Station was not significant ($t = -0.928$, $p = 0.358$). γ_{20} was –0.946, indicating that for every one-unit increase in pre scores, HBN students had a 0.946 decrease in post scores ($t = -2.871$, $p = 0.004$). The interaction of HBN*Field Station, $\gamma_{90,}$ was 1.267, indicating that students who are HBN and at the field station have a 1.267 increase on interest in a career in environmental research and problem solving. In other words, there was a stronger association between the field station setting and interest in a career in environmental research and problem solving for HBN students compared with their non-HBN peers.

To What Extent Do Perceptions about the Course (Class Learning Goal Orientation and Class Belonging) Mediate These Relationships? (Research Question 4)

We selected models examining research design and process skills and motivation to take more science courses, because multilevel regression demonstrated a positive relationship between field station setting and these outcomes. We ran the same serial-multiple mediation model for research design and process skills and motivation to take future science classes.

Field Station Setting and Perceived Scientific Literacy. In the model for research design and process skills (Figure 6), the total effect ($c = 0.23$, SE = 0.07, $t = 3.22$, $p < 0.01$) of the Field Station on research design and process skills was significant. In addition, the direct effects of field station on class learning goal orientation ($B = 0.39$, SE = 0.08, $t = 5.04$, $p < 0.001$) and class belonging ($B = 0.56$, SE = 0.09, $t = 6.64$, $p < 0.001$) were both significant. The direct effect of class learning goal orientation as the first mediating variable on the second mediating variable of class belonging was significant ($B = 0.31$, SE = 0.06, $t = 5.14$, $p < 0.001$). The direct effects of the mediating variables including class learning goal orientation ($B = 0.11$, SE = 0.05, $t = 2.25$, $p < 0.05$) and class belonging ($B = 0.29$, SE = 0.05, $t = 6.50$ $p < 0.001$) were both significant. When Field Station and all other mediating variables were entered into the equation, the relationship between Field Station and research design and process skills was not significant ($c' = -0.02$, SE = 0.07, $t = -0.22$, $p = 0.82$).

TABLE 13. Interaction terms predicting scientific literacy

Interaction terms	*B*	ΔR^2
Research process and design skills		
HBN*Station	0.06	0 .00
First-Generation*Station	0.14	0 .00
Scientific application		
HBN*Station	–0.43	0 .00
First-Generation*Station	0.28	0 .00
Synthesis skills		
HBN*Station	0.22	0 .00
First-Generation*Station	0.19	0 .00

*$p < 0.01$.

TABLE 14. Interaction terms predicting future science plans

Interaction terms	*B*	ΔR^2
Science courses		
HBN*Station	0.40	0 .00
First-Generation*Station	0.25	0 .00
Science major		
HBN*Station	0.26	0 .00
First-Generation*Station	0.15	0 .00
Career		
HBN*Station	1.23	0 .02*
First-Generation*Station	0.18	0 .00

*$p < 0.01$.

TABLE 15. Mixed model with pre scores, HBN, First-Generation, Male, and First/Second Year at level 1 and with Station, New Course, and Arts/Humanities at level 2 for interest in a career in environmental research and problem solving

Fixed effects	Estimate (SE)	*t* (*df*)	*p*
Model for intercept, interest in a career in environmental research and problem solving (β_0)			
Intercept (γ_{00})	1.32 (0.205)	6.456 (166.400)	0 < 0.001
Model for pre score slopes (β_1)			
Intercept (γ_{10})	0.683 (0.045)	15.339 (315.375)	0 < 0.001
Model for HBN slopes (β_2)			
Intercept (γ_{20})	–0.946 (0.330)	–2.871 (303.589)	0.004
Model for First-Generation slopes (β_3)			
Intercept (γ_{30})	0.142 (0.121)	1.168 (320.983)	0.244
Model for Male slope (β_4)			
Intercept (γ_{40})	0.190 (0.108)	1.757 (322.390)	0.080
Model for First/Second Year slope (β_5)			
Intercept (γ_{50})	0.089 (0.123)	0.722 (309.013)	0.471
Model for Field Station (β_6)			
Intercept (γ_{60})	–0.121 (0.131)	–0.928 (57.307)	0.358
Model for New Course (β_7)			
Intercept (γ_{70})	–0.162 (0.153)	–1.062 (63.279)	0.292
Model for Arts/Humanities (β_8)			
Intercept (γ_{80})	–0.139 (0.271)	–0.515 (65.210)	0.609
Model for HBN*Field Station (β_9)			
Intercept (γ_{90})	1.267 (0.393)	3.221 (313.624)	0.001
Random effects (Variance components)	**Estimate (SE)**	**Wald *Z***	***p***
Variance in intercepts (τ_{00})	0.685 (0.057)	11.994	0 < 0.001
Variance within classes (σ^2)	0.039 (0.030)	1.310	0.190

We also examined the indirect effects in the serial multiple mediation model. As can be seen in Table 16, the total effect overall was significant (point estimate = 0.2423; 95% BC CI [0.1532, 0.3518]). The single mediation of class learning goal orientation (point estimate = 0.0431; 95% BC CI [–0.004, 0.1038]) and the single mediation of class belonging (point estimate = 0.1642; 95% BC CI [0.0816, 0.2696]) were significant. In addition, the serial multiple mediation of class learning goal orientation and class belonging was significant (point estimate = 0.0349; 95% BC CI [0.0145, 0.0646]).

Based on the contrasting pairs of specific indirect effects (displayed in Table 16), the separate single mediation of class belonging and the serial multiple mediation of class learning orientation and class belonging were not found to differ from each other. However, the separate single mediation of class belonging was stronger than the separate single mediation of class learning orientation in relation to research process and design skills in each of the tested models. In addition, the separate single mediation of class learning goal orientation was stronger than the serial multiple mediation of class learning goal orientation and class belonging.

Mixed Model

$$\text{Motivation to Take More Science Classes}_{ij} = \gamma_{00} + \gamma_{10}\text{*Pre-Score}_{ij} + \gamma_{20}\text{*HBN}_{ij} + \gamma_{30}\text{*First-Generation}_{ij} + \gamma_{40}\text{*Male}_{ij} + \gamma_{50}\text{*First/Second Year}_{ij} + \gamma_{60}\text{*Field Station}_{ij} + \gamma_{70}\text{*New Course}_{ij} + \gamma_{80}\text{*Arts/Humanities}_{ij} + u_{0j} + r_{ij}$$

FIGURE 5. The final contextual model for interest in a career and environmental research and problem solving.

Field Station Setting and Future Science Plans. In the model for motivation to take more science classes (Figure 7), the total effect ($c = 0.26$, SE = 0.09, $t = 2.96$, $p < 0.01$) of Field Station on motivation to take more science classes was significant. In addition, the direct effects of Field Station on class learning goal orientation ($B = 0.24$, SE = 0.08, $t = 3.21$ $p < 0.01$) and class belonging ($B = 0.50$, SE = 0.08, $t = 5.99$, $p < 0.001$) were both significant. The direct effect of class learning goal orientation as the first mediating variable on the second mediating variable of class belonging was significant ($B = 0.27$, SE = 0.06, $t = 4.27$, $p < 0.001$). The direct effects of the mediating variables including class learning goal orientation ($B = 0.24$, SE = 0.07, $t = 3.70$, $p < 0.001$) and class belonging ($B = 0.17$, SE = 0.06, $t = 2.76$ $p < 0.01$) were both significant. When Field Station and all other mediating variables were entered into the equation, the relationship between Field Station and scientific understanding was not significant ($c' = 0.11$, SE = 0.09, $t = 1.17$, $p = 0.24$).

Mixed Model

$$\text{Interest in a Career in Environmental Research and Problem}_{ij} = \gamma_{00} + \gamma_{10}\text{*Pre-Score}_{ij} + \gamma_{20}\text{*HBN}_{ij} + \gamma_{30}\text{*First-Generation}_{ij} + \gamma_{40}\text{*Male}_{ij} + \gamma_{50}\text{*First/Second Year}_{ij} + \gamma_{60}\text{*Field Station}_{ij} + \gamma_{70}\text{*New Course}_{ij} + \gamma_{80}\text{*Arts/Humanities}_{ij} + \gamma_{90}\text{*HBN*Field Station}_{ij} + u_{0j} + r_{ij}$$

FIGURE 6. Serial mediation model of class learning goal orientation and class belonging on the relationship between field station setting and research design and process skills. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

TABLE 16. Indirect effects and model contrasts for research process and design skills[a]

Effect	Product of coefficients		Bootstrapping95% BC confidence interval (CI)	
	Point estimate	**Boot SE**	**Lower**	**Upper**
Total indirect effect of *X* on *Y*	0.2423	0.0506	0.1532	0.3518
Field Station→ Class Learning Goal Orientation→ Research Process and Design Skills	0.0431	0.0267	−0.0004	0.1038
Field Station→ Class Belonging→ Research Process and Design Skills	0.1642	0.0480	0.0816	0.2696
Field Station→ Class Learning Goal Orientation→ Class Belonging→ Research Process and Design Skills	0.0349	0.0130	0.0145	0.0646
Contrasts				
Model 1 vs. model 2	−0.1211	0.0635	−0.2294	0.0090
Model 1 vs. model 3	0.0083	0.0280	−0.0434	0.0687
Model 2 vs. model 3	0.1294	0.0466	0.0480	0.2305

[a] *N* = 173, *k* = 10,000. Model 1 = Field Station–Class Learning Goal Orientation–Research Process and Design Skills; model 2 = Field Station–Class Belonging–Research Process and Design Skills; model 3 = Field Station–Class Learning Goal Orientation–Class Belonging–Research Process and Design Skills.

We also examined the indirect effects in the serial multiple mediation model. As can be seen in Table 17, the total effect overall was significant (point estimate = 0.1546; 95% BC CI [0.0729, 0.2483]). The single mediation of class learning goal orientation (point estimate = 0.0604; 95% BC CI [0.0195, 0.1206]) and the single mediation of class belonging (point estimate = 0.0833; 95% BC CI [0.0197, 0.1575]) were significant. In addition, the serial multiple mediation of class learning goal orientation and class belonging was significant (point estimate = 0.0109; 95% BC CI [0.0064, 0.0266]).

Based on the contrasting pairs of specific indirect effects (displayed in Table 17), the separate single mediation of class learning goal orientation was not stronger than the serial mediation of class learning goal orientation and class belonging in terms of motivation to take more science courses. In addition, the separate single mediation of class learning goal orientation and the separate single mediation of class belonging were not found to statistically differ from each other in terms of motivation to take more science courses. However, the separate single mediation of class belonging was stronger than the separate single mediation of class learning goal orientation.

To review, the results showed that the relationship between the field station setting and research design and process skills, as well as the relationship between the field station setting and motivation to take more science courses were mediated by class learning goal orientation and by class belonging (as single mediators) as well as by the sequence of class learning orientation and class belonging together (multiple mediation). When comparing models, these data indicate that for two of the tested outcomes (research process and design skills and motivation to take more science classes), class belonging (as a single mediator) was stronger than the model that included class learning goal orientation (as a single mediator). Taken together, these data indicate that both class learning goal orientation and class belonging explain the benefits of the field station setting, and in particular, class belonging plays an important role in explaining these benefits.

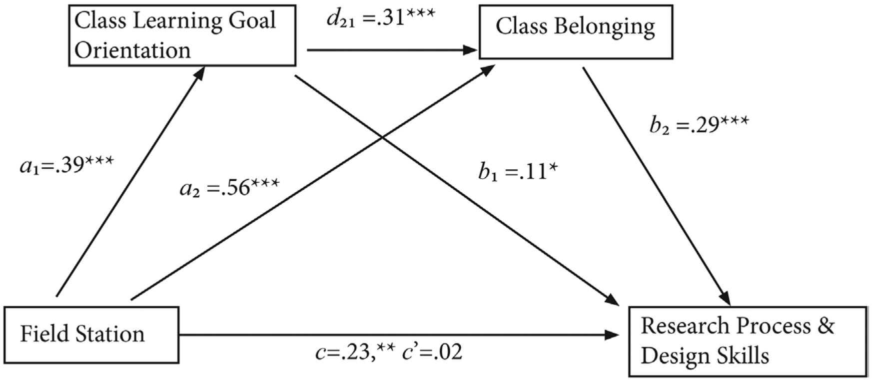

FIGURE 7. Serial mediation model of class learning goal orientation and class belonging on the relationship between field station setting and motivation to take more science classes.***p* < 0.01; ****p* < 0.001.

DISCUSSION

The existing body of research on field courses has documented many benefits from participation, but thus far, the mechanisms for how these benefits develop across field courses is not fully understood. A recent study (Beltran *et al.*, 2020) highlights the importance of future research efforts “seek[ing] to understand how social and psychological mechanisms such as sense of belonging, project ownership, and community building explain the benefits of field courses” (p. 9). Our study has extended previous research by looking at the mechanisms that drive the benefits of field courses, including class belonging and class learning goal orientation, across multiple kinds of field courses and on-campus courses over multiple years. In addition, by comparing multiple models of our variables of interest, we are able to provide evidence of which variables are most important for which outcomes.

Our results demonstrated that students who took science-based courses in the field station setting had higher levels of research design and process skills compared with those who took the course on the main campus (Table 5). These results support the body of evidence that immersion, or learning and living within the phenomena of study, can be an effective

TABLE 17. Indirect effects and model contrasts for motivation to take more science classes[a]

	Product of coefficients		Bootstrapping95% BC confidence interval (CI)	
Effect	**Point estimate**	**Boot SE**	**Lower**	**Upper**
Total indirect effect of *X* on *Y*	0.1546	0.0450	0.0729	0.2483
Field Station→ Class Learning Orientation→ Motivation to Take More Science Classes	0.0604	0.0261	0.0195	0.1206
Field Station→ Class Belonging→ Motivation to take more Science Classes	0.0833	0.0351	0.0197	0.1575
Field Station→ Class Learning Orientation→ Class Belonging→ Motivation to Take More Science Classes	0.0109	0.0064	0.0019	0.0266
Contrasts				
Model 1 vs. model 2	−0.0229	0.0476	−0.1127	0.0707
Model 1 vs. model 3	0.0495	0.0249	0.00107	0.1075
Model 2 vs. model 3	0.0724	0.0322	0.0159	0.1417

[a] N = 173, k = 10,000. Model 1 = Field Station–Class Learning Orientation–Motivation to Take More Science Classes; model 2 = Field Station–Class Belonging–Motivation to Take More Science Classes; model 3 = Field Station–Class Learning Orientation–Class Belonging–Motivation to Take More Science Classes.

pedagogical tool for developing science content knowledge (Orion and Hofstein, 1994; Ballantyne *et al.*, 2001; Giamellaro, 2014; Oliver *et al.*, 2018; Jolley *et al.*, 2019; O'Connell *et al.*, 2020). However, these results did not hold for every student who took courses in the field station setting. Specifically, we found a negative relationship between arts and humanities courses and research design and process skills as well as synthesis skills. Given that their course goals were not aligned to understand science and the research process and students in these courses were not conducting field research, this is not a surprising result. As these courses were only taught in the field setting, we do not know how these perceptions may have shifted in an on-campus setting compared with in the field.

No significant differences existed for motivation to be a science major or interest in a career in environmental research/problem solving in the field setting compared with the on-campus setting (Table 6). However, we do see that students in both the new and traditional courses had higher motivation to take more science courses compared with students in on-campus courses, indicating that the development of future interest may be achieved in shorter durations within the field setting. This finding held constant across all course types, including arts and humanities courses. These findings are in line with discussions about the affective benefits of fieldwork (e.g., Boyle *et al.*, 2007) and the significance of fieldwork in interest development (e.g., Levine *et al.*, 2007; Houlton, 2010; LaDue and Pacheco, 2013) and also build on connections between motivation and field experience (e.g., Boyle *et al.*, 2007; Stokes and Boyle, 2009; Gosselin *et al.*, 2016; Jolley *et al.*, 2018; Scott *et al.*, 2019). Thus, an important goal with field courses could be to "hook" students early in their studies (e.g., Malm *et al.*, 2020; Race *et al.* 2021). Given work that suggests field courses help reduce inequity gaps (Beltran *et al.*, 2020), offering well-designed and accessible field courses to first- and second-year students could have significant implications for achievement and retention in science.

There were no significant differences for perceived synthesis skills in the field versus the traditional classroom setting (Table 5). It may be the case that students focused more on the research process and design as opposed to the wider application of their course content. This finding is in line with previous research demonstrating that gains related to presenting or applying research to the larger field come toward the end of, or possibly even after, a research experience (Thiry *et al.*, 2012; Adedokun *et al.*, 2014). As our post survey occurred at the end of the course, we do not know if these skills were developed at a later time point.

Across our analysis, pre scores were related to post scores and were especially strongly related to post scores for future science plans. Similar to recent work (Beltran *et al.*, 2020), these data indicate that there may be little change in student intention to pursue future science-related majors or careers, as many students begin these experiences highly interested in these paths.

The results of the present study demonstrate that class belonging and class learning goal orientation are especially fostered in the field station setting (Figures 6 and 7) and are subsequently strongly related to students' perceived research process and design skills and motivation to take more science courses. In line with previous research, our findings support the sequence of learning goal orientation promoting perceptions of belonging (e.g., Walker, 2012), which then are related to positive outcomes. By further understanding the mechanisms of how these variables interact with one another to create benefits in the field setting, we can begin to prioritize how to create more inclusive experiences for students.

Field Course Benefits

Beltran *et al.* (2020) suggested that a topic for further investigation is the degree to which "field course benefits can be attributed to pedagogy (e.g., active learning) or the context in which they are taught (nature)" (p. 9). In this study, we believe a third major element also plays a role: the residential aspect of the field station, which supports students to be fully immersed within the object of study (nature) and have increased informal social interactions in the field.

Field courses provide opportunities for students to be engaged in many high-impact educational practices (e.g., collaborative assignments and projects, undergraduate research, community-based learning, and capstone courses and projects; Kuh, 2008). Much is known about the impact of these kinds of practices for learners (e.g., persistence, higher grades, intellectual development; Carini *et al.*, 2006; Hu *et al.*, 2008; Kuh *et al.*, 2008). Less is known about the degree to which being immersed in the object of study impacts student learning and personal growth, although many agree that it is a powerful experience that could impact learning. Undergraduate field experiences are a form of in situ learning (Bell *et al.*, 2009) in which the landscape is employed as a pedagogical tool (Giamellaro, 2014; Jolley *et al.*, 2018; Oliver *et al.*, 2018) and is the context of research and learning (Vogt and Skop, 2017). As such, field environments are contextualized learning environments that provide opportunities to use all of the senses to better develop skills and knowledge (Giamellaro, 2014). Full immersion in these contextualized learning environments represents a systemic, aesthetic experience (Roth and Jornet, 2014) with the potential to develop not just understanding but also a sense of awe and wonder (Mogk and Goodwin, 2012) and lead to individual discovery as an extension of the intended learning objectives (Giamellaro, 2014).

Aligned with positive social and professional outcomes previously reported in the field education literature (Fuller *et al.*, 2006; Stokes and Boyle, 2009; Mogk and Goodwin, 2012; Streule and Craig, 2016), the results of the present study build on the importance of social interactions by demonstrating the importance of class belonging in the field station setting. In a typical field station, social interactions occur through informal interactions across students, students and faculty, and students and other researchers staying at the field station. These increased opportunities for social interactions may be tied to more opportunities to learn about and develop group norms, which have strong ties to perceptions of belonging (Goodenow, 1992). For example, guest lectures about environmental research and topics prioritizes these issues, and they may become a topic of conversation in informal or formal discussions in classes or during shared meals. This may continue to foster a group norm in the field station setting that these are important topics, creating perceptions of inclusion and acceptance for students who value these issues, reinforcing their connection to other people in this community.

The contextual model of learning (Falk and Dierking, 2000; Falk and Storksdieck, 2005) recognizes that physical, social, and personal contexts together influence a learner's experience, similar to discussions in Goodenow's (1992) work on the importance of the social environment for learning. We argue that residential field courses provide an opportunity for students to put their whole selves into the experience: physically, socially, and emotionally. In this way, the living and learning environment and the object of study become one, and a combination of all three of these elements—immersion into the context, the pedagogy, and the social nature of the residential experience possibly influencing the student experience—create a "bundle" that is powerful for learning and personal growth.

Access and Inclusion in Field Courses

Given these results showing the benefits of residential field courses, what principles need to be considered to increase access and inclusion in residential field courses for a diversity of students? There are many different ways to increase access to field courses, such as offering funded housing or stipends for participation as well as prioritizing intentional outreach to students who may not be aware of field opportunities (for additional examples, see Zavaleta *et al.*, 2020; Flowers *et al.*, 2021). The field station in our study was able to alleviate some barriers for student participation by reducing costs associated with living in residence as well as creating course extensions that ran directly after or before academic terms so as not to interfere with summer jobs. While we had small numbers of HBN students in our study, the significant interaction between HBN*-Field Station for interest in a career in environmental research/problem solving suggests that the field station setting may be an especially important pathway to increase the number of HBN students in environmental professions.

Access to field experiences is the first step, but access needs to be followed with effective design of field courses that fosters both learning goal orientation and belonging. For example, in traditional college classrooms, perceptions of belonging are strongly linked to relationships with faculty and peers (Zumbrunn *et al.*, 2014). In ecology and evolutionary biology fields, higher levels of exposure to ecology, knowledge of evolution, and most relevantly to this study, perceived comfort in the outdoors all have positive associations with perceptions of belonging (O'Brien *et al.*, 2020). Thus, when planning an inclusive field course, organizers need to take into account prior student experiences and might further consider preparation of detailed packing lists, thorough orientations, clear daily itineraries, and even recommended reading before the course begins to ensure that students feel comfortable and prepared for the field setting (e.g., Orion and Hofstein, 1994; Kingsbury *et al.*, 2020). Similarly, there may be natural opportunities in field courses to promote a learning goal orientation by focusing on the mastery content or the research process as opposed to getting a "correct" final result. For example, giving students the opportunity to repeat an experiment if their samples were destroyed is one way in which students could learn from a "failed" experiment and focus on having an authentic research process (Goodwin *et al.*, 2021). Many other teacher practices, such as encouraging help-seeking, enthusiasm, interest in students, agency and autonomy in the field, and even humor are all associated with a focus on learning goal orientation (Anderman *et al.*, 2011; Zhang, 2014; Jolley *et al.*, 2019; Petcovic *et al.*, 2020).

LIMITATIONS

This study focused on self-reported student perceptions and not direct measures of their skill development. Further studies could explore whether or not our findings are consistent with direct measures of research design, process, and synthesis skills. While we did have similar demographic composition in the field station setting as well as on campus, we realize that this does not account for all other potential differences in student characteristics. Relatedly, as students who enrolled in field station courses had high levels of interest in future science plans in both new and traditional courses, there is some degree of self-selection in our study population. We acknowledge limitations related to our comparison group and the nature of student choice to enroll in field courses. While students are not required to enroll in field courses, field courses are an attractive option for many students, because they efficiently satisfy multiple degree requirements across several academic disciplines. We recognize the importance of volunteer bias in our responses as an additional limitation in our study and the impact this has on the generalizability of our results (e.g., Brownell *et al.*, 2013). While we made efforts to suggest ways to increase response rates across courses, such as suggesting faculty offer extra credit and/or offering incentives if extra credit was not offered, our response rates were not equal across all courses, and we are not able to determine whether students who responded to our surveys were in general more favorable to the field station setting, even in the on-campus courses. Recognizing that we could not have an exact comparison group, we chose to incorporate pre scores to give a sense of where all students initially started with their perceptions and to see how they changed across the time periods of their courses. We recognize, however, that there may be other measures not captured within the pre scores we examined that may be more related to student motivation or intentions toward learning. This would be an important area to consider in future work on field education, and our results need to be interpreted with this in mind, as well as the fact that this study was limited to one field station setting and one campus environment.

In addition, though we did find an additional benefit of the field station setting for interest in a career in environmental research/problem solving for HBN students compared with non-HBN students, these findings should be interpreted with caution, as we had small numbers of HBN students in our study in general. We also recognize the limitations of combining multiple groups into the HBN category and recognize the importance of examining the experiences of individual groups of students with larger quantitative samples or through more in-depth qualitative work.

Further, we did not have exact matches for every course taught in the field setting, as some were not offered in the same way as an on-campus course, and we were only able to include arts and humanities courses in the field setting. We acknowledge that, within the field setting, there are a great number of differences from a traditional on-campus setting, such as differences in course size or time spent each day in class, and we cannot distinguish which factors in this study contributed to perceptions of class learning goal orientation or class belonging. In addition, it is important to note that seasonal differences may impact what students are able to learn in specific environments. For example, certain plants or species may be visible during Spring and Summer terms compared with Winter term, creating differences in the ability to easily contextualize learning across seasons.

FUTURE WORK

Though researchers have examined the factors that contribute to belonging in traditional classroom settings such as building relationships with faculty and peers (Freeman *et al.*, 2007; Zumbrunn *et al.*, 2014), future work should explore how perceptions of belonging are formed in field settings.

Studies in both field settings and CUREs have suggested that an experience conducting an independent research project and having autonomy over the project have a significant impact on subsequent student motivation and engagement as well as perceptions of belonging to the scientific community (Corwin *et al.*, 2015; Scott *et al.*, 2019). These findings are especially relevant given that the majority of courses in the field station setting in our study contained a research project component. Future work in field courses could further disentangle how autonomy, learning goal orientation, and belonging play a role in scientific literacy and future science plans across settings. Future work could also examine how CUREs in an on-campus setting compare with courses taught in a field station setting.

The impact of the COVID-19 pandemic on field education led to many virtual course offerings. The limited available research on virtual field experiences demonstrates that they have less of an impact on student sense of community compared with in-person field experiences (Race *et al.*, 2021), yet virtual field courses can possibly mitigate issues of access to traditional field courses (Morales *et al.*, 2020; Race *et al.*, 2021). Future work could further examine the development of how perceptions of belonging are developed in virtual field learning experiences.

In addition, the timeframe in which we ask these questions is related to a single field experience, and prior research indicates the importance of multiple experiences for interest development (Hidi and Renninger, 2006). Future studies may consider using a longer time frame to assess outcomes related to future science plans.

CONCLUSIONS

The results of this study demonstrate that the field setting is associated with higher levels of research design and process skills and synthesis skills, as well as higher levels of motivation to take more science classes, after controlling for demographics, course type, and pre scores. In addition, comparisons of various models suggest that, independently, both class belonging and class learning orientation play an important role in explaining perceptions of research process and design skills, synthesis skills, and motivation to take more science courses, and understanding how both class belonging and class learning orientation are fostered within the field setting is an important next step in research. Our results suggest that class belonging in particular plays an important role when comparing different models for each outcome. This finding extends previous work that demonstrates the importance of perceptions of belonging in classrooms on college campuses for achievement and motivation in understanding science (Freeman *et al.*, 2007; Zumbrunn *et al.*, 2014) and is especially important given that a common reason students choose to leave STEM fields is due to perceived lack of competence or understanding of content (Rainey *et al.*, 2018). Future attention to how the field setting fosters adaptive motivational perspectives such as class learning goal orientation and class belonging will continue to explain the benefits of field experiences.

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