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Disclosure Statement

The authors report there are no competing interests to declare.

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Abstract

Given the ongoing socio-ecological crises, higher education institutions need curricular interventions to support students in developing the knowledge, skills, and perspectives needed to create a sustainable future. Campus farms are increasingly becoming sites for sustainability and environmental education toward this end. This paper describes the design and outcomes of a farm-situated place-based experiential learning (PBEL) intervention in two undergraduate biology courses and one environmental studies course over two academic years. We conducted a mixed-method study using pre/post-surveys and focus groups to examine the relationship between the PBEL intervention and students' sense of place and expressions of pro-environmentalism. The qualitative analysis indicated measurable shifts in students' place attachment and place-meaning scores. The qualitative findings illustrate a complex relationship between students' academic/career interests, backgrounds, and pro-environmentalism. We integrated these findings to generate a model of sustainability learning through PBEL and argue for deepening learning to encourage active participation in socio-ecological change.

Keywords: *campus farms, place-based experiential learning, pro-environmentalism, sense of place, sustainability*

Introduction

Sustainability curriculum in higher education offers a critical site for preparing the next generation of scientists, leaders, and community members to address socio-ecological crises (Association for the Advancement of Sustainability in Higher Education, 2010; Garibay et al., 2016; Michel, 2020). Compared to traditional undergraduate curriculum, which focuses on developing disciplinary skills (Tytler, 2012), sustainability curriculum engages multiple disciplinary perspectives, situates content within sociohistorical contexts, explores real-world problems, and fosters an ethic of sustainability (Burns, 2011; Orr, 1994). Throughout the years, the campus farm has become a common site for place-based sustainability education in postsecondary settings, often through student-led co-curricular activities (Clarke, 2010; Parr et al., 2007). Importantly, studies show place-based education with campus farms and similar ecological sites enhances students' problem-solving skills, civic-mindedness, and pro-environmentalism (Krzic et al., 2015; Kudryavstev et al., 2012; Scannell & Gifford, 2013**;** Semken et al., 2009). The research on student learning through campus agricultural projects is nascent (LaCharite, 2016). Nevertheless, studies show student engagement with campus agricultural sites can cultivate sense of place, justice-oriented thinking, and the interdisciplinary engagement needed to create a sustainable future ([Author(s)]; Cropps & Ester, 2021).

While practices for facilitating sustainability-themed agricultural projects are widely studied in K-12 settings (Rahm, 2018; Smith, 2007; Strong et al., 2016), we know less about how college faculty incorporate these projects into their courses or the outcomes of doing so (Burns, 2011; LaCharite, 2016). Moreover, recent studies demonstrate that college students have few opportunities to learn about sustainability or participate in place-based projects within core curricula (Garibay et al., 2016; Leal Filho et al., 2019; Michel, 2020; Shawe et al., 2019). These

gaps in opportunities to learn about and through sustainability themes limit our ability to support all students in forming meaningful connections with the environment and considering their role in our collective striving for sustainable living. We view course-based sustainability interventions with a campus site as an important strategy for reaching students who may not otherwise be drawn to socio-ecological issues.

Study Purpose

This paper describes the outcomes of sustainability-themed place-based experiential learning (PBEL) intervention involving a campus farm. We used a mixed-methods approach (Creswell, 2015) to investigate how incorporating the intervention into required courses impacted students' sense of place and pro-environmentalism. Past studies show that when students learn more about the ecological significance of a site (e.g., neighborhood), they become more connected to the place and motivated to adopt pro-environmental behaviors (Kudryanvstev et al., 2012; Scannell & Gifford, 2013). Research also indicates people are more likely to enact pro-environmentalism when they have multiple opportunities to learn and practice these behaviors (Burns, 2011; Vaske & Korbin, 2001). The literature, however, includes few studies of PBEL interventions in college settings or examples of how faculty design learning to encourage pro-environmentalism.

Therefore, we build on previous work by exploring how PBEL with the campus farm develops students' capacity for contributing to socio-ecological change. We focus on sense of place and pro-environmentalism as past studies show these factors relate to people's willingness to change their habits to reduce environmental harm (Berenstein & Szuster, 2019; Félonneau & Becker, 2008; Hernández et., 2007). The following research questions guided this study:

1. To what extent does a sustainability-themed PBEL intervention facilitate measurable shifts in students' sense of place? How, if at all, do students relate their sense of place to the activities in the PBEL courses?
2. Given their experiences in the intervention courses, how, if at all, do students characterize pro-environmentalism and describe their role in contributing to sustainable futures?

The following sections provide an overview of the literature and concepts that ground this study. We first discuss literature on educational activities on campus farms, and we situate this discussion within the context of the pedagogical approach of intervention. Next, we introduce three framing concepts – sustainability, sense of place, and pro-environmentalism – that inform the intervention and research approach. The rest of the article describes the study design, presents results, and discusses implications for research and practice.

Learning through the Campus Farm

Since the 1990s, the number of campus farms on college campuses has grown from 23 to around 300 (LaCharite, 2016). While campus farms have traditionally been sites for agricultural education at land grant institutions, the recent uptick of campus agricultural projects is primarily a consequence of student-led and community-engaged activism concerning food access, sustainability, and environmentalism (Hudler et al., 2019; LaCharite, 2016). Within this context, the campus farm serves as a site for students to lead public pedagogy and co-curricular engagement to extend what they learn in college to other settings. Though valuable, co-curricular sustainability learning is limited for reaching broad audiences because it typically serves students with pre-existing interests and lacks structures to sustain long-term participation (Clarke, 2010). There is also a dearth of research on the outcomes of learning on campus farms, especially in non-agriculture courses (LaCharite, 2021; LaCharite, 2016). Thus, while we know these

activities are beneficial, we have much to learn about the transformative possibilities of sustainability education with the campus farm ([Author(s)]).

In our intervention, the campus farm is an ecological place conducive to sustainability learning. The intervention combines the principles of place-based education (Gruenwald, 2003) and experiential learning (Kolb & Kolb, 2005). The goals of place-based education are to facilitate meaningful interactions with material environments and contextualize learning within the concerns of a local community. As a place, the campus farm offers (1) a unit of analysis of sociohistorical dimensions on campus, (2) a medium for learning to care for the environment, and (3) a site of praxis – critical reflection and action – and accountability to local and global concerns (Gruenwald, 2003). Studies show engagement with material environments can foster collaboration, connection, and accessibility among faculty and students and reveal how local and global dynamics shape places ([Author(s)]; Kuntz & Berger, 2011).

Further, place-based education can unsettle Western cultural and knowledge practices and support students to consider Indigenous and non-Western conceptions of land, environment, and sustainability (Bang et al., 2014; Collins & Mueller, 2016). Unsettling singular narratives of place is necessary to support deep learning about how colonial and capitalist dynamics shape local sites (Calderon, 2014). The possibility of leveraging campus farms for such learning in higher education settings is yet to be realized (see Tuck et al., 2014 for further discussion of this point).

Along with centering place, the intervention aligns with principles of experiential learning theory (Kolb & Kolb, 2005). This theory suggests learning occurs through a cyclical process with (1) a concrete experience, (2) a reflective observation, (3) abstract conceptualization, and (4) active experimentation. The campus farm provides a site for students

to enact sustainable practices (*concrete experience*) and critically reflect on place (*reflective observation*). For the intervention, faculty connect students' farm experiences with course content (*abstract conceptualization*) and encourage them to apply disciplinary concepts to socio-ecological problems. Students also complete inquiry projects (*active experimentation*) to explore disciplinary practices for developing solutions. Educators have drawn on experiential and participatory frameworks for interventions to develop various skills, such as innovation (Mayhew et al., 2021) and civic engagement (Rockenbach et al., 2014). Rather than prescribing ways of thinking and acting, experiential interventions encourage students to enact their agency and creativity to achieve a goal (Kolb & Kolb, 2005). This study's intervention leverages the campus farm to encourage students to critically reflect on and act in place toward sustainability.

Conceptual Framing

Three concepts informed the PBEL intervention and study designs: sustainability, sense of place, and pro-environmentalism**.** *Sustainability* is a construct that includes three pillars (Purvis et al., 2019): environmental health, economic viability, and social equity. Sustainability education requires integrated exploration of complex socio-ecological problems that reveal threats to each pillar (Burns, 2011). In previous studies of sustainability learning in higher education, researchers found that curriculum often overemphasizes the environmental pillar (Garibay et al., 2016; Michel, 2020). The components of the PBEL intervention were designed to align with all three pillars of sustainability through a food systems theme. We also use this framework to relate students' self-reported outcomes to each pillar.

The second concept is *sense of place*, a term to characterize the meanings (i.e., place-meaning) and connections (i.e., place-attachment) people make with geographic sites (Relph, 1976; Tuan, 1977). Place-meaning refers to the multiple meanings (e.g., social, cultural,

political) people ascribe to a geographic area (Semken & Freeman, 2008). By contrast, place-attachment describes the bond and sense of belonging a person or community has with a site (Hernández et al., 2007; William & Vaske, 2003). Place-attachment also includes two subconstructs: place dependence and place identity (William & Vaske, 2003). Whereas place dependence measures functional attachments (e.g., living, working) to a geographic area (Jorgensen & Stedman, 2000), place identity assesses how individuals develop a sense of self or identity through involvement with a site (Williams & Patterson, 1999). Together, place-meaning and place-attachment are mediated by individual, social, cognitive, and affective processes that contribute to a person's overall sense of place (Scannell & Gifford, 2010; Semken & Freeman, 2008). We use sense of place to examine shifts in students' place-meaning and place-attachment after participating in sustainability-themed PBEL activities.

The third concept, *pro-environmentalism*, refers to the intentions and behaviors to limit or reduce environmental harm (Félonneau & Becker, 2008). Pro-environmentalist worldviews can vary because of differences in social norms, motivations, and other social determinants (e.g., identity, values) (Félonneau & Causse, 2017). Previous research also indicates that pro-environmentalism is difficult to measure quantitatively because people commit to scale-specific (e.g., local vs. global) concerns and aspects of environmental issues that may be at odds (Berenstein & Szuster, 2019; Félonneau & Becker, 2008). In their review of prior conceptualizations of environmentalism, Berenstein and Szuster (2019) proposed three aspects of pro-environmentalist worldviews that vary: views of nature, technology, and societal responses.

Berenstein and Szuster (2019) argued that the environmental movement was never a singular or coherent set of worldviews. Their proposed framework accounts for inherent variability in worldviews. For example, one could view nature as resilient and consider

technological innovation the most effective way to address environmental issues. They might advocate for policies (i.e., macro response) that permit researchers to develop technical solutions to agricultural problems. By contrast, one could hold the same view about nature yet consider technology a problem rather than a solution. Instead, they could advocate for local, sustainable farming practices (i.e., meso response) to address environmental concerns within their community. Berenstein and Szuster (2019) suggested quantitative measures miss this variation. As such, we use Berenstein and Szuster's (2019) framework for qualitative analysis of students' pro-environmental expressions. We also interpret qualitative findings alongside quantitative measures of students' sense of place to explore how the PBEL courses enhanced aspects of their pro-environmentalism.

Method

Study Design

Rooted in the constructivist paradigm (Guba & Lincoln, 2005), we sought to understand how participants made meaning of their experiences in PBEL intervention courses to leverage these insights for improving educational practice. We used a convergent parallel mixed-methods design (Creswell, 2015) to examine the impact of the intervention on student learning outcomes: sense of place and pro-environmentalism. In convergent parallel designs, qualitative and quantitative data collection and analyses occur independently, and the findings are considered in tandem. The quantitative data comprised pre-and post-surveys on place-attachment and place-meaning to address the first research question about changes in students' sense of place. The qualitative data sources were focus groups and were used to analyzes students' statements related to sense of place and pro-environmentalism. We used this mixed-methods approach to generate a

multidimensional view of the outcomes of the PBEL intervention. The Institutional Review Board approved this study.

Setting and Participants

The study took place at a small, private institution in the Midwestern United States. In 2016, the National Science Foundation (NSF) awarded the institution a three-year grant to study PBEL with local diversified campus and urban farms. As part of the NSF grant, we recruited faculty teaching science and environmental studies courses to develop and implement the PBEL module. We collected baseline data during the first year of the grant (2016-2017) and pre-and post-data in implementation years (2017-2018 and 2018-2019). The current study focuses on student outcomes in biological sciences and environmental studies courses during the two implementation years (Table 1).

Table 1. Demographic Characteristics for Students (n=84) in Participating Courses

	Gender		Academic Level				Minority	
	M	F	1	2	3	4	NM	M
200-Level Biology	13	43	1	35	13	7	50	6
400-Level Biology	6	4	0	1	3	6	9	1
200-Level Environmental Studies	6	12	4	4	7	3	16	2
Total	25	59	5	40	23	16	75	9

Note: NM refers to non-minorities as classified by the institution.

PBEL Intervention

With support from the research team, faculty designed 4-6 week-long modules with multiple components to situate biological and environmental studies concepts within agricultural contexts based on our PBEL framework for the intervention (see [Author(s)] for more details). The modules focused on local and global food systems and sustainable farming practices to align with the sustainability theme and campus farm context. In addition to direct experience with the farm (*concrete experience*), the three main components of the module were: a set of introductory activities (*abstract conceptualization* and *reflective observation*), a student inquiry project

(*active experimentation*), and a dissemination activity. The introductory activities covered discipline-specific modes of inquiry, relevant agricultural and food system concepts, connections between content and the sustainability pillars. Introductory activities included Ana Sofia Joanes' (2010) documentary *FRESH* and a class discussion, a farm sensory walk reflection, and a food journal homework assignment for students to explore their carbon footprint based on their diet. For the inquiry component of the module, students completed discipline-specific research projects related to the course content. The final component of the module required students to share results from their inquiry project with community stakeholders through either a poster session, final papers, or in-class presentation. Below, we summarize how faculty tailored the PBEL module to their courses.

Biology Courses

The 200-level biology course is the fundamentals lab for biology majors and was comprised of three sections taught by three different professors. The professor for one of the sections acted as a lead course instructor and designed the PBEL module for all three biology sections. Students first learned about agricultural production and local grassroots solutions to global food system problems through viewing and discussing the documentary FRESH (Joanes, 2010). After the introductory lesson, students complete soil respiration and arthropod diversity inquiry on the campus farm to compare adjacent turfgrass, prairie, and forested ecosystem types. Both soil respiration and biodiversity were covered in the lecture portion of the course, during nutrient cycling and community composition topics, respectively.

The 400-level biology course is an elective taken primarily by biology, chemistry, environmental studies, and science, technology & society majors. A recurring course topic is the ecosystem role of carbon (C) at the molecular (photosynthesis and decomposition), landscape

(ecosystem respiration), and global (atmospheric) scales. Students first learned about local and global industrial agricultural production through an on-farm scavenger hunt and tour. They then conducted student-led research on inputs and outputs of soil C on the campus farm and adjacent prairie and how C processes in controlled by environmental factors such as moisture and temperature. Student projects culminated in end-of-semester presentations tying scientific findings to sustainability outcomes.

Environmental Studies Course

The 200-level environmental studies course is a requirement for environmental studies majors and minors. Students participated in reading, reflection, and discussion of Michael Pollan's (2015) *The Omnivore's Dilemma* to become familiar with food system issues. They then researched the broad question—What factors contribute to diverse farmer perspectives on policies, practices, and perceptions of food production and consumption for establishing sustainable local food economies?—through ethnographic methods at the campus farm and another urban farm in the city. Students conducted six hours of participant observations and interviewed local farmers about their perspectives on local and global food systems, policy issues, and sustainable farming practices. The instructors asked students to use course concepts to analyze their data to ground these activities in course content. Students used this inquiry project and group discussion to prepare a research paper for the course and a presentation for local stakeholders (e.g., faculty, urban farmers).

Instruments and Data Sources

We used quantitative and qualitative methods to assess the impact of the PBEL intervention on students' sense of place and pro-environmentalism, respectively. During the first week of the semester, members of the research team visited each course to recruit students to

participate in the study. Within the first three weeks of the term, we emailed the pre-survey to students who consented to participate in the study. Post-surveys were sent a few weeks before the end of the semester. At the end of the semester, we invited students to participate in focus groups to discuss their experience in the intervention courses.

Place Attachment Survey

We adapted a validated 12-item place-attachment survey (Williams & Vaske, 2003) to measure students' attachment to Midwest University, home, and local and campus farms. The place-attachment survey includes place-identity and place-dependence subconstructs for each site.

Situated Sustainability Meaning Making Survey

With support from authors 3-5, the second author developed a situated sustainability meaning-making survey for this project using relevant literature for place-meaning scales (Kudryanvstev et al., 2012; Stedman, 2002; Young, 1999). The instrument included a place-meaning survey to understand students' perceptions of local and campus farms' features that could influence the meanings they attributed to the campus farm. This survey contains 20 Likert-scale questions to assess the possible meanings students could ascribe to the farms based on three pillars of sustainability (i.e., environmental health, economic viability, and social equity, Purvis et al., 2019). Example items from survey are as follows:

The campus farm is a place to…

- observe eco-friendly food production (pillar: environmental health)
- support the local economy (pillar: economic)
- to contribute to social well-being (pillar: social equity)

Focus Groups

We conducted student focus groups using a semi-structured interview protocol with probing questions to gain insights into students' collective experiences with PBEL modules (Bernard, 2006). In keeping with the convergent parallel mixed-methods design, we used this qualitative data source to contextualize the quantitative sense of place findings and to characterize the various ways students expressed pro-environmentalism (Berenstein & Szuster, 2019), and examine whether PBEL activities influenced students' pro-environmental intentions or behaviors. The second author facilitated four groups with four to six students during the first year of the intervention. When possible, the focus groups were organized by course or with no more than two courses represented. The focus groups lasted 60-90 minutes and were transcribed verbatim.

Data Analysis

Quantitative Analysis

Paired-sample t-tests along with effect size and power were analyzed for the module intervention for the entire population through pre- and post-place- attachment and SSMMS surveys. Internal consistency was calculated for place attachment and SSMMS using Cronbach's α. If items are evaluating the same underlying construct, then their intercorrelation should be high (Spector, 1992). Thus, a Cronbach's $\alpha \geq 0.70$ should be produced (Adams & Lawrence, 2015), which was used to base acceptance. Calculations were performed via SPSS V. 27 (SPSS Inc., 2017) and G*Power 3.1 (Faul et al., 2009) accordingly.

Qualitative Analysis

Authors 1 and 3 conducted a reflexive thematic analysis (Braun & Clarke, 2019) to identify and analyze patterns across students' experiences in the PBEL intervention courses. We used Bingham and Witkowsky's (2021) Five-Cycle approach for deductive and inductive

analysis. First, we familiarized ourselves with the transcripts and used deductive codes to label sections of the transcripts related to sense of place, pro-environmentalism, and PBEL activities. Next, two researchers individually read and inductively coded the data to identify excerpts relevant to the research questions. We held research meetings to discuss our interpretations and developed a codebook using the frameworks that guided the study. Following this, we coded the data and completed consensus checks to assess alignment in codebook application (Cascio et al., 2019). When coding did not align between researchers, we discussed the interpretations and worked to reach a consensus. To pursue rigor and quality in the qualitative data analysis process, we had two coders with expertise in qualitative research, held debriefing meetings throughout the analysis process, and maintained an audit trail. We also considered the ethical implication of our interpretations of the data and considered the limitations to the kinds of claims we could make given the data we used for the study (Tracy, 2010). We analyzed patterns within and across codes to generate the qualitative findings and selected representative excerpts to demonstrate each theme.

Mixed-Methods Analysis

Following independent analyses of the quantitative and qualitative data, the results related to sense of place were reviewed and compared to identify areas of convergence and divergence. In the results and discussion sessions, we integrate our interpretations of the quantitative and qualitative findings related to sense of place to address the first research question (Creswell, 2015). Additionally, we draw connections between qualitative findings about students' pro-environmental expressions, quantitative sense of place measures, and PBEL activities to address the second research question.

Results

Quantitative Results

The results of the quantitative analysis address part of the first research question: *To what extent does a sustainability-themed PBEL intervention facilitate measurable shifts in students' sense of place?* The pre-place- attachment and meaning surveys included questions about students' previous knowledge of and interaction with the campus farm. Of the cohort that provided responses to the sense of place surveys, 94% (79 students) knew that the university had an urban farm, but only 40.5% (34 students) of students had previously visited the farm. The post-survey contained follow-up questions on students' intent to continue to interact with an urban farm. On the post-survey, 89.3% (75 students) responded affirmatively (yes and maybe) that they intended to interact with the campus farm or another urban farm in the future. For the students who answered with an absolute 'Yes' (32.1%), the majority responded that their intentions were to either intern or volunteer. Most students, 79.5% (66 students), also answered affirmatively (yes and maybe) that they would come to visit the campus farm after graduating.

The adapted place attachment survey (Williams & Vaske, 2003) contained two sub-constructs: place identity and place dependence. The sub-construct place dependence contains the reverse coded question. Pre-place identity (α =0.909), post-place identity (α = 0.948), pre-place dependence (α = 0.913), and post-place dependence (α = 0.891) were all acceptable. (Adams & Lawrence, 2015). The place identity and reassessed place dependence constructs calculated together as pre-place attachment (α = 0.948) and post-place attachment (α = 0.956) resulted in acceptable internal consistencies.

Paired-sample *t*-tests compared changes in farm sense of place scores pre- and post-module. For testing the normal distribution of farm place-attachment and farm place-meaning samples, Shapiro-Wilks tests were conducted. Results showed their *p*-values were statistically

not significant ($p < 0.05$), and thus normally distributed. Farm place-attachment had no outliers. Farm place-meaning had one outlier. After reviewing the raw data, the outlier case was kept due to responses showing nothing unusual. Also, removing the outlier did not create a change in outcomes for the urban farm place meaning dependent *t*-test. The outcome remained statistically significant at the same level for a one-tailed *t*-test, $p < 0.01$.

For final combined population, a statistically significant increase in place-attachment was found between the pre-implementation (M = 28.58, SD = 10.25) and post-implementation scores (M = 33.01, SD = 11.86); $t(83) = -4.06$, $p < .001$ for a two-tailed *t*-test. Additionally, a power of 0.980 and an effect size of 0.443 were calculated for this population of students. There was also a statistically significant increase in scores for place meaning pre-implementation (M= 82.71, SD= 10.58) to post-implementation (M = 85.43, SD = 9.98); $t(83) = -2.433$, $p < .05$ for a two-tailed *t*-test with a power of 0.67 and an effect size of 0.265 (Table 2).

Table 2. Paired Sample t-test Results

				95% Confidence Interval Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig (2-tailed)
Farm Place Attachment	-4.42857	9.99311	1.09037	-6.59721	-2.25993	-4062	83	.000
Farm Place Meaning	-2.71429	10.22467	1.11560	-4.93318	.49540	-2.433	83	.017

Qualitative Results

The qualitative analysis revealed additional factors that may have contributed to changes in quantitative measures of students' sense of place. We also found that students' statement in focus group interviews aligned with some of the aspects of Berenstein and Szuster's (2019) conceptualization of pro-environmentalism. The findings of the qualitative analysis are organized into two main themes that addresses part of both research questions: *How, if at all, do*

students relate their sense of place to the activities in the PBEL courses? Given their experiences in the intervention courses, how, if at all, do students characterize pro-environmentalism and describe their role in contributing to sustainable futures? To do this, we will, first, explore how the students' backgrounds and pre-existing interests in the environment shaped how they interacted with the farm and the PBEL module activities. If so, how did student backgrounds and interests affect the development of place attachment and place meaning making? Second, we will examine how the PBEL modules inspired pro-environmental behaviors and intentions as evidenced by student desires to act locally in their personal and professional lives.

The Role of Students' Academic Interests and Backgrounds in Developing Sense of Place

Academic/Career Interests. Sense of place was, in part, developed in relation to students' academic/career goals and interests. The PBEL farm content and a student's developing sense of place were often related to their academic or career goals. A student majoring in marketing, for example, shared what they gained through interacting with the farm:

> I'm a marketing major. So, I just like to broaden my knowledge on a lot of different topics, because marketers need to know about a lot of different things if they're trying to market to different people.

For this student, the campus farm appears to have represented a way for them to gain insight into matters of sustainability that were likely to be important to the consumers for whom they would be creating marketing materials once they entered the workforce.

Many STEM majors highlighted the hands-on experiences on the farm. Several students described participating in scientific inquiry with the farm as the most meaningful part of the PBEL course. A biology/pre-med student, described a positive experience with their inquiry project at the farm:

> I enjoyed going out for lab... I enjoyed being able to actually see the research itself rather than be given a data set…[which is] less interesting than collecting your own data set of like these leaves fell at this time or these insects were found that we set in our traps. So, I enjoyed the practical aspect of [the inquiry project].

This student found enjoyment in their encounters with the farm precisely because these encounters provided them with the opportunity to practice their chosen discipline. The farm, then, was how this student was able to participate in their discipline in peripheral, yet legitimate, ways. This example demonstrates another way that a student's dependence upon a place can be influenced through that student's chosen discipline.

A few students also reported that the PBEL courses helped them clarify or find new areas of interest related to sustainability. A biology major, for example, shared that the PBEL activities with the farm helped them realize they were more interested in ecology. Another student shared, "I'm a political science and history major and after taking this I may want to change to environmental studies." Students frequently reported that learning about sustainability helped them see their academic interests in new ways.

Experiential Background. This subsection explores how a student's background may affect their sense of place relative to the campus farm. Here, we conceptualize a student's background as being constituted by their prior experiences, whether those experiences are relatively recent to or distant from their present (at the time of the focus group). Therefore, these "background" experiences could be from childhood, or such experiences could be from a more recent event at the university outside of the PBEL course.

Students with low interest in nature described negative experiences that shaped their engagement with the PBEL activities. A student majoring in biology, for example, expressed a

negative sentiment about farming based on an experience with gardening in their family: "we have a garden at my house at home and my mom always tried to get me to work in it and I hated it." Only three students indicated that adverse experiences in outdoor settings made them less inclined to feel attached to or engage with nature. Those with low interest/inexperience also shared a general apprehension about nature when completing PBEL activities that was consistent with a view of nature as delicate (e.g., "I don't want to mess up something on the farm"). It was often the case that students with low interest/experience in farming referred to the FRESH documentary and sensory walk assignment as the most impactful components of the PBEL courses, in part, because these activities reportedly helped to familiarize them with agricultural spaces.

By contrast, students who shared that they had experience with farming or an affinity for the environment favored the PBEL activities. In addition to academic gains, they often described feeling more connected to nature, experiencing less stress, or enjoying the aesthetic aspects of the farm through PBEL activities. The political science major who considered changing their major to environmental studies recounted how experiences with agricultural learning in high school helped them feel more connected to the kinds of practices happening on the campus farm:

> I think back to what I did in high school, like [Future Farmers of America] and 4-H. So, I have an [agriculture] background. So, when we finally got to the AG unit, I really got pumped up … we talk about these problems in class, and they seem so big and like how are we going to fix this? And then it comes back to there are ways that we can go about doing that, like with just starting small, like advocating, like how the [campus farm] does. So, I think just connecting … what we are doing to a real place is cool.

Similarly, a student who was considering a shift from biology to focus on conservation biology reported being an avid runner, who frequented the trails that run parallel to the campus farm: "I'm up running through there in the morning like every day, so I just love that area because I think it is really beautiful…especially in the morning." This student's experiential background as a runner brought her into daily contact with the campus farm, and through that interaction, she developed an aesthetic appreciation for the farm that reportedly, along with the PBEL activities, contributed to her desire to focus on conservation.

When asked about their attachment to the campus farm, another student implied that recent events – the student did not elaborate – had left them feeling a greater level of stress. They reported that in the past they had "felt so much better and calm" in their school environment. This student, who intended to pursue graduate studies in sustainability, described feeling less stressed while completing PBEL activities:

> … [the campus farm is] where I'm going right after this [focus group] … I just feel a lot more in control of my life, I guess, like less stressed from being there. Being there has gotten me to take this [academic] path and being in the environmental classes have taught me a lot about how [agriculture] affects the world.

Recent experiences contributing to heightened anxiety and stress may have affected how this student interacted with the farm and constructed their place-attachements and place-meanings. The campus farm PBEL activities, then, provided the student with opportunities to create new experiences at the campus farm, which, when interpreted through that student's experiential lens, were capable of creating a sense of "control" that was perceived to have been lost. This suggests that the emotional relief experienced by the student contributed to their attachment to the campus farm.

As the examples above demonstrate, students' backgrounds played a vital role in their experiences with the PBEL activities. Inexperienced students highlighted the content aspects (e.g., learning about agricultural practices) of the PBEL activities. In contrast, students with a lot of experience with or affinity for the environment emphasized connection to nature and emotional experiences (e.g., feeling "calm"). Therefore, as they experienced the PBEL activities, students' backgrounds contributed to 1) the kinds of meanings they ascribed to the campus farm (e.g., positive, negative) and 2) their feelings of attachment to the campus farm.

Students' Described Pro-Environmentalism as Enacted Locally and through Future Careers

Individual (Micro) and Local (Meso) Pro-Environmentalism. The overwhelming majority of students participating in PBEL activities expressed pro-environmental intentions related to individual and local actions. These intentions align with pro-environmentalist views of societal responses as micro- and meso-level change (Berenstein & Szuster, 2019). Many students reported that the PBEL activities provided new ideas for pro-environmental action or reinforced their prior commitments. Embedded within the talk of local and individual actions, students often described feeling limited in their ability to change systems. One student shared that in-class and farm activities "reinforced" their understanding of the kinds of actions they could take:

> You can make better choices, and the FRESH Documentary and, I think, going to the Farm kind of reinforced that. It was like, hey, there are a lot of bad things happening to our environment, and there are a lot of things that us as one person can't control. But there are these little tiny things that we can do, and they lead into bigger things that make an overall positive impact.

Some students also suggested learning how to grow their own food as a way they could contribute to change. Most students who made this suggestion had previous experience with agricultural work (e.g., family gardening, farm internship). A student who was also a former campus farm intern described a range of everyday practices individuals could take to make a significant difference. This student stressed that there are several simple options for making a difference, such as "having a rain barrel in [your] backyard" or initiating a "meatless Monday" in your home. The student added that a feasible though more labor-intensive option could be starting one's own farming operation or working at a local farm.

As part of the PBEL activities, some students interviewed local farmers. While very few students mentioned systems-level change, some drew on interviews with farmers to suggest using local and individual practices to challenge or create alternatives to the industrial agricultural system. One student shared: "It's like so much is possible. Even like a backyard garden or something so small that random people can do … fights against the industrial system." Another student characterized collective action among local farmers as another way to "fight" against the industrial agricultural system:

> [Local farmers] are working together to fight against industrial farming which, is really, really cool. The reason I think they do that winter farmer's market is that they are trying to create their own market for what they are selling [i.e., produce from local sustainable farming], which is definitely a big thing.

Aligned with the view of societal response as meso-level change, students commonly reported new commitments to shop at farmer's markets to contribute to sustainable food systems instead of the industrial food system. Students also reported that the PBEL courses helped them realize the extent to which industrial farming harmed the environment (i.e., view of technology as a

problem). One student argued that support for farmer markets should connect with broader systems of change, forming an "ecology" of agriculture, noting that "everybody has their niche … but if you don't interconnect the whole system, then it's not going to function properly and sustain it."

During these discussions about change efforts, students integrated their pro-environmentalist views with new place-meanings for local farms/farmers' markets. They characterized local farmers' markets as sites for sustainable action (i.e., view of societal response as local/meso-level change) requiring less technological intervention (i.e., view of technology as a problem). Students also emphasized individual actions (e.g., supporting farmer's markets) they could take in their everyday lives. Notably, economic and environmental pillars of sustainability were most salient in students' discussion of pro-environmental intentions. Only one student discussed a connection between local food systems and social equity (i.e., addressing food deserts).

Career as Environmental Response. This subsection is concerned with, first, how students reported wanting to perform pro-environmental actions in their professional training and in their careers and, second, how students often conceived of their pro-environmentalism in civic and ethical/moral terms. The purpose in doing so is to illustrate students' desires to act in pro-environmental ways moving forward and connect these goals to deeply held beliefs and values.

In addition to potential changes in academic majors (e.g., adding an ecological focus), some students reported that the PBEL activities helped them consider new career pathways and goals. For example, they expressed their desire to change/add majors and pursue campus farm internships and ecological summer research internships to explore sustainability-related career

options further. A biology major, for example, added a second major in environmental studies after developing a new awareness of sustainability issues:

> I changed my major, I added [environmental studies] this year as my second major. The environmental studies class kind of opened my eyes about policies and economic factors you have to consider when looking at all these issues, because before I was ... [interested in] the science about it, not really the application of it.

Other students reported that focusing on sustainable food systems was not directly relevant to their careers; however, they were able to consider diverse ways to continue environmental work through professional activities. An education student, for example, shared that the PBEL activities helped them consider the possibility of incorporating gardening into their future teaching practice:

> From my education degree, we visited a lot of the local schools, and a lot of the elementary schools have some type of garden that the students maintain. And that kind of got me thinking: I want to try to implement something like that wherever I teach, and then ideally have it be more like a farm stand that you can sell whatever it is you're growing. The [campus farm] kind of helped flush [sic] that out to see that this is a thing that you can actually do, it's not a dream or anything.

Here, the campus farm served as an exemplar case for this student to mimic as they imagined a future curriculum, which would provide environmental experiences to K-12 students related to the science of agriculture, and the study of business and finance.

Student attitudes toward entangling pro-environmentalism with their careers intersected with several concepts in focus group conversations. These related concepts included civic engagement and morality/ethics. When asked about the relationship between civic engagement

and careers, a pre-law student expressed that many professions are involved in environmental change at multiple scales:

> What it takes is like putting the community and the environment before your own needs. And, like other professions, anything you are going to do on a local or even a global scale is going to affect the environment. So, like honestly, I can't think of a single job that doesn't have some sort of root in being civically engaged and being aware of [environmental] problems not only locally but statewide and countrywide.

This quote began with an appeal to the moral value of selflessness in one's life within both the environment and society. Along with this selflessness was the expressed need for awareness of the impact of one's professional activity on the environment and society and the ethical problems that may arise therefrom.

Several students took this a step further and described how a moral obligation to the environment could be fulfilled through their future careers. When asked how interaction with the farm impacted them personally and professionally, students often expressed that all people are responsible for contributing to sustainability. For instance, a pre-med student shared that contributing to sustainable futures was implicated in everyday life as a citizen:

> I think just being involved is the first step in making a difference. Like most people in their careers ...want to be doing something for the greater good or ...just being a knowledgeable citizen, like staying informed with the news or participating in your local community.

Throughout the focus group interviews, students mentioned specific PBEL activities (e.g., work on the farm, FRESH the Film) as sources of new ideas for pro-environmental actions. As one student shared, "no matter what your situation is you can always be doing something to be

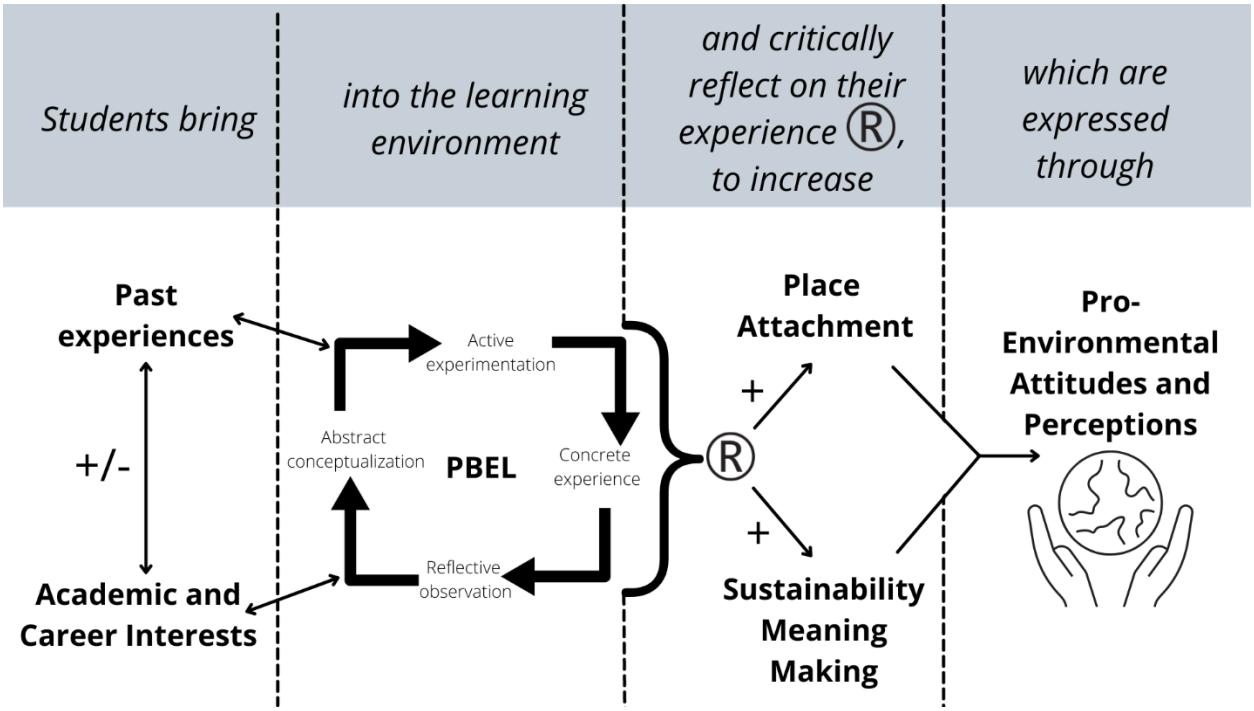
helpful." The students shared concern for contributing to the "greater good" and described learning new ways to do so in the PBEL courses. Based on students' responses in the focus group interviews, we contend that the PBEL intervention introduced students to new ways of enacting pro-environmentalism while simultaneously supporting them to develop new place-meanings and attachments (i.e., enhanced sense of place) related to the campus and local sustainable farms.

Discussion

This study aimed to examine the outcomes of a sustainability-themed PBEL intervention in biological science and environmental studies courses. Specifically, we sought to learn how the intervention with the campus farm could cultivate students' sense of place and pro-environmental intentions and behaviors.

Below, we address the research questions by (1) demonstrating how aspects of students' PBEL experiences, background, and interest intermingle and, thereby, contribute to the constitution of place-meaning and place attachment in students and (2) exploring how these developments in place meaning and attachment contribute to pro-environmental thought, intentions, and practices (Figure 1).

Figure 1. Summary of Findings



We found quantitative and qualitative differences in how students' sense of place developed in PBEL courses. Notably, we found statistically significant increases for both place-attachment and place-meaning. Findings from the focus groups illuminated how students' academic interests and backgrounds played an essential role in their experiences in the PBEL, the ecological meanings they ascribed to places, and whether they felt a sense of attachment to the campus farm. These results are consistent with previous research demonstrating that sustainability-themed educational interventions are associated with differences in students' sense of place and the ecological meanings they ascribe to a place (Scannell & Gifford, 2010; Semken & Freeman, 2008; Stedman, 2002).

The qualitative results indicated that students' characteristics (i.e., experiences, academic interests) shaped how they interacted with the PBEL modules and their sense of place. For example, some students with an affinity for nature emphasized farm activities and their place-

meanings centered on an emotional connection to nature. In comparison, students with less experience or negative experiences foregrounded the in-class components of the PBEL intervention (e.g., FRESH the Film). The results of this study underscore the importance of universal design to support students to engage with multiple representations of sustainability content and multiple ways to demonstrate learning (Ferreira, 2017; Sims et al., 2020). Future research should examine how the various modalities of sustainability educational interventions differentially impact students' place attachment, place meaning, or overall sense of place.

Despite research that indicates the importance of cross-curricular sustainability education, recent studies show that college students often have few opportunities to engage with sustainability content in higher education (Garibay et al., 2016; Michel, 2020). Moreover, the literature offers few examples of effectively incorporating sustainability content into the undergraduate formal and informal curriculum (Burns, 2011). Findings from the focus groups demonstrate that the sustainability theme appealed to students with varying interests, majors, and experiences with farming or gardening practices. We contend that sustainability as a theme for the PBEL intervention offered an accessible entry point for students to develop their sense of place and understanding of sustainability.

Consistent with previous studies of sustainability education (Change et al., 2016; Fisher & McAdams, 2015), however, we also found that students primarily discussed the ecological and economic pillars of sustainability, with only minimal consideration of social equity. This finding aligns with literature showing that faculty in science, technology, and engineering programs often underemphasize the social equity pillar of sustainability (Ferreira, 2017; Garibay et al., 2016). In this study, only one faculty member implementing PBEL activities had substantive expertise in sustainability. Two students in their course briefly mentioned social inequities

concerning sustainability (e.g., food desert). These discussions, however, were cursory compared to students' extensive consideration of environmental health impacts and entrepreneurial solutions to sustainability. To be sure, students' implicitly neoliberal uptake of sustainability is part of the normalized discourse in higher education (Cachelin et al., 2015; Ferreira, 2017).

Nevertheless, while we found measurable differences in students' sense of place across courses, students' minimal articulation of a more holistic understanding of sustainability points to a potential area of improvement for the PBEL intervention. This finding also warrants further inquiry into strategies to support faculty to implement a sustainability-themed curriculum effectively. For example, Holdsworth and Thomas' (2016) Sustainability Education Academic Development (SEAD) framework, one of the few sustainability-focused professional development frameworks for higher education faculty, could support instructors in designing their courses to address each pillar of sustainability. This approach to faculty development as part of a farm-situated PBEL course could help faculty promote a holistic understanding of sustainability. This holistic understanding is necessary precisely because the kind of sustainability-making done by students undergirds their pro-environmentalism.

Focus group interviews illuminated similarities and differences in how students expressed pro-environmentalism in terms of their views of nature, technology, and societal response (Berenstein and Szuster, 2019) Overall, students were mixed in their views of nature – some oriented to the environment as a moral obligation, whereas others viewed nature as delicate. Similarly, students varied in whether they viewed technology as a problem or solution to socio-ecological problems. However, students' pro-environmentalism cohered in their views of societal response. Notably, we found that students primarily characterized their pro-environmentalism as individual (micro) and local (meso) actions. Consistent with previous studies of willingness to

adopt pro-environmental behaviors (Félonneau & Causse, 2017; Tasquier & Pongiglione, 2017), students most often expressed commitments to behaviors with immediate impact (e.g., shopping at farmers' markets). Few students discussed systems-level change, and those who did reported that they felt limited in their ability to contribute to broad-scale efforts.

In addition to focusing on individual and local levels of actions, students generally characterized their careers and professional activities as environmental responses. Students discussed plans for incorporating pro-environmentalism into their careers in multiple ways. Examples include adding ecological focus to their academic programs to support new career pathways, embedding environmental activities within their professional practices, and various forms of civic participation. Students reported that they gained new perspectives, ideas, and practices for enacting pro-environmentalism from multiple components of the PBEL intervention. These findings align with studies that demonstrate that place-based interventions can support learners' efficacy for participating in socio-ecological change (Burns, 2011; Kudryanvstev et al., 2012). Further, these findings contribute new insights into how students' career-related goals – in addition to sense of place and pro-environmentalism – may shape how they envision their contributions to socio-ecological change.

The mixed-methods approach taken for this study put measurable changes in students' sense of place in conversations with their experiences in the PBEL intervention courses and their distinctive expressions of pro-environmentalism. Though some scholars agree that sense of place and pro-environmentalism are related, these concepts are typically studied separately using either quantitative or qualitative research approaches. The empirical literature also consistently points to difficulties with quantitatively assessing pro-environmentalism due to variation in how individuals view nature, technology, and societal response (Berenstein & Szuster, 2019).

Juxtaposed with the statistically significant changes in students' sense of place, the qualitative analysis illuminated how variation in how students oriented to a site and conceived of pro-environmentalism impacted how they engaged with the PBEL activities and what they gained from the course. As shown in this study, a mixed-methods approach can help produce a nuanced view of college students' sense of place, pro-environmentalism, and understanding of their role in contributing to socio-ecological change.

To contribute to broader efforts to create sustainable futures, college-level educators and science departments should provide more opportunities for students to learn about sustainability within their core curricula. Sustainability-themed PBEL offers one strategy for moving beyond solely focusing on technical skills to support students in developing the knowledge and skills needed to address socio-ecological challenges (Garibay et al., 2016; Tytler, 2012). As demonstrated in this study, incorporating sustainability content into required coursework can support college students to relate sustainability to their disciplinary and career interests in meaningful ways. Michel (2020) argued that to leverage higher education to address socio-ecological challenges, colleges and universities need to support deep learning about sustainability through repeated exposure, a reiteration of ideas, and application of principles throughout the entirety of the undergraduate curriculum. Such efforts hinge upon institutional resources and support for faculty and departments to coordinate cross-disciplinary collaborations and establish sustainability-mindedness as a central learning outcome of higher education in all majors.

Limitations

We want to highlight a few study limitations. First, the study took place at a small, private liberal arts college. The findings of this study may not be transferable to institutions

where faculty have more restrictions on course content and delivery because they have to accommodate large course sizes and complex schedules. Second, the intervention involved courses for two disciplines relevant to sustainability. Student outcomes may differ in other STEM and non-STEM courses where connections to sustainability are not readily apparent. Third, we found that focus group participants unanimously supported pro-environmental action, which does not align the heterogeneity of views in society more broadly (Sapiaains et al., 2016). Thus, our participants could have been more aligned with pro-environmentalism than the general population, or our methods were limited in eliciting dissenting views (or both). Finally, a methodological limitation was that we did not use course observations due to the limited availability of observers. Insights into the implemented PBEL activities may have provided a more nuanced perspective on how students' place-meaning, place-attachment, and expressions of pro-environmentalism developed throughout the semester.

Conclusion and Implications

Grenni and colleagues (2020) argued that place-based learning facilitates a complex, transformative process that changes how individuals see themselves, others, and their relationship to nature. Incorporating place-based sustainability content into undergraduate courses is an effective strategy for preparing students to participate in local, national, and global efforts to address socio-ecological crises (Garibay et al., 2016; Michel, 2020). The impetus of this study was the need to strengthen the evidence base for college-level sustainability-focused curricular interventions to support students in developing the knowledge, perspectives, and behaviors needed to achieve a sustainable future. The results of this study support existing research about meaningful relationship between students' sense of place and pro-environmentalism. Additionally, the study results contribute new insights into how college

students' career-related interests shape how they envision their own contributions to socio-ecological change. The study has important implications for designing and implementing sustainability-themed interventions with campus farms or similar sites.

Scholars have drawn attention to the dearth of empirical examples of how to incorporate sustainability education into higher education curriculum (Burns, 2011). The current study offers one example, though more research is needed on college-level sustainability-themed PBEL in varying institutional contexts and places. The study results indicate a need to support faculty in designing and successfully incorporating sustainability content and PBEL into their courses. Though biology and environmental studies faculty may already be familiar with environmental issues, they may be less familiar with sustainability's economic and social equity pillars and have difficulty connecting them to course content. Structured support for faculty can help them effectively implement PBEL activities in ways that foster sense of place and simultaneously develop both a holistic understanding of sustainability and an affinity for pro-environmental thought and action.

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