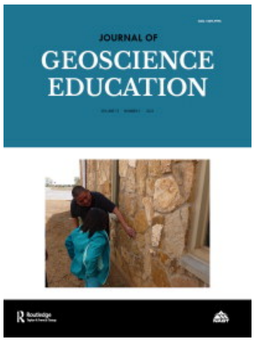


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# Impact of a place-based educational approach on student and community members' experiences and learning within a post-secondary GIS course

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**ABSTRACT**

Students develop personal connections to local places and build critical thinking skills as they engage in meaningful problem-solving rooted in place. At the same time, when students work within local communities, they can contribute to increased community technical capacity and well-being. In this case study, we sought to explore student and community perceptions of a place-based activity integrated within a college-level GIS course in Maine, USA. We partnered with a local conservation organization to develop place-based activities to address our partner's geospatial needs. We drew on multiple data generation methods including pre-/post-test student responses within a quasi-experimental design, student reflections, and a group interview with community partners to illuminate the diverse benefits and challenges of place-based education (PBE). Our findings indicate that while quantitative results did not detect differences between the place-based, technologically-mediated place-based, and campus-based approaches, qualitative results – such as student reflections and community partner perceptions – depicted complex reciprocal gains resulting from education rooted in local community. Community partners benefit from PBE by increasing their GIS capacity and engaging on a personal level with students. We conclude with implications for GIS instructors seeking to incorporate place-based approaches within their college-level courses, such as the need to engage community partners thoughtfully and transparently, think critically about measurement and assessment of learning outcomes, and remain flexible to student needs.

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## Introduction

As society faces increasingly complex large-scale environmental challenges, Geographic information systems (GIS) training is critical for educating the next generation of problem-solvers and spatial thinkers (Bearman et al., 2016; Blickley et al., 2013; Sinton, 2009). The geospatial technology industry is experiencing rapid growth and requires that students are trained in technical, communication, and problem-solving skills (Mathews & Wikle, 2019). As a result, there is a growing need to understand pedagogical approaches that incorporate technical development of GIS skills alongside opportunities for more critical thinking (Bearman et al., 2016). GIS educators are using interdisciplinary approaches to build these diverse skill sets (Bearman et al., 2016); for instance, *via* real-world examples in the classroom that give students the opportunity to learn GIS software *and* apply that knowledge to solve problems (Lloyd, 2001).

A place-based teaching approach enables students to work on personally meaningful issues of local interest grounded in place (Hougham et al., 2015; Perkins et al., 2010; Semken et al., 2017) by bringing together multiple forms of knowledge to foster intense study of a local issue (Bartsch, 2007; Ignatius & Flood, 2021). Place-based education (PBE) empowers students to tackle complex environmental challenges by bridging theory and practice. Engaging in real-world problem-solving scenarios fosters critical thinking, creativity, and the application of knowledge (Sobel, 2004). Gruenewald and Smith (2008) define PBE as a community-based effort to reconnect education and human development to the well-being of community life by drawing on local phenomena as a source of student learning. Distinct advantages of PBE include: (1) connecting learning to students' lived experiences, (2) fostering a sense of place, (3) building social capital, (4) developing a civic responsibility through authentic partnerships, and (5) accounting for expanded ease of knowing (Demarest, 2015). Within the context of geoscience education, place-based learning is particularly relevant for engaging students in authentic

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experiences in place, while supporting both environmental and cultural awareness of local place (Semken et al., 2017). Geoscience, and environmental science more broadly, is highly dependent on place, and a PBE curriculum allows students to understand local environments when given the opportunity to develop a sense of place (Monet & Greene, 2012). We draw on the theory of place as described by Semken et al. (2017), where place is any locality imbued with meaning *via* human experience (Tuan, 1977).

## Literature review

Within a university, students' experiences can shape (and are shaped by) place (Sun & Maliki, 2015). Previous research highlights the importance of developing a sense of place for undergraduate student success (Holton, 2015). Sense of place includes the combination of place attachments—or bonds between people and places (Low & Altman, 1992, Scannell & Gifford, 2010)—and place meanings—the ways individuals understand place (Semken & Freeman, 2008; Young, 1999). Place attachment consists of place identity and place dependence, where place identity refers to an emotional attachment that helps individuals understand themselves (Proshansky et al., 1983; Stedman, 2002), and place dependence is a functional attachment related to the place providing necessary amenities (Williams et al., 1995). Place attachment and place meanings are associated with pro-environmental behaviors (Scannell & Gifford, 2010), student engagement (Semken & Freeman, 2008), and connection to nature (Basu et al., 2020). Researchers extensively study sense of place within educational contexts, finding support for PBE in increasing place attachment and place meanings (Semken & Freeman, 2008) using quantitative (Lee & Chiang, 2016) and qualitative methods (Russ et al., 2015; Williams & Semken, 2011). Place-based education has also been linked with student self-efficacy (Bright, 2020), or an individual's perception of their skill and ability to complete a task (Bandura, 1977).

In addition to student learning and sense of place outcomes, education that is rooted in place also brings classrooms and communities together where students can contribute to community well-being and resilience—or the ability to respond to change (Krasny & Roth, 2010; Tidball & Krasny, 2011). As a result, students can become agents of change (Bartsch, 2007), while developing a sense of belonging and social responsibility (Chawla, 2015). Place-based school and community partnerships support the long-term sustainability of communities (Zuckerman, 2019) by increasing social capital (Krasny et al., 2015)—or the connections among people and organizations (Emery & Flora, 2006). We have chosen to situate our discussion of social capital through a community development lens (Flora, 1998) given its focus on social relationships, well-being of communities in place, and application within environmental change research (Carmen et al., 2022).

Within conservation, GIS is an important tool (Speaker et al., 2022); however, due to the lack of funding or trained personnel there is often a limited capacity for GIS (Rissman et al., 2019). Therefore, the possibilities for community-university partnerships (Bieluch et al., 2021) for addressing GIS needs are of importance. Social capital literature identifies how involvement and participation in groups can have positive consequences for individuals and communities *via* bonding, bridging, and linking social capital (Aldrich & Meyer, 2015). Bonding social capital describes the ties among individuals that lead to community cohesion. Bridging is the ties connecting social groups, and linking is the connections between people and those in power (Emery & Flora, 2006). When there are opportunities for youth—defined by the United Nations as individuals under the age of 24—and adults to work together, social capital can increase and spiral up as youth see themselves as part of the community (Emery & Flora, 2006). Therefore, collaborative efforts between college students and community groups often result in innovative and sustainable solutions to local environmental challenges (Chen et al., 2015; Massaro et al., 2021; Zuckerman, 2019).

The concepts of PBE, intergenerational learning (Ballantyne et al., 1998), and service-learning (Molnar et al., 2010) are all tightly linked and embedded within community-university partnerships that allow students to participate in community activities (Keen & Baldwin, 2004; Galante, 2019). PBE is particularly poised to foster social connectivity, trust, civic engagement, and intergenerational learning (Mannion & Adey, 2011; Shiel et al., 2016). Compared to studies that assess student outcomes of PBE, relatively fewer studies explore the impacts of PBE on community members (Gerstanblatt & Gilbert, 2014). More specifically, within GIS university courses, the literature on both student and community perceptions of PBE approaches is scant, despite a recent emergence of youth voices on community-engaged GIS projects (e.g., Solís & Zeballos, 2023).

The purpose of this case study was to explore student and community perceptions of a place-based activity integrated within a college-level GIS course. We partnered with a local conservation organization to co-develop activities to address their GIS needs while allowing students the flexibility to bring personal meaning to their projects, an approach suggested by previous scholars like Roth and Lee's (2004) service learning work with middle school students and Norton et al. (2019) work with mobile field data collection on a local stream. We collaboratively identified multiple GIS needs with the local conservation organization. Using a case study approach, we triangulated across several data collection and generation methods to understand perceptions of PBE outcomes for students and community members. Our research addressed the following key questions: (1) Does a two-week place-based project lead to a higher sense of place and self-efficacy among college GIS students as compared to a traditional or technologically-mediated place-based approach?, (2) How do students experience local place as they engage in a GIS place-based activity?, and (3) How do members of the partner community conservation organization perceive benefits and challenges of collaborating with a local university to meet conservation needs?

## Methodology

We adopted a single instrumental case study methodology (Yin, 2018) to understand how, if at all, a two-week place-based activity within a college-level GIS course impacted students and local community partners (Figure 1). A case study design was particularly useful for this research because it allowed for an in-depth understanding of participants' experiences, perceptions, and behaviors within their socio-ecological contexts (Yin, 2018). We used a concurrent mixed methods approach (Creswell & Clark, 2017) to gain an in-depth understanding of student and community perceptions, experiences, and outcomes. Multiple data generation methods, including qualitative and quantitative, from several sources enabled us to better understand the various 'lenses' through which multiple facets of the activity could be revealed (Yin, 2018).

We adopted a pragmatic paradigm (Greene et al., 2003), and therefore engaged multiple perspectives and ways of knowing to develop a broader, deeper understanding of experiences. We adopt the approach of crystallization as a way to describe triangulation that better reflects multiple realities. Crystallization makes use of multiple data generation methods, participants, and theories that allow different facets of the problem to be explored (Tracy, 2010), and hence provide a richer and more complete understanding of an issue. We draw on the theoretical contributions of phenomenology—or a philosophical approach to studying human experience—to make sense of student and community members ways of making meaning (Moustakas, 1994). Thus, we offer our findings as an interpretation of individuals' experiences and acknowledge our positionality within the work.

The first author (Soucy) instructed one of the course lab sections, while the second author (Rahimzadeh-Bajgiran) was a lead instructor for the lectures and instructed one of the lab sections. Both Soucy and Rahimzadeh-Bajgiran collected student and partner data, while Soucy analyzed student reflections and the group interview data and engaged in peer debriefing with Rahimzadeh-Bajgiran and De Urioste-Stone. Soucy is a white female social scientist who holds personal and professional interests in environmental education, intergenerational learning, and stewardship shaped by her mixed methods research as well as experiences as an environmental educator. Soucy seeks practical and useful approaches that solve concrete problems *via* a pragmatic approach to inquiry. Rahimzadeh-Bajgiran is geospatial scientist and the lead instructor of the GIS course in which the study was formulated and has interest in place-based education. Rahimzadeh-Bajgiran's research is at the intersection of social and biophysical sciences in the field of environment and natural resources.

### *Study site*

We conducted this case study at a medium-sized land grant university located in a town in Maine, USA. Conservation planning in Maine integrates spatial data into prioritization and acquisition decisions (Walker & Ryan, 2008). However, previous work in the region identified limited personnel and funding capacities, especially in rural communities, which

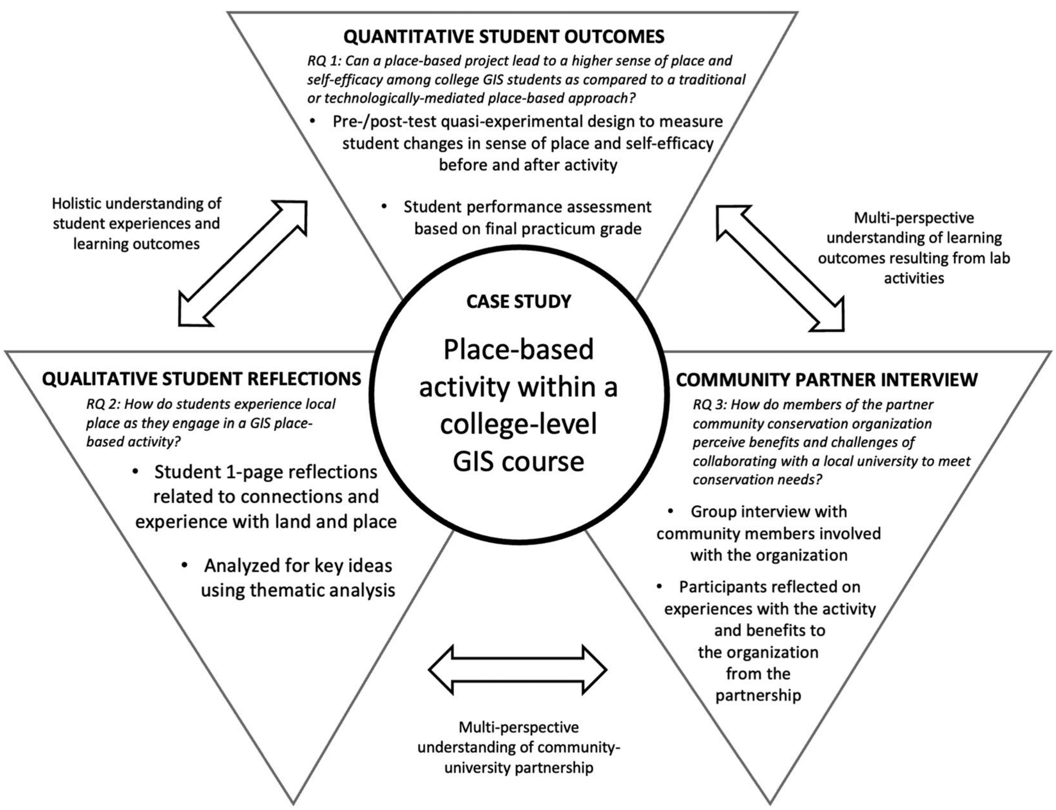


**Figure 1.** Case study methodology involving multiple methods and their associated research question (RQ) and triangulation across data generation methods and participant types.

hinder the use of technologies such as GIS for conservation (Rissman et al., 2019; Soucy et al., 2023). At the same time, a combination of youth out-migration and lack of in-migration led to a population decline in Maine, which has resulted in growing concerns for the future of Maine's natural resource-dependent communities and industries (Bernsen, 2020). Therefore, we advance previous work that has sought to address the aging population and complex challenges rural communities face in Maine by connecting students with community needs (Bartsch, 2007). This study was approved by the Institutional Review Board (IRB) for research on human subjects.

## Course design

The GIS course under study is a mixed undergraduate and graduate-level course offered each year. During the Spring of 2023, 73 students (8 graduate students, 65 undergraduate students) enrolled in the course. The course consists of two 90-minute lectures each week, and one two-hour lab. The lectures are conducted with all 73 students, while the labs feature smaller class sizes (~23 students), such that three lab instructors teach one lab section each. Two graduate student teaching assistants share lab duties and assist students across all lab sections. In the lab, the students apply the skills they learned during lecture to practice creating map products and models while answering spatial questions. The course is designed for environmental science and forestry students with minimal GIS experience, and covers topics ranging from coordinate systems, map design, working with tables, queries, model builder, GPS data collection, and spatial analysis.

While students benefit from field trips that expose them to local environments and allow 'real-world' experiences; obstacles, such as the COVID-19 pandemic (Lowenthal et al., 2020), resource strains (e.g., limited funding for transportation or personnel), and large undergraduate courses (Leydon & Turner, 2013) all create logistical challenges that can limit the possibility of in-person field trips. In a post-COVID-19 world, a combination of in-person and technologically-mediated field experiences may be necessary (Cho & Clary, 2020; Whitmeyer & Dordevic, 2021); therefore; one lab section engaged with the community organization and site *via* a technologically-mediated approach. The technology-mediated approach provided a means for students to see and experience *via* a short video (Mead et al., 2019).

Beginning in the Fall of 2022, we contacted a local conservation group to initiate a partnership with the goal of integrating course learning goals and local GIS needs. After several meetings with members of the local conservation organization (referred to as community partners), we jointly identified two student tasks to meet organizational needs: (1) developing a georeferenced trail map for one of the organization's local preserves, and (2) acquiring geospatial data and creating a model for prioritizing conservation efforts. We developed two lab activities to address these two projects over the course of two weeks. Students participated in the lab in one of three lab sections; therefore, we adopted a quasi-experimental design to understand changes in student learning outcomes across a place-based, technologically-mediated place-based, and control (hereafter, 'campus-based') group (Figure 2). Students did not know which treatment group they would be assigned when they enrolled in the course.

In Lab Activity #1, the students in the place-based group collected GPS data at the conservation organization preserve using the Avenza app (Merry & Bettinger, 2019)—a free app for marking locations, measuring distances, and recording GPS tracks—and used these data to work in groups to create a georeferenced trail map to be presented to members of the local conservation organization. Students in both the campus-based group and technologically-mediated groups used the Avenza app to collect GPS points on campus for Lab Activity #1. This lab activity was not connected to the local organization, rather, the campus-based group and technologically-mediated students created a mini-map of campus based on their GPS collection for Lab Activity #1.

In Lab Activity #2, both the place-based group and technologically-mediated groups searched for and used local GIS data to create a conservation priority model and map for the conservation organization. The technologically-mediated group began by watching a 5-min video on a projected screen that detailed the group's mission and showcased imagery and video from the local preserve (following best practices from Wang et al., 2022). Students were then allowed to ask questions about the organization to instructors. Students in the place-based

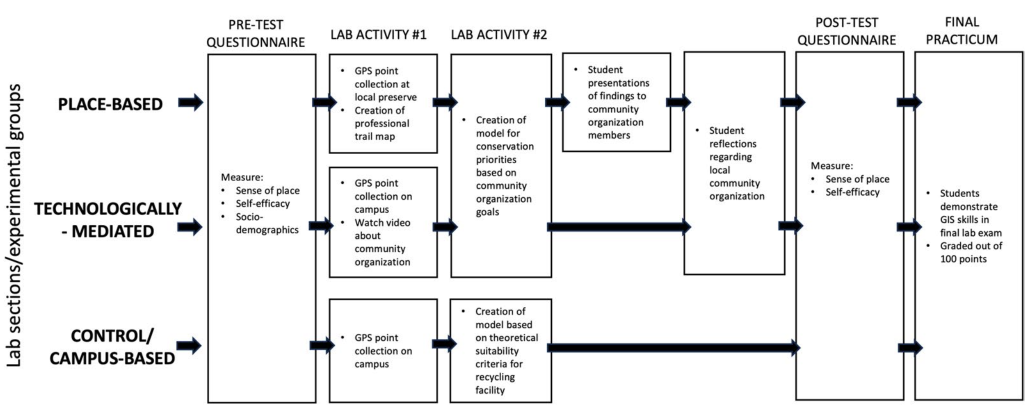


**Figure 2.** Overview of the PBE activity within the three GIS lab sections, including the quasi-experimental design and student reflections.

group presented their finished maps and models within small groups over the course of ~90 min to community partners one week after Lab Activity #2. Students in the technologically-mediated group did not present their findings to community partners. Students in the campus-based group created a model for site selection for a recycling facility not grounded in local mapping needs for Lab Activity #2, and did not interact with the community partners in any way.

### Description of student population

Out of 73 students enrolled in the course, 71 completed the pretest and 70 completed the post-test questionnaires. Students were, on average, 22.7 years old (SD = 7.48), with an age range of 19 to 68 years, with six students over the age of 30. Twenty-two students identified as female, 45 as male, and 4 as non-binary or other. Students resided in the town where the campus is located and the place of interest for sense of place in this study, for an average of 2.6 years (SD = 3.1) with residency ranging from 0 to 20 years. Students were primarily juniors (48%), followed by sophomores (25%), seniors (15%), and graduate students (11%). Fifty-five percent (55%) of students indicated that they had 'no experience with GIS prior to the course', while 43% indicated they had 'some GIS experience', and 1% self-reported 'a lot of GIS experience.' Students identified as White (67), and/or Hispanic/Latinx (2), Black (1), Asian/Pacific Islander (2), native (1), and Middle Eastern (1). Thirty-six percent (36%) of students indicated that they enrolled in the course to fulfill degree requirements, while 64% enrolled in the course for at least one other reason (e.g., personal interest, project needs, and/or building career skills). There were no significant differences between lab sections in students majors ($\chi^2$ = 11.51, $p = 0.32$, Cramer's $V = 0.28$), residency ($\chi^2$ = 3.02, $p = 0.55$, Cramer's $V = 0.15$), gender ($\chi^2$ = 8.49, $p = 0.39$, Cramer's $V = 0.25$), or prior GIS experiences ($\chi^2$ = 5.59, $p = 0.23$, Cramer's $V = 0.19$). However, differences existed in the grade composition of the lab sections, such that the PBE section had more sophomores, and the technologically-mediated section had more graduate students ($\chi^2$ = 28.72, $p < 0.001$, Cramer's $V = 0.45$) (See Supplemental Table 1). Graduate students were encouraged to enroll in a specific section to aid in instruction for the course in general; therefore, it is important to note this assignment of graduate students may be a confounding variable.

## Methods

### Student outcomes: Pre-/post-test questionnaire

We used a pre-/post-test nonequivalent quasi-experimental design (Cook et al., 1979) to understand differences in self-efficacy and sense of place between lab sections over the course of the activities. Students completed the pretest and post-test questionnaires one week prior to and following the lab exercises studied, respectively. The questionnaire consisted of mostly Likert-scale items to measure students' self-efficacy, sense of place, and socio-demographics (i.e., age, gender, residency, grade, GIS experience) (Puttick et al., 2022) (see Supplemental Table 2). We formulated learning objectives to measure self-efficacy (Bandura, 2006) specific to the exercises, based on cognitive, affective, and behavioral dimensions of student learning (Stedman, 2002). We designed a unique instrument to reflect the specific learning context (Bandura, 2006) totaling 18 statements to understand students' perceptions. These self-efficacy items addressed various skills (e.g., "I can collect GPS points," and "I can make a positive contribution to the community"). Students rated each of the statements on a scale of 0-100 (Pajares et al., 2001). Researchers have used the 0-100 scale over a Likert scale assessment to measure self-efficacy given its increased predictive power (Kan, 2009; Pajares et al., 2001), and increased sensitivity for detecting self-efficacy beliefs (Bandura, 1977). Additionally, we aimed to assess self-efficacy at an appropriate level of specificity by linking the items to specific student outcomes (Pajares et al., 2001). Given the unique nature of the items in the self-efficacy construct, we conducted an exploratory factor analysis using a maximum likelihood extraction to determine the possible dimensions of self-efficacy ($\alpha$ = 0.92) (Tabachnik et al., 2019). The Kaiser-Mayer-Olkin (KMO) index was 0.86, and Bartlett's Test of Sphericity reached statistical significance ($\chi^2$ =851.87, $p < 0.001$), indicating that our data were suitable for factor analysis. Results from the pretest data indicated that all self-efficacy skills loaded (i.e., had a component loading greater than 0.50) onto one of four factors, which we defined as (1) analytical skills ($\alpha$ = 0.91), consisting of 7 items related to creating maps, finding appropriate data, and solving GIS challenges, (2) problem solving skills ($\alpha$ = 0.88), consisting of 5 items related to finding and analyzing geospatial information, (3) technical GPS skills ($\alpha$ = 0.92), consisting of 2 items related to collecting and digitizing GPS data, and (4) community skills ($\alpha$ = 0.72), consisting of 4 items related to making a difference (Supplemental Table 3). We then created mean scores for the various dimensions of self-efficacy, where higher values indicate a higher perception of self-efficacy.

We measured students' place attachment and place meanings using Williams and Vaske (2003) place attachment instrument which consists of 12 items on a five-point Likert scale. We created mean scores for place attachment for further analysis, such that higher scores indicate a higher place attachment (pretest $\alpha$ = 0.90; post-test $\alpha$ = 0.89). All place attachment items loaded onto one component based on an exploratory principal components analysis; therefore, we considered place attachment as one construct. We measured place meanings using 31 items adapted from Young (1999) and Semken and Freeman (2008) to understand the diversity of meanings students associate with the town where the university is located (e.g., remote, beautiful, scientifically valuable, historical, etc.). We reverse-coded the following items: overdeveloped, threatened, crowded, small, boring, and dangerous, as they indicate negative place meanings (Semken & Freeman, 2008). We summed the 31 place meaning scores for all items such that a lower score indicates that the town holds minimal and/or negative meaning for the student, and a higher score indicates rich, positive, diverse meanings (Semken & Freeman, 2008) (pretest $\alpha$ = 0.87; post-test $\alpha$ = 0.88). We administered the questionnaire to all lab sections using Qualtrics, and conducted all analyses using SPSS 25.0 (IBM Corp., Armonk, NY). We assessed the internal consistency of all constructs using Cronbach's α scores (Cronbach, 1951; Vaske et al., 2017).

We assessed the distribution of all variables, and winsorized outliers using Tukey's (1997) box plot method (Vaske, 2019). To address our first research questions, we used paired t-tests to examine the relationships between pretest and post-test measures and then conducted a one-way ANCOVA to determine whether there was a statistically significant difference in post-test place attachment, place meanings, and self-efficacy between the lab sections when controlling for the pretest scores and covariates (Seltman, 2018). We determined the relevant covariates based on theoretical predictors from the literature and correlations between variables (Tabachnick et al., 2019; see Supplemental Table 4).

### Student outcomes: Reflections

We triangulated the quantitative results from student pre/post-test questionnaires with qualitative reflections of students' experiences and learning (Ash & Clayton, 2009) to address our second research question. Following the second activity, we asked students in the place-based and technologically-mediated groups to write a 1-page reflection on their experiences with the local community organization. Students in the campus-based group did not complete a reflection because they did not learn about the local community organization partner. The prompt read: "Please reflect on your experiences with [community organization] (e.g., have you visited one of their preserves for a hike prior to lab, etc.). Describe these experiences - what did you enjoy? Why do you visit [these areas]? And in a couple of sentences share how GIS may be useful for [the community organization]." Soucy analyzed the reflections using qualitative thematic analysis (Braun & Clarke, 2006), with a phenomenological lens (Smith et al., 2021). She assigned initial codes to meaningful units of data, with a focus on students' connections to place and skill development, and then further organized the codes into categories and higher-order themes (Braun & Clarke, 2006; Miles et al., 2014). We use identification codes (e.g., 09-P) for students to preserve anonymity. The letter after the number corresponds to the students' lab section, where P stands for place-based and T stands for technologically-mediated.

Strategies for addressing dimensions of trustworthiness specific to a phenomenological lens included prolonged engagement, reflexivity, use of thick description, triangulation, and peer debriefing (Nowell et al., 2017; Tracy, 2010). Here we acknowledge the dynamic nature of qualitative interpretation as the researcher attempts to make sense of the participants' experiences (Smith et al., 2021). Throughout the multiple rounds of coding, Soucy engaged in peer debriefing (Bogdan & Biklen, 1997) with De Urioste-Stone and Rahimzadeh-Bajgiran. A focus on understanding and analyzing each individual reflection before moving on to the next reflection (Smith et al., 2021) ensured we captured the diverse perspectives and experiences among the students (Gibbs, 2018). A phenomenological approach emphasizes the exploration of subjective experiences and meanings from the perspective of the participants, which involves employing a single coder who engages in reflexivity (i.e., reflective journaling and acknowledgement of positionality), and in-depth engagement with the data (Smith et al., 2021). The decision to use a single coder and forego interrater reliability aligns with the epistemological stance of phenomenology. As the single coder, Soucy practiced reflexivity by keeping a reflective journal and constantly being cognizant of her role in data generation and interpretation (Bogdan & Biklen, 1997). Interpretations were informed by direct quotes from the reflections to support key findings and enhance the trustworthiness of the analysis. Through this process, we uncovered commonalities, divergences, and significant insights regarding students' sense of place and connections with the community organization.

### Community partner group interview

We (specifically, Soucy and Rahimzadeh-Bajgiran) conducted one group interview to explore community partner perceptions (Parker & Tritter, 2006; Wilkinson, 1998). Approximately three weeks following the student presentations, we met with four of the community organization members involved with the conceptualization of the PBE activities and student presentations. Over the course of the project, we engaged with nine (three identified as women and six as men) different community partners from the organization. We built rapport and increased trustworthiness with community participants as we engaged in multiple interactions prior to the GIS course as well as throughout the semester-long class (Tracy, 2010). All interview participants were volunteers who held various positions of power, were white, and two identified as men and two identified as women. Some held various other volunteer and/or board member positions with other local environmental groups, and several held deep connections to the university as alumni—two of whom attended the group interview. The group interview lasted 55 min and occurred *via* Zoom. The purpose of the group interview was to stimulate discussion and understand the meanings, experiences, and perceptions of the place-based activity of the participants (Bloor et al., 2001). We emphasized the importance of understanding participants' experiences and context and allowed participants to reflect on those experiences (Seidman, 2006), while recognizing the potential roles of power and norms within a group interview setting (Sim & Waterfield, 2019). We adopted a semi-structured approach, which allowed participants to shape the discussion and the interviewers to pose follow-up questions (Kvale, 2011). Interview questions focused on the benefits and challenges of the project, potential improvements for future collaborations, organizational changes because of the activity, and student learning (Supplemental Table 5). We recorded and transcribed the group interview verbatim (Bloor et al., 2001).

Soucy inductively analyzed the group interview data (Braun & Clarke, 2006), using categorization and coding to understand the nature of participants' experiences and perspectives (Miles et al., 2014), while staying close to participants' words (Bazeley & Jackson, 2013), and constantly moving between units of analysis in an iterative approach (Krueger, 1998; Miles et al., 2014). Soucy also reflected on group-level data, making note of areas of consensus and divergence (Krueger & Casey, 2009), interactions among participants (Hydén & Bulow, 2003), and the ways that meaning was negotiated and co-produced in the group context (Bazeley & Jackson, 2013; Parker & Tritter, 2006). The interpretations were supported by direct quotes from participants to illustrate key points and enhance the trustworthiness of the findings. All qualitative analysis was conducted in NVivo (Bazeley & Jackson, 2013).

## Results

### *Pre-post student differences*

Pre and post-test place attachment levels were not significantly different within any lab section based on a paired t-test (Table 1). None of the pre-/post-test changes in place attachment and meanings were statistically significant (Table 1). Students' self-efficacy perceptions of their technical GPS skills experienced the greatest change from the pretest to post-test questionnaires in regards to self-efficacy differences. Community skills significantly increased only within the PBE group—increasing by 7.4 points on average ($t(21)=2.4$, $p=0.02$, $d=0.52$). Additionally, technical GPS skills increased by 26.1 points on average ($t(21)=5.4$, $p<0.001$, $d=1.2$), and analytical skills increased by 11.5 points on average ($t(21)=3.2$, $p=0.01$) within the PBE section. Within the technologically-mediated lab section, analytical skills increased by 13.3 points on average ($t(22=4.2$, $p<0.001$, $d=0.99$), and technical GPS skills increased by 22.0 points on average ($t(22=4.2$, $p<0.001$, $d=0.89$). Within the campus-based lab section, technical GPS skills increased by 18.7 points on average ($t(23)=5.4$, $p<0.001$, $d=1.1$), and analytical skills increased by 12.2 points on average ($t(23)=4.5$, $p<0.001$, $d=0.93$). Across all lab sections, students' perceptions of self-efficacy related to problem-solving skills did not significantly change from before the activity to after the activity.

Pretest place attachment was significantly related to post-test place attachment ($F(1)=98.0$, $p=0.001$); however, we found no significant differences on post-test place attachment between lab sections when controlling for pretest place attachment ($F(2)=0.8$, $p=0.5$) (Figure 3). An investigation of correlations between place meanings and socio-demographics identified students' age as a covariate for the one-way ANCOVA; however, age did not significantly predict post-test place meanings. Similarly, we found a significant effect of pretest place meanings on post-test place meanings ($F(1)=77.1$, $p=0.001$); however, when controlling for pretest place meanings, we found no significant differences on post-test place meanings between lab sections ($F(2)=2.9$, $p=0.06$). Therefore, students who participated in the place-based activity did not develop a greater or lesser sense of place as compared to the students who received the technologically-mediated treatment or even the campus-based treatment.

We found a significant effect of pretest analytical, technical GPS, and community skills on post-test analytical, technical GPS, and community skills [$F(1)=46.15$, $p<0.001$; $F(1)=69.80$, $p<0.001$; $F(1)=11.19$, $p<0.001$]; however, we did not find a significant effect of pretest problem-solving skills on post-test problem-solving skills ($F(1)=3.51$, $p=0.07$). When controlling for the pretest scores, we found no significant differences between lab sections on post-test analytical, problem-solving, technical GPS, and community [$F(2)=2.3$, $p$=.12; $F(2)=1.49$, $p=0.23$; $F(2)=0.12$, $p=0.89$, $F(2)=1.37$, $p=0.26$] (Figure 4). This finding indicates that pretest perceived self-efficacy significantly predicts post-test rankings for most skills; yet, students did not perceive their self-efficacy rankings differently across lab sections after the activities. Students' prior GIS experience was a covariate for student's perceptions of self-efficacy. GIS experience had a significant effect on post-test analytical, problem-solving, and community skills [$F(1)=7.45$, $p=0.01$; $F(1)=12.86$, $p<0.001$; $F(1)=12.48$, $p=0.001$], such that across all lab sections, students with more GIS experience entering the course

**Table 1.** Paired t-test results for pre-/post-test sense of place and self-efficacy scores across treatment groups.

| | | Mean (or sum) score (SD) | | | | |
|---|---|---|---|---|---|---|
| Group | Construct | Pretest | Post-test | Mean difference | t | Cohen's d[a] |
| Place-based treatment ($N=22$) | Place attachment | 2.69 (0.56) | 2.7 (0.6) | 0.02 | −0.2 | 0.05 |
| | Place meanings | 72.2 (10.9) | 75.3 (13.3) | 3.1 | −1.6 | 0.34 |
| | Analytical skills | 72.0 (14.7) | 83.45 (12.4 | 11.5 | 3.2** | 0.68 |
| | Problem-solving skills | 88.0 (7.5) | 87.3 (11.2) | −0.75 | −0.4 | 0.09 |
| | Technical GPS skills | 60.7 (26.9) | 86.7 (14.3) | 26.1 | 5.4*** | 1.2 |
| | Community skills | 69.8 (16.8) | 77.2 (13.7) | 7.4 | 2.4* | 0.52 |
| Technologically-mediated place-based treatment ($N=23$) | Place attachment | 2.34 (0.7) | 2.5 (0.6) | 0.1 | −1.8 | 0.37 |
| | Place meanings | 75.9 (11.0) | 74.9 (10.5) | −1.0 | 0.7 | 0.15 |
| | Analytical skills | 63.4 (21.9) | 76.7 (16.6) | 13.3 | 4.2*** | 0.9 |
| | Problem-solving skills | 84.19 (15.2) | 87.8 (12.7) | 3.6 | 1.9 | 0.39 |
| | Technical GPS skills | 57.9 (33.39) | 82.9 (16.4) | 22.0 | 4.2*** | 0.89 |
| | Community skills | 67.2 (21.9) | 71.7 (10.2) | 4.5 | 1.5 | 0.31 |
| Campus-based ($N=24$) | Place attachment | 2.5 (0.9) | 2.5 (0.8) | −0.06 | 0.5 | 0.09 |
| | Place meanings | 73.9 (13.3) | 72.1 (11.8) | −1.8 | 1.1 | 0.23 |
| | Analytical skills | 61.9 (21.8) | 74.2 (17.5) | 12.2 | 4.5*** | 0.93 |
| | Problem-solving skills | 79.4 (16.2) | 84.2 (11.4) | 4.8 | 1.5 | 0.31 |
| | Technical GPS skills | 62.1 (28.3) | 80.8 (24.4) | 18.7 | 5.4*** | 1.10 |
| | Community skills | 62.7 (17.9) | 68.8 (14.2) | 6.1 | 1.8 | 0.39 |

[a]Cohen's d relates to the effect size where 0.0-0.19 = very small, 0.20-0.49 = small, 0.40-0.79 = moderate, and 0.80 or more = large effect size.
Note: all pre-/post-test scores are significantly correlated.

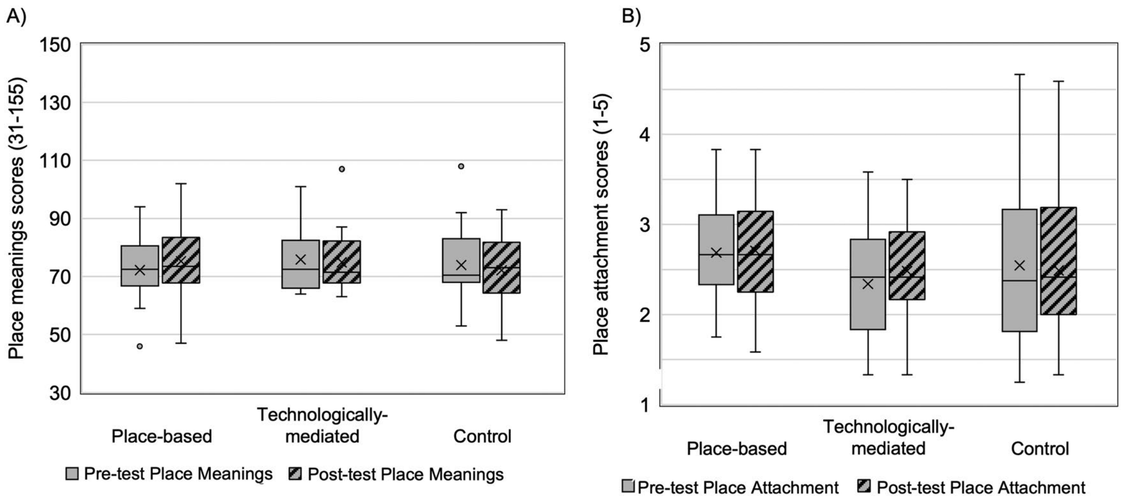


**Figure 3.** Pretest and post-test (A) place meanings and (B) place attachment scores across lab sections; hatched markings indicate post-test scores.

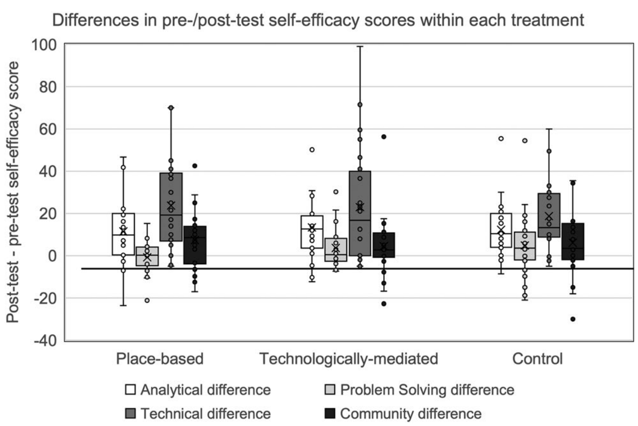


**Figure 4.** Pretest and post-test dimensions of self-efficacy (technical, community, problem-solving, and analytical) scores across lab sections; positive (negative) differences indicate increases (decreases) in scores from pretest to post-test.

had significantly higher perceived self-efficacy after the activities. However, GIS experience did not have a significant effect on post-test technical GPS skills ($F(1)=1.68$, $p=0.20$).

## Student reflections

We analyzed 19 student reflections – 10 students in the place-based treatment lab section, and 9 students in the technologically-mediated lab section. All students reflected on their prior experiences with the local conservation organization; additionally, some students described their experiences with the GIS activities, especially those students from the place-based treatment group. Most students had been to at least one preserve managed by the conservation organization. We identified three key themes: (1) place-based education allows students to authentically engage in course materials, (2) important connections are made when students work with communities, and (3) access to nature is a critical part of college students' well-being (see Table 2).

The place-based education activities allowed students to authentically engage in course materials by enabling them to practice skills in real-world contexts, as well as ask meaningful questions derived from personal interests and observations. This theme was particularly salient among students in the place-based lab section given their field trip and connections with community members during the presentations. In reflecting on their GIS skills, students described how the activities showed them "practical, real-life applications of GIS" (09-P) and offered "an excellent way to get out there and apply classroom knowledge to the field" (08-P). Students reflected that they enjoyed the activities and were motivated to do well because of the real-world application. 19-P described their experience, "I honestly enjoyed being able to go outside and gather the data for our assignment. I think it is more meaningful when you have some sort of personal connection to what you are [doing]." These quotes illustrate how students derived personal meaning from a real-world experience where they perceived their work as being useful and valued. Students also posed questions within their reflections. For example, 01-P reflected, "I remember seeing maps, as I mentioned previously, at the [preserve]. I'd like to go back and view these maps now that I have a better understanding of the process of map-making." When students engaged with a local conservation group to address spatial challenges, they began to see the connections between GIS and local real-world needs.

Additionally, students described the benefits of working with local community members, including the positive feeling of "helping" the organization, and their newfound connections to local place as a result of the activity. Students reflected on discovering (or rediscovering for some) the local preserve due to the class activities. Despite living in the community, the field trip appeared necessary to introduce some students to the local organization and trail network. 05-P wrote, "This experience has taught me to be more aware of my surroundings as I never noticed how often I use the [preserve] trail….Oftentimes the everyday citizen is blind to how much community leaders do for their enjoyment." In connecting course materials

Table 2. Illustrative quotes from student reflections corresponding to each theme.

**1. Place-based education allows students to authentically engage in course materials**

***a. PBE enables students to practice skills in real-world contexts***

"This exercise was overall a great learning experience for me. It showed me the practical, real-life applications of GIS and how it is a tremendous resource in many disciplines. It was also a rewarding experience to be able to present the information I gathered to a group of professionals that truly value the work that was done." (09-P)

"To know that my efforts were going to be used by someone else made me want to do better." (05-P)

"This lab activity was an excellent way to get out there and apply classroom knowledge to the field. Being able to go out and actually collect our own data, piece it together on our own and then work with a group to create a finished product added needed dimensions to this course. " (08-P)

***b. PBE sparks student interest such that they ask personally meaningful questions***

"Having access to a map that helps them better understand the time commitment required to go for a walk may make them more likely to spend some time on the trails enjoying the beautiful area that is located right in their backyards." (18-P)

"For example, [the conservation organization] aims to assess public access to natural areas, which involves relating roads and trails to [organization] areas. ArcGIS provides a way for [the conservation organization] to see what areas already have public access and what road types can be used to reach each area, as well as identify what areas need better access." (12-T)

**2. Important connections are made when students work with communities**

"A project like this one provided by the University students eliminates the cost required to do a project like this internally…If the least this project does is save some money and some headaches for the busy lives of the [conservation organization] volunteers, than that is still pretty cool in my opinion." (19-P)

"It was [a] great experience and practice to present in front of personnel from [the conservation organization]. I enjoyed hearing their comments and stories about balancing managing the land for conservation, recreation, and wildlife viewing." (13-P)

"Prior to this activity, I was not familiar with the work done by [the conservation organization] to preserve local natural areas. After going out and collecting GPS tracks with the class, I was fascinated by the [preserve] trails. I couldn't believe that after living [in this town] now for almost two years, I had never found the time to explore the trails that are essentially in my backyard. I went back the next day and did a long hike on the blue trail to see more of [the preserve] for myself." (09-P)

**3. Access to nature is a critical part of college students' well-being**

"I also feel that the [university] community of students appreciates [conservation organization] preserves very much for running, skiing and walks. It is a blessing to have accessible land so close to campus in a semi-urban environment." (07-P)

"They are always a lovely place to be, there are typically a few other people on the trails but rarely crowded, and people are usually quite friendly when you pass by them. I see a lot of dogs there, which always makes me happy, and I also tend to walk my dog there whenever he comes up to visit for a weekend." (18-P)

"I love that [conservation organization] has provided such great access to natural spaces close to city. I can walk to multiple trailheads from my house, and I often stop at [omitted trail] on my way home from school." (04-T)

with a local place, students gained an appreciation of the conservation organization as well as the access to the preserves they manage. Even one student who did not go to the preserve, but learned about the preserve in the video wrote,

> "I visited a preserve…after participating in lab. I pass by the trails daily on my drive to campus but this was the first time visiting and walking the trails. The trails are connected to my apartment complex which makes it convenient." (03-T)

This quote illustrates the potential impacts place-based learning can have on student engagement in local communities as they seek new experiences in place.

Finally, students reflected on the importance of connecting with nature for their well-being. Students commented on the necessity of local green space access for their mental health. For example, 10-T wrote, "I enjoy running in this area because I often admire the flora and fauna that Marsh Island has to offer.…These allow me to clear my head and make me ready to start my day." Similarly, 11-P reflected, "I visit [the preserve] for a great experience out in the woods close to campus. It makes me feel more focused during my time at [the university]." Students in both the place-based and technologically-mediated groups acknowledged their experiences accessing local preserves managed by the community organization for recreational opportunities (e.g., hunting, biking, hiking, viewing wildlife, etc.). The ability to recreate in a green space "so close to campus" (07-P) is of note to students and an important aspect of their enjoyment and connection with local place. In considering the previous theme as well, the place-based activities may have increased the salience of the conservation organization and allowed students to make the connections between their well-being, forests, and the community organization.

### *Community partner perceptions and experiences*

Community partners described organizational as well as individual benefits because of the collaboration with the university GIS course instructors and students. Specifically, we identified the following themes: (1) university partnerships increase organizational GIS capacity while catalyzing interest in addressing spatial questions, and (2) individuals benefit from and commit to forming community connections as a result of partnerships. Partners described how students provide useful information for decision-making and organization; for example, 01 said, "So it's a nice pairing, since we're right here and the school's right there, that we work together." (01). Regarding outputs, partners expressed excitement about the trail maps students produced—a need that had been reiterated over the course of past meetings. 03 said, "I see that we've made some progress [with trail mapping] with some good clear templates to use." By creating a space to discuss GIS needs in the group interview, following student presentation, the community organization members brainstormed several ideas for spatial projects as a result of what they observed and learned from the process. Student work and discussion appeared to generate a consensus for the importance of GIS capacity within the group. 03 said,

> "More data than we're using was collected just by the nature of the field work [students] did. And I think that's really useful to the [conservation organization]. It may not be the intent we started out on with this exercise, but it's an intriguing possibility

for sure, and GIS is a good tool for that. I don't know if we have GIS capabilities [here]."

The information students collected in the field sparked an interest and avenue for GIS exploration among partners. Partners therefore acknowledged the potential for GIS to improve organizational development; however, long-term capacity for continuing to maintain and develop that GIS database and knowledge remained unknown. Following 03's reflection, 02 added, "I think what 03 was talking about in…getting some help and developing GIS capability within the [community organization] would be beneficial…So maybe some really super brave graduate student could help us with that." While partners recognized the need for GIS, barriers still remain for developing capacity within the organization; instead, continuing to leverage community connections (e.g., graduate students at the university) rather than internal staff appears to be the solution.

Finally, partners discussed the individual benefits they derived from the collaboration, including the development of a sense of community and authentic commitment to working with students. 02 reflected on the benefits of student collaboration,

> "Overall the more student collaboration we have, the happier it makes me feel… that it's more of a community. That we have the students working alongside us, and that it's not so much an *us versus them*, you know, students are on the island. It's just a good feeling to get to know all of the people in your community, not just the ones who look like you."

04 similarly adds, "I enjoy working with the students… It's healthy for me to see that young people are really wonderful people." Partners address the differences between themselves (as perhaps, older, community members), and students who attend the university, and the subsequent divides that can occur between a university and local community. Working with students allows partners to feel engaged with their communities, and similarly, they hope in doing so students feel connected to a community outside of campus. Partners perceived the collaboration as beneficial to the students for not only skill development, but also for student's now greater understanding of place and local conservation. 04 also reflected on the importance of students getting outside, "That would be healthy for the students to actually get out and get some fresh air and realize there's more than the campus - that there's other parts to the town." 04 further went on to offer to join the GIS classes in future semesters as they collect data at the local preserve. In doing so, they hoped that students would take away a deeper understanding of place as they interact with a member of the community organization.

## Discussion

### *Development of student self-efficacy*

The results of the pre-/post-test quasi-experiment suggest that regardless of whether students received a place-based activity or not, they rated their self-efficacy similarly. Due to the lack of significant differences in the pre-/post-test results, we primarily focus on the different aspects of the experiences which may have impacted student outcomes, as supported through their reflections. All lab sections engaged in hands-on student-centered activities where students all had opportunities to develop technical skills, as well as engage in activities outside of the GIS lab. Research supports the increase of student knowledge and critical thinking skills when instruction is student-centered (rather than instructor-centered) (Granger et al., 2012). The hands-on approach to GIS learning—regardless of lab section—likely supported student analytical and technical skill development, such that the activities across all lab sections may have been perceived as authentic learning tasks (Gulikers et al., 2005).

Student reflections within the PBE group illuminated the ways in which place-based learning supported students' analytical, problem-solving, and community skill development, specifically the student presentation and in-person field trip components. Students from the place-based group expressed a personal connection to the project because they collected their own data and felt as though the output was useful and valued by the community organization– a finding that is consistent with past research on the empowerment of students during PBE activities (Bartsch, 2008; Jolley et al., 2019; Krasny et al., 2015; Sobel, 2004). Students reflections from the place-based group demonstrate how students critically thought about local conservation management and multiple use spaces as a result of their conversations with community partners and walk through the organization's trails. It is possible the problem-solving skills extended beyond those associated with GIS as measured on the questionnaire, and were more so related to critical thinking around community and conservation more broadly. This may be the case given the introductory nature of the course as well, where students may not be pursuing GIS as a career, but rather more broadly interested in conservation in general. In addition, pretest problem solving skills did not significantly influence post-test problem solving skills, which may have been influenced by some students in the PBE lab section ranking their post-test problem solving skills lower than their pretest scores. The critical thinking involved in the PBE group project may have resulted in students questioning their ability to draw conclusions, analyze spatial data, and ask questions. Previous GIS education research has primarily focused on map-making dimensions of self-efficacy (Baker & White, 2003; Songer, 2010); therefore, our results shed light on potential additional learning objectives associated with GIS place-based education that require further exploration on traditional self-efficacy assessments. Similar to other studies of community-university partners (Keen & Baldwin, 2004), we found that partners, like students, felt that the activity allowed students real-world experiences. We did not find evidence of a tension between developing analytical and technical GIS skills previously identified in research (Whyatt et al., 2022) within student reflections. Rather, students expressed satisfaction with problem-solving within a group to create a meaningful product. Additionally, the presentations allowed students to connect their maps to real-world decision-making as they engaged with community partners and responded to their questions. Our results therefore support a continued need to help students better analyze the data they produce, and create relevant, accessible activities that allow students the opportunity to both learn GIS and work with GIS to address challenges (Baker & White, 2003).

Characteristics of the technologically-mediated PBE approach, which included a short video and the use of real-world localized data, allowed students the opportunity to develop technical and analytical skills and increase their awareness of the connections between themselves, course materials, and local place. In both the technologically-mediated PBE and PBE groups, student reflections demonstrated a broadening of their connections with the local environmental as they reflected on the community organization and their own personal experiences. Similar to other place-based learning environments (Bouillion & Gomez, 2001), students connected the course material to relevant local place-based challenges. Within PBE research, field trips have demonstrated similar positive impacts on student learning within geoscience courses (Wallgrün et al., 2022; Zhao et al., 2020). The reflections demonstrate the potential advantages of a place-based approach, whether that is in-person, or *via* online videos or virtual experiences, for sparking student interest in local community outside of campus, and/or reminding students of opportunities for green space access locally. In particular, student reflections from the technologically-mediated section suggest that students appreciated how community members shared information about their local organization. The video and activity raised student awareness around the local organization, prompted some students to visit the organization, and allowed students the opportunity to reflect on the role of GIS in local environmental issues.

### Community connections and student's complex sense of place

The quasi-experimental results indicated that student's sense of place did not significantly change during the activities across all lab sections. These results are largely distinct from past quantitative studies on PBE and sense of place (e.g., Kudryavtsev et al., 2012; Lee & Chiang, 2016; Semken & Freeman, 2008), and point to potential measurement challenges associated with sense of place in a population with an already high connection to place. Previous research has shown that students familiarity with a place is significantly related to place attachment (Williams & Vaske, 2003). Socio-demographics and reflections provide greater insight into students' sense of place. Students began the course with a range of prior, complex, and diverse connections to the town where the university is located and the conservation organization as exhibited in their reflections. It is possible sense of place, once established, may be relatively resilient to enhancement. It is also possible that repeat visits (i.e., more than one during the in-person field trip) were needed to further enhance student's place attachment, as previous research has demonstrated that place attachment increases with increased number of visits (Williams & Vaske, 2003). Our results build off existing studies of sense of place among college students (e.g., Johnson et al., 2020; Semken & Freeman, 2008), by emphasizing the importance of attending to diverse student experiences with place in courses with a range of student experiences and student ages (i.e., students under 30 with some who have lived in the place their whole lives, and those who are older with diverse histories within the place). Within our place-based learning context, qualitative methods enabled an in-depth understanding of complex student experiences and contexts. Our mixed methods approach builds off previous research that has similarly triangulated across qualitative and quantitative methods to evaluate student's complex sense of place (Williams & Semken, 2011).

The qualitative findings demonstrate that the activities allowed students across both place-based and technologically-mediated groups to reflect on the importance of local conservation areas for their well-being and mental health. Community partners similarly noted the importance for students to get outside, which goes beyond skill or capacity benefits as students engage in PBE. The connections students made between their well-being, access to the forest, and the place-based activity suggest that in our case, PBE may have further developed students' connection to nature and the ways in which their own understanding of their identity is tied to local environments. In qualitative studies related to sense of place, similar findings indicate a deeper understanding of stewardship, community, and place when students experience PBE (Shiel et al., 2016; Williams & Semken, 2011). Similar to a study in New York City (Russ et al., 2015) and California (Galante, 2019), as students engaged in learning environments within the community, they acknowledged the benefits of that community on their well-being, and the importance of local stewardship. Like students at the university in California (Galante, 2019), despite their proximity, it was not until the GIS activities that some students visited a local preserve.

While students noted the value of personally contributing to local community needs, community partners also appreciated the increased GIS capacity students provided. Similar to previous work on community-university partnerships, the partnership enabled the discovery of new ideas for research and resources, and partner learning (Keen & Baldwin, 2004). Partners derived benefits from being connected to the university as a source of enhancing social capital (Sandy & Holland, 2006), such that the university provided hands-on support and expertise free of charge—an opportunity to solve spatial challenges that would otherwise not be possible (Klein et al., 2011).

As students reflected on their connections to the local community organization, and partners expressed joy in their relationships with the university students, both campus and community members understood that they are part of the same community, with similar interests, and a common capacity to influence the other. Community partner perceptions aligned with previous research in service learning which identifies multiple motivations for university partnerships, including not just capacity-building (Tidball & Krasny, 2011) but an altruistic motivation to help students (Bell & Carlson, 2009). Similar to previous work within the USA

(Sandy & Holland, 2006) and Ireland (McIlrath et al., 2012), we found that partners dedicated themselves to educating students, even when this was not the expectation. For example, partners expressed genuine interest in student learning, asking students critical questions during the class presentations, and offering to join students in the lab for future courses to help them further understand place. The opportunity to work with students—*via* intergenerational learning and partnership—also allowed community partners to feel more connected to their community and better appreciate a younger generation. While social capital research has highlighted the ways that youth involvement can allow students to see themselves as part of the community (Emery & Flora, 2006), we found that older community members may also see themselves as part of the community due to involvement in the partnership. Therefore, our PBE approach may have decreased the perceived gap, or isolation, between the university and the larger community in which it is embedded. We found that intergenerational learning increased reciprocal communication and community well-being by creating a bridge between the community organization and university students (i.e., developing bridging social capital) (Hata et al., 2021).

### Implications for educators

There is a large body of research supporting the importance of community-university partnerships; however, we also acknowledge the practical challenges of PBE. Over the course of planning and implementing the activities, we reflected on the challenges and benefits *via* reflective journaling and peer debriefing. Here we offer some considerations for educators seeking to implement PBE within a college-level GIS course:

1. Working with communities requires developing a deep understanding and self-awareness to identify joint goals and expectations (Kindred & Petrescu, 2015; Klein et al., 2011). Early and frequent communication with the organization proved valuable for ensuring the student work met the goals of students, instructors, and community partners. Similarly, we maintained a high degree of flexibility when entering these early conversations to ensure the partnership offered reciprocity (Molnar et al., 2010).
2. While building independent critical thinking and problem-solving skills is critical, we designed the activities with feasibility and student needs in mind. Specifically, we offered directions for many of the technical skills in the activities, while remaining flexible in the methods for student collaboration, data management, and map creation. As an instructor, this required a good deal of letting go of control regarding student work. At the same time, we could not make any promises to the community organization about the quality of student work.
3. The field trip required four trained instructors/teaching assistants to ensure timely collection of data and student supervision. Therefore, trained GIS personnel is necessary for large class sizes. In reflecting on the diverse experiences of students on the field trip within their groups, it may also be important to consider instructors who are trained in not only GIS, but also in principles of environmental education and PBE.
4. Place-based educational opportunities that enable students to meet local community members can transform student understanding of course concepts and help them apply their learning to their own life.
5. Long-term partnerships for addressing the GIS gap are important. By engaging with several community partners as a team of instructors we hope to embed this partnership within the GIS course in future years (Grohs et al., 2020). Partners also did not experience a time burden associated with working with students, rather they were willing to spend more time with students in future courses – a contrast from previous research (Drahota et al., 2016). The design of the exercise, partners' personal connections to the place and university, authentic commitment to work with students, and their positionality as volunteers (most of whom were retired) are all plausible explanations for the lack of this challenge. These characteristics point to specific attributes of community partners which may enhance partnerships.

### Future research and limitations

Several threats to internal validity exist, including differences in student socio-demographics between lab sections. For example, the technologically-mediated section had more graduate students and fewer sophomores, while students in the PBE section had relatively more sophomores. Based on the shared themes between undergraduate and graduate student reflections, it appears despite differences in educational level, these students experienced commonalities within the activities; however, further research could explore in greater depth the potential for different learning outcomes between graduate and undergraduate students in PBE. The lab sections also occurred at different times of day, which may have influenced the demographics of students who enrolled in a particular section.

We also recognize that we were unable to control for all confounding variables. First, within the quasi-experimental design as students across lab sessions could have interacted with each other over the course of the lab activities. Students also have varying histories and backgrounds related to living and interacting in place and conducting geospatial analysis. While we can control for some of these that can be measured quantitatively, an individual's history in place and sense of place is quite complex and cannot be entirely measured and controlled. Retrospective pretests (Pratt et al., 2000) provide an additional method for measuring pre and post-sense of place which could be considered in similar diverse populations to better understand student's perceptions of their past and present connections to place.

We also acknowledge the tradeoffs of some of the decisions we made for data collection. First, the 100-point self-efficacy scale without anchor points (i.e., 1 = no ability to perform this skill, 50 = some knowledge of how to perform this skill, etc.), may have resulted in students differentially interpreting the scale. For example, students highly rated their pretest self-efficacy (e.g., as *a* ~70) despite not knowing the skill. We are limited by not having a word label at the different response categories, which may have reduced the possibility of measurement error (DeVellis, 2012). Future research must continue to consider the benefits and challenges of different methods to assess self-efficacy (Toland & Usher, 2016). Given the limitations of the self-efficacy findings, we triangulated across student reflections to gain a more in-depth understanding of student outcomes. Finally, we did not ask the campus-based group to describe any pre-existing connection with the community organization *via* a reflection, and therefore remain limited regarding in-depth understanding of their complex sense of connection to the organization.

Regarding future research, the results indicate that students' GIS experience as they enter the course significantly predicts perceptions of their skills; therefore, it is important to account for potential differences in students' experiences to ensure equitable and inclusive teaching. Researchers must consider the potential opportunities and drawbacks of measuring self-efficacy using a 100-point scale (Pajares et al., 2001), and rather consider an approach that enables a measurement to be similarly understood and interpreted among all students. At the same time, developing a more in-depth understanding of sense of place requires a recognition of college student's complex histories with the local community that may not be well-suited to quantitative measurement alone. Similarly, further work is needed to explore the differences in sense of place when more than one field trip or visit occurs. Additionally, the group interview engaged four community members. Not all who had attended the initial collaborative meetings attended student presentations and/or the group interview due to schedule conflicts. Therefore, partner attrition limited the breadth of experiences we captured in the group interview, and future research would benefit from a more comprehensive understanding of partner experiences. We hope to build on these lessons learned in future iterations of the course, where we wish to expand PBE across all lab sections.

## Conclusions

Student and community experiences, perceptions, and outcomes highlight the positive contributions of place-based education involving community-university partnerships. The collaboration with the community partner organization embodied PBE, as it allowed students to engage in authentic learning based on real-world issues of local relevance, where students had opportunities to collaborate, reflect, and create a valued product. While the pre-/post-test quasi-experiment results did not indicate a difference between approaches that engaged community and those that did not, student reflections and partner perceptions emphasized the complexity of reciprocal gains resulting from education rooted in local community beyond the bounds of campus.

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## References

Aldrich, D. P., & Meyer, M. A. (2015). Social capital and community resilience. *American Behavioral Scientist*, *59*(2), 254–269. https://doi.org/10.1177/0002764214550299

Ash, S., & Clayton, P. (2009). Generating, deepening, and documenting learning: The power of critical reflection in applied learning. *Journal of Applied Learning in Higher Education*, *01*(Fall), 25–48. https://doi.org/10.57186/jalhe_2009_v1a2p25-48

Baker, T. R., & White, S. H. (2003). The effects of G.I.S. on students' attitudes, self-efficacy, and achievement in middle school science classrooms. *Journal of Geography*, *102*(6), 243–254. https://doi.org/10.1080/00221340308978556

Ballantyne, R., Connell, S., & Fien, J. (1998). Students as catalysts of environmental change: A framework for researching intergenerational influence through environmental education. *Environmental Education Research*, *4*(3), 285–298. https://doi.org/10.1080/1350462980040304

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, *84* (2), 191–215. https://doi.org/10.1037/0033-295X.84.2.191

Bandura, A. (2006). Guide for constructing self-efficacy scales. *Self-Efficacy Beliefs of Adolescents*, *5*, 307–337. https://doi.org/10.1017/CBO9781107415324.004

Bartsch, J. (2007). Youth as resources in revitalizing communities. In G.A. Smith & D.A. Gruenwald (Eds.) *Place-based education in the global age* (p. 20). Routledge.

Basu, M., Hashimoto, S., & Dasgupta, R. (2020). The mediating role of place attachment between nature connectedness and human well-being: Perspectives from Japan. *Sustainability Science*, *15*(3), 849–862. https://doi.org/10.1007/s11625-019-00765-x

Bazeley, P., & Jackson, K. (2013). *Qualitative data analysis with NVivo*. SAGE publications.

Bearman, N., Jones, N., André, I., Cachinho, H. A., & DeMers, M. (2016). The future role of GIS education in creating critical spatial thinkers. *Journal of Geography in Higher Education*, *40*(3), 394–408. https://doi.org/10.1080/03098265.2016.1144729

Bell, S., & Carlson, R. (2009). Motivations of community organizations for service learning. In R. Stoecker, & E. Tryon (Eds.), *The unheard voices: Community organizations and service learning* (pp. 19–37). Temple University Press.

Bernsen, N. R. (2020). *The next generation of labor in rural, resource-rich places: Forestry needs and youth aspirations* [Doctoral dissertation]. University of Maine. ProQuest Dissertations Publishing.

Bieluch, K., Silka, L., & Lindenfeld, L. A. (2021). Stakeholder preferences for process and outcomes in community-university research partnerships: Implications for research collaborations. *Journal of Community Engagement and Scholarship*, *13*(2). https://doi.org/10.54656/SBJB4688

Blickley, J. L., Deiner, K., Garbach, K., Lacher, I., Meek, M. H., Porensky, L. M., Wilkerson, M. L., Winford, E. M., & Schwartz, M.

W. (2013). Graduate student's guide to necessary skills for nonacademic conservation careers. *Conservation Biology: The Journal of the Society for Conservation Biology*, *27*(1), 24–34. https://doi.org/10.1111/j.1523-1739.2012.01956.x
Bloor, M., Frankland, J., Thomas, M., & Robson, K. (2001). *Focus groups in social research*. SAGE Publications. https://doi.org/10.4135/9781849209175
Bogdan, R., & Biklen, S. K. (1997). *Qualitative research for education*. Allyn &.
Bouillion, L. M., & Gomez, L. M. (2001). Connecting school and community with science learning: Real world problems and school–community partnerships as contextual scaffolds. *Journal of Research in Science Teaching*, *38*(8), 878–898. https://doi.org/10.1002/tea.1037
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
Bright, J. (2020). *Place attachment, academic self-efficacy, and academic aspirations among rural elementary students: An exploratory study* [Dissertation]. The Pennsylvania State University.
Carmen, E., Fazey, I., Ross, H., Bedinger, M., Smith, F. M., Prager, K., McClymont, K., & Morrison, D. (2022). Building community resilience in a context of climate change: The role of social capital. *Ambio*, *51*(6), 1371–1387. https://doi.org/10.1007/s13280-021-01678-9
Change Walker et al., 2008 line 308 to Walker & Ryan, 2008.
Chawla, L. (2015). Benefits of nature contact for children. *Journal of Planning Literature*, *30*(4), 433–452. https://doi.org/10.1177/0885412215595441
Chen, Q., Acey, C., & Lara, J. J. (2015). Sustainable futures for Linden Village: A model for increasing social capital and the quality of life in an urban neighborhood. *Sustainable Cities and Society*, *14*, 359–373. https://doi.org/10.1016/j.scs.2014.03.008
Cho, Y., & Clary, R. M. (2020). Challenges and opportunities for virtual learning in college geology. In *Active learning in college science: The case for evidence-based practice* (pp. 713–728). Springer Nature.
Cook, T. D., Campbell, D. T., & Day, A. (1979). *Quasi-experimentation: Design & analysis issues for field settings* (Vol. 351). Houghton Mifflin.
Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research approach*. SAGE Publications.
Cronbach, L. J. (1951). Coefficient α and the internal structure of tests. *Psychometrika*, *16*(3), 297–334. https://doi.org/10.1007/BF02310555
Demarest, A. (2015). *Place-based curriculum design*. Taylor & Francis.
DeVellis, R. F. (2012). *Scale development: Theory and applications* (3rd ed.). SAGE.
Drahota, A., Meza, R. D., Brikho, B., Naaf, M., Estabillo, J. A., Gomez, E. D., Vejnoska, S. F., Dufek, S., Stahmer, A. C., & Aarons, G. A. (2016). Community-academic partnerships: A systematic review of the state of the literature and recommendations for future research. *The Milbank Quarterly*, *94*(1), 163–214. https://doi.org/10.1111/1468-0009.12184
Emery, M., & Flora, C. (2006). Spiraling-up: Mapping community transformation with community capitals framework. *Community Development*, *37*(1), 19–35. https://doi.org/10.1080/15575330609490152
Flora, J. L. (1998). Social capital and communities of place. *Rural Sociology*, *63*(4), 481–506. https://doi.org/10.1111/j.1549-0831.1998.tb00689.x
Galante, G. F. (2019). *Connectedness to nature and place-based education* [Doctoral dissertation]. California State University.
Gerstenblatt, P., & Gilbert, D. J. (2014). Framing service learning in social work: An interdisciplinary elective course embedded within a university–community partnership. *Social Work Education*, *33*(8), 1037–1053. https://doi.org/10.1080/02615479.2014.935731
Gibbs, G. R. (2018). *Analyzing qualitative data* (Vol. 6). SAGE Publications.
Granger, E. M., Bevis, T. H., Saka, Y., Southerland, S. A., Sampson, V., & Tate, R. L. (2012). The efficacy of student-centered instruction in supporting science learning. *Science (New York, N.Y.)*, *338*(6103), 105–108. https://doi.org/10.1126/science.1223709
Greene, J. C., Caracelli, V. J., & Graham, W. F. (2003). Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis*, *11*(3), 255–274. https://doi.org/10.3102/01623737011003255
Grohs, J. R., Gillen, A. L., Matusovich, H. M., Kirk, G. R., Lesko, H. L., Brantley, J., & Carrico, C. (2020). Building community capacity for integrating engineering in rural middle school science classrooms. *The Journal of STEM Outreach*, *3*(1), 1–12. https://doi.org/10.15695/jstem/v3i1.01
Gruenewald, D. A., & Smith, G. (2008). *Place-based education in the global age*. Taylor & Francis.
Gulikers, J. T. M., Bastiaens, T. J., & Martens, R. L. (2005). The surplus value of an authentic learning environment. *Computers in Human Behavior*, *21*(3), 509–521. https://doi.org/10.1016/j.chb.2004.10.028
Hata, N., Kondo, J., Allen, D., Singer, J., & Furihata, S. (2021). The role of place-based education in strengthening community resilience against climate change. *Japanese Journal of Environmental Education*, *31*(2), 2_14–24. https://doi.org/10.5647/jsoee.31.2_14
Holton, M. (2015). 'I already know the city, I don't have to explore it': Adjustments to 'sense of Place' for 'local' UK university students. *Population, Space and Place*, *21*(8), 820–831. https://doi.org/10.1002/psp.1866
Hougham, J. R., Eitel, K. C., & Miller, B. G. (2015). Technology-enriched STEM investigations of place: Using technology to extend the senses and build connections to and between places in science education. *Journal of Geoscience Education*, *63*(2), 90–97. https://doi.org/10.5408/12-399.1
Hydén, L.-C., & Bülow, P. (2003). Who's talking: Drawing conclusions from focus groups—some methodological considerations. *International Journal of Social Research Methodology*, *6*(4), 305–321. https://doi.org/10.1080/13645570210124865
Ignatius, A. R., & Flood, M. G. (2021). Integration of remote sensing & environmental science in placed-based learning. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, *44*(M–3), 73–78. https://doi.org/10.5194/isprs-archives-XLIV-M-3-2021-73-2021
Johnson, M. D., Sprowles, A. E., Goldenberg, K. R., Margell, S. T., & Castellino, L. (2020). Effect of a place-based learning community on belonging, persistence, and equity gaps for first-year STEM students. *Innovative Higher Education*, *45*(6), 509–531. https://doi.org/10.1007/s10755-020-09519-5
Jolley, A., Hampton, S. J., Brogt, E., Kennedy, B. M., Fraser, L., & Knox, A. (2019). Student field experiences: Designing for different instructors and variable weather. *Journal of Geography in Higher Education*, *43*(1), 71–95. https://doi.org/10.1080/03098265.2018.1554632
Kan, A. (2009). Effect of scale response format on psychometric properties in teaching self-efficacy. *Egitim Arastirmalari-Eurasian Journal of Educational Research*, *34*, 215–228. Retrieved from http://www.ejer.com.tr/index.php
Keen, C., & Baldwin, E. (2004). Students promoting economic development and environmental sustainability: An analysis of the impact of involvement in a community-based research and service-learning program. *International Journal of Sustainability in Higher Education*, *5*(4), 384–394. https://doi.org/10.1108/14676370410561081
Kindred, J., & Petrescu, C. (2015). Expectations versus reality in a university–community partnership: A case study. *VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations*, *26*(3), 823–845. https://doi.org/10.1007/s11266-014-9471-0
Klein, P., Fatima, M., McEwen, L., Moser, S. C., Schmidt, D., & Zupan, S. (2011). Dismantling the Ivory Tower: Engaging geographers in university–community partnerships. *Journal of Geography in Higher Education*, *35*(3), 425–444. https://doi.org/10.1080/03098265.2011.576337
Krasny, M. E., Kalbacker, L., Stedman, R. C., & Russ, A. (2015). Measuring social capital among youth: Applications in environmental education. *Environmental Education Research*, *21*(1), 1–23. https://doi.org/10.1080/13504622.2013.843647
Krasny, M. E., & Roth, W. M. (2010). Environmental education for social-ecological system resilience: A perspective from activity theory. *Environmental Education Research*, *16*(5-6), 545–558. https://doi.org/10.1080/13504622.2010.505431
Krasny, M. E., Tidball, K. G., & Sriskandarajah, N. (2009). Education and resilience: Social and situated learning among university and secondary students. *Ecology and Society*, *14*(2). https://doi.org/10.5751/ES-03032-140238

Krueger, R. A. (1998). *Analyzing and reporting focus group results*. SAGE.
Krueger, R., & Casey, M. (2009). *Focus groups: A practical guide for applied research*. Sage Publications.
Kudryavtsev, A., Stedman, R. C., & Krasny, M. E. (2012). Sense of place in environmental education. *Environmental Education Research*, *18*(2), 229–250. https://doi.org/10.1080/13504622.2011.609615
Kvale, S. (2011). Planning an interview study. In S. Kvale (Ed.), *Doing interviews* (pp. 34–50). SAGE Publications. https://doi.org/10.4135/9781849208963.n4
Lee, H., & Chiang, C.-L. (2016). Sense of place and science achievement in the place-based science curriculum. *International Journal of Information and Education Technology*, *6*(9), 700–704. https://doi.org/10.7763/IJIET.2016.V6.777
Leydon, J., & Turner, S. (2013). The challenges and rewards of introducing field trips into a large introductory geography class. *Journal of Geography*, *112*(6), 248–261. https://doi.org/10.1080/00221341.2013.833279
Lloyd, W. J. (2001). Integrating GIS into the undergraduate learning environment. *Journal of Geography*, *100*(5), 158–163. https://doi.org/10.1080/00221340108978443
Low, S. M., & Altman, I. (1992). *Place attachment* (I. Altman & S. M. Low, Eds.). Springer US. https://doi.org/10.1007/978-1-4684-8753-4_1
Lowenthal, P. P., Borup, J., West, R., & Archambault, L. (2020). Thinking beyond Zoom: Using asynchronous video to maintain connection and engagement during the COVID-19 pandemic. *Journal of Technology and Teacher Education*, *28*(2), 383–391. https://doi.org/10.24252/elite.v7i1a6
Mannion, G., & Adey, C. (2011). Place-based education is an intergenerational practice. *Children, Youth and Environments*, *21*(1), 35–58. https://doi.org/10.1353/cye.2011.0058
Massaro, V. A., Barnhart, S., Lasky, M., & Jeremiah, K. (2021). Building sustainable communities through engaged learning: A university-community partnership for sustained change in a central Pennsylvania coal town. *Journal of Community Engagement & Scholarship*, *14*(1).
Mathews, A. J., & Wikle, T. A. (2019). GIS&T pedagogies and instructional challenges in higher education: A survey of educators. *Transactions in GIS*, *23*(5), 892–907. https://doi.org/10.1111/tgis.12534
McIlrath, L., Lyons, A., & Munck, R. (Eds.). (2012). *Higher education and civic engagement*. Palgrave Macmillan US. https://doi.org/10.1057/9781137074829
Mead, C., Buxner, S., Bruce, G., Taylor, W., Semken, S., & Anbar, A. D. (2019). Immersive, interactive virtual field trips promote science learning. *Journal of Geoscience Education*, *67*(2), 131–142. https://doi.org/10.1080/10899995.2019.1565285
Merry, K., & Bettinger, P. (2019). Smartphone GPS accuracy study in an urban environment. *PloS One*, *14*(7), e0219890. https://doi.org/10.1371/journal.pone.0219890
Miles, M. B., Huberman, A. M., & Saldana, J. (2014). *Qualitative data analysis: A methods sourcebook*. Sage Publications.
Molnar, C., Ritz, T., Heller, B., & Solecki, W. (2010). Using higher education-community partnerships to promote urban sustainability. *Environment: Science and Policy for Sustainable Development*, *53*(1), 18–28. https://doi.org/10.1080/00139157.2011.539944
Monet, J., & Greene, T. (2012). Using Google Earth and satellite imagery to foster place-based teaching in an introductory physical geology course. *Journal of Geoscience Education*, *60*(1), 10–20. https://doi.org/10.5408/10-203.1
Moustakas, C. (1994). *Phenomenological research methods*. SAGE Publications.
Norton, E., Li, Y., Mason, L. R., & Washington-Allen, R. A. (2019). Assessing the impact of a geospatial data collection app on student engagement in environmental education. *Education Sciences*, *9*(2), 118. https://doi.org/10.3390/educsci9020118
Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, *16*(1), 160940691773384. https://doi.org/10.1177/1609406917733847
Pajares, F., Hartley, J., & Valiante, G. (2001). Response format in writing self-efficacy assessment: Greater discrimination increases prediction. *Measurement and Evaluation in Counseling and Development*, *33*(4), 214–221. https://doi.org/10.1080/07481756.2001.12069012
Parker, A., & Tritter, J. (2006). Focus group method and methodology: Current practice and recent debate. *International Journal of Research & Method in Education*, *29*(1), 23–37. https://doi.org/10.1080/01406720500537304
Perkins, N., Hazelton, E., Erickson, J., & Allan, W. (2010). Place-based education and Geographic Information Systems: Enhancing the spatial awareness of middle school students in Maine. *Journal of Geography*, *109*(5), 213–218. https://doi.org/10.1080/00221341.2010.501457
Pratt, C. C., McGuigan, W. M., & Katzev, A. R. (2000). Measuring program outcomes: Using retrospective pre-test methodology. *American Journal of Evaluation*, *21*(3), 341–349. https://doi.org/10.1177/109821400002100305
Proshansky, H. M., Fabian, A. K., & Kaminoff, R. (1983). Place-identity: Physical world socialization of the self. *Journal of Environmental Psychology*, *3*(1), 57–83. https://doi.org/10.4324/9781315816852
Puttick, B. G. M., Drayton, B., & Silva, C. (2022). Innovations in undergraduate teaching and learning of earth and environmental science, with a focus on climate change. *Journal of College Science Teaching*, *51*(4), 65–78. https://doi.org/10.1080/0047231X.2022.12290573
Rissman, A. R., Morris, A. W., Kalinin, A., Kohl, P. A., Parker, D. P., & Selles, O. (2019). Private organizations, public data: Land trust choices about mapping conservation easements. *Land Use Policy*, *89*, 104221. https://doi.org/10.1016/j.landusepol.2019.104221
Roth, W. M., & Lee, S. (2004). Science education as/for participation in the community. *Science Education*, *88*(2), 263–291. https://doi.org/10.1002/sce.10113
Russ, A., Peters, S. J., E. Krasny, M., & Stedman, R. C. (2015). Development of ecological place meaning in New York City. *The Journal of Environmental Education*, *46*(2), 73–93. https://doi.org/10.1080/00958964.2014.999743
Sandy, M., & Holland, B. A. (2006). Different worlds and common ground: Community partner perspectives on campus-community partnerships. *Michigan Journal of Community Service Learning*, *13*(1), 30–43.
Scannell, L., & Gifford, R. (2010). Defining place attachment: A tripartite organizing framework. *Journal of Environmental Psychology*, *30*(1), 1–10. https://doi.org/10.1016/j.jenvp.2009.09.006
Seidman, I. (2006). *Interviewing as qualitative research: A guide for researchers in education and the social sciences* (3rd ed.) Teachers College Press.
Seltman, H. J. (2018). *Experimental design and analysis*. Carnegie Mellon University.
Semken, S., & Freeman, C. B. (2008). Sense of place in the practice and assessment of place-based science teaching. *Science Education*, *92*(6), 1042–1057. https://doi.org/10.1002/sce.20279
Semken, S., Ward, E. G., Moosavi, S., & Chinn, P. W. U. (2017). Place-based education in geoscience: Theory, research, practice, and assessment. *Journal of Geoscience Education*, *65*(4), 542–562. https://doi.org/10.5408/17-276.1
Shiel, C., Leal Filho, W., Do Paço, A., & Brandli, L. (2016). Evaluating the engagement of universities in capacity building for sustainable development in local communities. *Evaluation and Program Planning*, *54*, 123–134. https://doi.org/10.1016/j.evalprogplan.2015.07.006
Sim, J., & Waterfield, J. (2019). Focus group methodology: Some ethical challenges. *Quality & Quantity*, *53*(6), 3003–3022. https://doi.org/10.1007/s11135-019-00914-5
Sinton, D. S. (2009). Roles for GIS within higher education. *Journal of Geography in Higher Education*, *33*(sup1), S7–S16. https://doi.org/10.1080/03098260903034046
Smith, J. A., Larkin, M., & Flowers, P. (2021). *Interpretative phenomenological analysis: Theory, method and research. Interpretative phenomenological analysis*. Sage Publications.
Solis, P., Huynh, N. T., Carpenter, D., Newbill, A. D., & Ojeda, L. (2017). Using an authentic project based learning framework to support integrated geography education linked to standards and geospatial competencies. *Research in Geographic Education*, *19*(2), 36–65.
Solís, P., & Zeballos, M. (2023). *Open mapping towards sustainable development goals: Voices of youthmappers on community engaged scholarship* (p. 382). Springer Nature.

Songer, L. C. (2010). Using web-based GIS in introductory human geography. *Journal of Geography in Higher Education*, *34*(3), 401–417. https://doi.org/10.1080/03098265.2010.487202

Soucy, A. R., De Urioste-Stone, S., Rahimzadeh-Bajgiran, P., Jansujwicz, J., Eitel, K., & Brownlee, M. (2023). Finding hope and fulfillment in meaningful work: An interpretative phenomenological analysis of conservation and stewardship practitioners' experience, values, and motivations. *PLOS Sustainability and Transformation*, *2*(11), e0000087. https://doi.org/10.1371/journal.pstr.0000087

Speaker, T., O'Donnell, S., Wittemyer, G., Bruyere, B., Loucks, C., Dancer, A., Carter, M., Fegraus, E., Palmer, J., Warren, E., & Solomon, J. (2022). A global community-sourced assessment of the state of conservation technology. *Conservation Biology: The Journal of the Society for Conservation Biology*, *36*(3), e13871. https://doi.org/10.1111/cobi.13871

Stedman, R. C. (2002). Toward a social psychology of place: Predicting behavior from place-based cognitions, attitude, and identity. *Environment and Behavior*, *34*(5), 561–581. https://doi.org/10.1177/0013916502034005001

Sun, Q., & Maliki, N. Z. B. (2015 *Sense of place to campus amongst undergraduate students in USM* [Paper presentation]. International Conference on Social Science, Education Management and Sports Education. https://doi.org/10.2991/ssemse-15.2015.44

Tabachnick, B. G., Fidell, L. S., & Ullman, J. B. (2019). *Using multivariate statistics* (Vol. 6, pp. 497–516). Pearson.

Tidball, K. G., & Krasny, M. E. (2011). Toward an ecology of environmental education and learning. *Ecosphere*, *2*(2), art21. https://doi.org/10.1890/ES10-00153.1

Toland, M. D., & Usher, E. L. (2016). Assessing mathematics self-efficacy: How many categories do we really need? *The Journal of Early Adolescence*, *36*(7), 932–960. https://doi.org/10.1177/0272431615588952

Tracy, S. J. (2010). Qualitative quality: Eight "big-tent" criteria for excellent qualitative research. *Qualitative Inquiry*, *16*(10), 837–851. https://doi.org/10.1177/1077800410383121

Vaske, J. J. (2019). *Survey research and analysis: Applications in parks, recreation and human dimensions*. Venture Publishing, Inc.

Vaske, J. J., Beaman, J., & Sponarski, C. C. (2017). Rethinking internal consistency in Cronbach's alpha. *Leisure Sciences*, *39*(2), 163–173. https://doi.org/10.1080/01490400.2015.1127189

Walker, A. J., & Ryan, R. L. (2008). Place attachment and landscape preservation in rural New England: A Maine case study. *Landscape and Urban Planning*, *86*(2), 141–152. https://doi.org/10.1016/j.landurbplan.2008.02.001

Wallgrün, J. O., Chang, J. S.-K., Zhao, J., Trenham, P., Sajjadi, P., Simpson, M., & Klippel, A. (2022). Place-based education through immersive virtual experiences—Preparing biology students for the field. *Journal of Biological Education*, *58*(2), 406–429. https://doi.org/10.1080/00219266.2022.2067580

Wang, N., Stern, R. J., & Waite, L. (2022). Workflow for designing instructional videos to support place-based geoscience education for geoscience majors. *Journal of Geoscience Education*, *71*(1), 107–125. https://doi.org/10.1080/10899995.2022.2093543

Whitmeyer, S. J., & Dordevic, M. (2021). Creating virtual geologic mapping exercises in a changing world. *Geosphere*, *17*(1), 226–243. https://doi.org/10.1130/GES02308.1

Whyatt, D., Davies, G., & Clark, G. (2022). Going solo: Students' strategies for coping with an independent GIS project. *Journal of Geography in Higher Education*, *47*(3), 381–398. https://doi.org/10.1080/03098265.2022.2065668

Williams, D. R., Anderson, B. S., McDonald, C. D., & Patterson, M. E. (1995). Measuring place attachment: More preliminary results. In *Outdoor recreation planning and management research session* (pp. 1–4).

Williams, D., & Semken, S. (2011). Ethnographic methods in analysis of place-based geoscience curriculum and pedagogy. In A. Fieg & A. Stokes (Eds.), *Qualitative inquiry in geoscience education research* (pp. 49–62). Geological Society of America Special Paper 474.

Williams, D. R., & Vaske, J. J. (2003). The measurement of place attachment: Validity and generalizability of a psychometric approach. *Forest Science*, *49*(6), 830–840. https://doi.org/10.1093/forestscience/49.6.830

Yin, R. K. (2018). *Case study research and applications*. Sage Publications.

Young, M. (1999). The social construction of tourist places. *Australian Geographer*, *30*(3), 373–389. https://doi.org/10.1080/00049189993648

Zhao, J., LaFemina, P., Carr, J., Sajjadi, P., Wallgrun, J. O., & Klippel, A. (2020 *Learning in the field: Comparison of desktop, immersive virtual reality, and actual field trips for place-based STEM education* [Paper presentation]. 2020 IEEE Conference on Virtual Reality and 3D User Interfaces (VR) (pp. 893–902). https://doi.org/10.1109/VR46266.2020.00012

Zuckerman, S. J. (2019). Making sense of place: A case study of a sensemaking in a rural school-community partnership. *Journal of Research in Rural Education*, *35*(6), 1–18. https://doi.org/10.26209/JRRE3506