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Instructors use of high leverage practices and tools in environmental service-learning courses

Byung-Yeol Park^{a,b} , Rebecca Campbell-Montalvo^a , Todd Campbell^a , Hannah Cooke^a , Chester Arnold^c , Maria Chrysochoou^d and Peter Diplock^e

^aDepartment of Curriculum & Instruction, Neag School of Education, University of Connecticut, Storrs, CT, USA; ^bInstitute of Integrated Science Education, Dankook University, Yongin-si, South Korea; ^cCenter for Land Use Education & Research (CLEAR), University of Connecticut, Storrs, CT, USA; ^dCivil and Environmental Engineering, School of Engineering, University of Connecticut, Storrs, CT, USA; ^eCenter for Excellence in Teaching and Learning, University of Connecticut, Storrs, CT, USA

ABSTRACT

There has been little scholarship about the use of instructional practices in undergraduate environmental service-learning courses. In this study, we examined the implementation of high leverage practices (HLPs) in environmental service-learning courses (i.e. E-Corps). These HLPs included: eliciting initial ideas, informing approaches to problems, and developing informed solutions. We employed interviews and observations to gather data to investigate the characteristics of instructors' use of HLPs over the course of three academic years, from Fall 2019 to Spring 2022. First, several specific moment-to-moment instructional moves as tools emerged as important when enacting the HLPs (e.g., questioning, making connections between environmental issues and impacts, proposing initial solutions, and considering diverse perspectives). Second, a range of instructional tools were identified (e.g., use of real-world scenarios, group discussions, guest lectures, roleplaying, and presentations to the community). These tools were used in both similar and different ways within the three different E-Corps courses (i.e. Brownfields, Climate Change, and Stormwater) depending on the specific teaching and learning contexts. Findings illuminate the role HLPs can play as anchors for supporting students' environmental service learning as well as instructors' use of tools in the context of implementing HLPs in higher education contexts.

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Introduction

A valuable new educational model of university-community engagement, known as the Environment Corps or E-Corps, combines both environmental education and service learning with genuine community partnerships (Arnold et al., 2021). This model crosses departmental boundaries and discipline silos, and includes courses on remediating brownfields, adapting to climate change, and stormwater management, involving instructors from environmental sciences, environmental engineering, and natural resource management, as well as students from over ten undergraduate programs. Though valuable in its potential to benefit students and communities (Arnold et al., 2021), research on such interdisciplinary environmental service learning at the undergraduate level is only nascent.

Broadly, researchers in science and environmental education have called for education with instructional practices that move away from solely teaching about science and environmental principles and towards student sensemaking and inquiry (Monroe et al., 2019; Windschitl et al., 2012). High-leverage practices (HLPs), or core practices, are instructional routines that encourage maximum student learning across contexts (Ball & Forzani, 2009), including sensemaking and inquiry. Tools are more specific

CONTACT Byung-Yeol Park bypark2025@gmail.com College of Education Bldg, Room 610, 152 Jukjeon-ro, Suji-gu, Yongin-si, South Korea 16890

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strategies used to carry out the practices. HLPs as a pedagogical framework is a useful unit of analysis when undertaking inquiries on environmental service-learning pedagogy since it provides a way to bring forward effective routines, particularly helpful in identifying effective features of new educational models.

We conjectured that instructional strategies, specifically HLPs, for environmental education (Monroe et al., 2019; NAAEE, 2019) and service learning (Salam et al., 2019; Williams & Sembiante, 2022)—the constituent parts of environmental service learning—likely offer a solid pedagogical base on which to scaffold the new E-Corps model. Unfortunately, unlike some discipline-based education research (DBER), it is difficult to identify core practices for environmental education because it spans multiple disciplines and focuses on environmental issues, which are inherently complex. We add that what makes understanding the new model even more complex is that it is a ‘STEM DBER Alliance’, which involves the integration of pedagogical practices from different individual STEM fields (Henderson et al., 2017). In such Alliances, there may be conflict as the pedagogical norms in the various STEM fields come in contact with each other. Our analysis explores effective instructional practices across multiple disciplines of STEM that are using DBER, advancing work on the germane topics of this inquiry given that most DBER focuses on one specific discipline (chemistry, physics, etc.). Indeed, because the Alliance of focus, E-Corps, involves multiple departments, colleges, and offices mobilizing DBER, this study offers an inside look at how core practices can be implemented across STEM disciplines. Thus, our work on this STEM DBER Alliance is poised to inform broader STEM pedagogy given it provides an example that can be used to help fields draw upon the strengths of the individual fields, in addition to synergies between STEM fields (Henderson et al., 2017).

Yet, it is known that identifying environmental issues, investigating the nature of relevant interacting factors, and proposing possible solutions to these complex issues require interdisciplinary thinking (Tovar-Gálvez, 2022; Valderrama-Hernández et al., 2017). Such interdisciplinarity would potentially involve the mixture and rearticulation of core practices across these disciplines. More recently, some core practices have emerged as useful in environmental education, and accordingly include giving students opportunities to engage in interdisciplinary peer-based and problem-oriented collaborative groups as they seek to address environmental concerns (Weber et al., 2021). More specifically, practice-based approaches to learning, whereby students identify local environmental challenges, collaborate with interested parties in communities, and engage in professional problem-solving in real-world contexts in partnership with communities, have been shown to be effective (De Hooge & van Dam, 2019; Salovaara & Soini, 2021).

When it comes to how these difficulties and recent pedagogical innovations might translate to the niche context of environmental service learning, it has been so far demonstrated that identifying effective instructional strategies across courses in environmental service learning benefits from iterative collaboration of instructors (Campbell-Montalvo et al., 2021; Park et al., 2022, 2023). However, what exactly those instructional strategies are and how they are employed in environmental service learning is still unclear. To uncover this, the present study explores the implementation of high-leverage practices in university environmental service-learning E-Corps courses. The specific research questions guiding this work are:

1. How did E-Corps instructors use HLPs to support students’ engagement?
2. What were the specific tools used in these practices?

Examining instructors’ use of HLPs and tools can provide context-specific examples of how instructors support students’ engagement in undergraduate environmental education that can help organize instructional practices. By identifying the specific ways of using HLPs and tools used in this environmental service-learning context, we seek to advance both theory and practice when it comes to the interdisciplinary merging of environmental and service-learning pedagogies. We situate this exploration in the handful of recent studies in environmental service-learning which focused on how instructors identified and refined HLPs (Campbell et al., 2023; Park et al., 2022), understanding the conditions supporting HLP establishment (Campbell-Montalvo et al., 2021), and instructor teaching practices and alterations during Covid (Park et al., 2023).

Literature framing

Two assumptions are embedded throughout this research: 1) service learning benefits students and the community, and 2) when instructors understand the purpose of specific instructional strategies, they can implement them with more fidelity, maximizing student learning. The first assumption comes from decades of research on active, experiential learning, which crosses many contexts. The second assumption comes from research on practice-based K-12 teacher education. We bring these bodies of literature together with the hope that student learning can be improved and made more meaningful in the undergraduate environmental service learning sphere and beyond.

Service learning

While the act of defining service learning has been somewhat ambiguous (Salam et al., 2019), we use Bringle and Hatcher's (1995) definition: 'a course-based, credit-bearing educational experience', where students take action to meet a community need while reflecting on course content and gaining an 'enhanced sense of civic responsibility' (p. 112). There are both benefits and challenges with service learning. On one hand, benefits include supporting students' application of knowledge (Meyer et al., 2016), deepening students' understanding of course content (Dienhart et al., 2016), and developing reciprocity between campus and communities (Olberding & Hacker, 2016). On the other hand, traditional service learning has been criticized for reifying the power imbalance between interested university parties and community partners (Cronley et al., 2015; Dempsey, 2010) and can offer inconsistent outcomes for communities (Gibson et al., 2020; Volchok, 2017). Much of the service-learning scholarship is aimed at practitioners looking to implement programs, while little attention is drawn to the actual classroom practices of instructors. Therefore, we overlay our work upon these guiding principles, advantages, and critiques of service learning as we interpret the HLPs instructors used and how their use unfolded.

High Leverage Practices (HLPs)

The conception of High Leverage Practices (HLPs) in education emerged from the work of the American Association of Colleges for Teacher Education (AACTE) and the Stanford Center for Assessment, Learning, and Equity (SCALE) (AACTE & SCALE, n.d.). It was developed as part of the teacher professional development initiative, which aimed to improve teacher preparation programs and assessment practices. Ball and Forzani (2009) conceptualized HLPs as 'teaching practices in which the proficient enactment by a teacher is likely to lead to comparatively large advances in student learning' and as a set of practices that can 'equip beginners with capabilities for the fundamental elements of professional work and that are unlikely to be learned on one's own through experience' (p.460). Teaching is a complex task that requires content knowledge, pedagogical decision-making, and improvisation. Because of this complexity, novice educators may find it challenging to implement what they see experts doing (Ball & Forzani, 2009). HLPs can promote teachers' development of practices that are supportive of students' engagement in knowledge development and application (Grossman, Hammerness et al., 2009; Lampert & Graziani, 2009) as they represent strategies that are exercised with instructional context-specific judgements (Ball & Forzani, 2009; Zeichner, 2012; Ford, 2008). Because of this, HLPs work best when educators spend enough time to get familiar with each practice, and the number of practices involved is manageable (Windschitl & Calabrese Barton, 2016).

Researchers in special education, general education, and higher education have collaborated to identify effective instructional strategies and adapt them to meet the needs of diverse learners in classrooms from K-12 to higher-education (Grossman, Compton et al., 2009; McLeskey et al., 2017; National Education Association (NEA), 2018). Science teacher education research has documented the benefits of high leverage practices for pre-service science teachers (e.g. Windschitl et al., 2012). Drawing on this body of research, we see HLPs as a way for educators in the cross-departmental E-Corps program to 'speak the same language' about specific teaching strategies.

While STEM DBER is increasing, HLPs, or by extension any non-traditional instructional strategies, have yet to take hold in higher education classrooms (see Apkarian et al., 2021; Shadle et al., 2017). In their systematic review of STEM education, Li et al. (2020) found that only 18 out of 798 publications

Table 1. High Leverage Practices (HLPs) for students' engagement in environmental service learning.

High Leverage Practices (HLPs)	
HLP 1. Eliciting students' initial ideas	Eliciting students' initial ideas activates students' prior knowledge early in instruction in ways that recognize how previous ideas and experiences can serve as assets or stepping stones in developing more sophisticated explanations (Gray et al., 2022; Windschitl & Calabrese Barton, 2016). As part of the HLP of eliciting students' ideas, students present ideas publicly in ways that support them to organize and connect ideas to assess their usefulness, while also expanding the ideas available with which peers in the classroom can work (Windschitl & Calabrese Barton, 2016).
HLP 2. Informing approaches to problems	Informing approaches to problems includes helping students to understand important science and engineering principles, practices, frameworks, and approaches to address environmental issues (Campbell-Montalvo et al., 2021). Connecting content and topics to students' personally relevant experiences (e.g. real-world context) can be central in informing approaches to problems as this HLP supports students to build on their initial ideas (Monroe et al., 2019).
HLP 3. Developing informed solutions	In developing informed solutions, students consider possible solutions to the community environmental issues based on what they have learned. In this, students are supported to revisit their initial elicited ideas (i.e. HLP 1), draw on what they learned as their instructor introduced them to science and engineering principles, practices, frameworks, and approaches to address environmental issues (i.e. HLP 2) to meet the aim of developing informed solutions to environmental problems (i.e. HLP 3) (Park et al., 2022).

focused on 'post-secondary teacher and teaching', indicating a gap in the research. Henderson et al. (2011) systematically reviewed publications pertaining to the implementation of undergraduate STEM instructional strategies, finding that there are several research communities whose members do not consistently 'talk' to each other, including higher education research, science education research, and faculty development. The authors also found that 'top-down' approaches are not effective at creating instructional change. Since that review, DBER has increased significantly but has continued to focus on siloed departments (e.g. Aikens, 2020; Bancroft et al., 2021; Cronin et al., 2021; Gibbons et al., 2018).

HLPs in E-Corps

Teacher education researchers have noted the benefits that come from supporting beginning educators with HLPs in ways that allow them to learn how to apply knowledge of teaching to the contexts within which they will work (Grossman, Compton et al., 2009; Grossman, Hammerness et al., 2009; McDonald et al., 2013). Within the context of this study, we focused on previously identified HLPs for students' engagement in E-Corps (Campbell et al., 2023; Park et al., 2022). These HLPs include: 1) eliciting students' initial ideas, 2) informing approaches to problems, and 3) developing informed solutions (Table 1).

Tools

Within our focus on the application of these HLPs, we consider tools as relevant teaching strategies, materials, activities, and other scaffolds that instructors used to support students' engagement with course content. For example, an instructor's use of a roleplaying activity can be seen as a tool for informing approaches to problems (i.e. HLP 2). More specifically, if the roleplaying activity is focused on preventing and minimizing the impact of sea-level rise in a coastal community, students can gain a deeper understanding of diverse interested parties' perspectives which need to be considered in proposing informed solutions to environmental problems.

Method

Context

As mentioned, this study focuses on the E-Corps program, which includes the following three environmental service-learning courses: Brownfield Corps, Climate Corps, and Stormwater Corps. All courses were taught at the same public research university in the northeast United States. Each of these courses spans two semesters, including an initial classroom semester followed by a second semester internship where students participate in an in-depth service-learning project collaborating with communities to address environmental challenges and needs. E-Corps is unique in that it addresses environmental issues at the municipal level (i.e. helping locales make specific changes) rather than through direct individual action (e.g. picking up litter, planting trees) or at the structural level (e.g. national policy change, advocacy).

In the classroom semester, students investigate real-world scenarios to understand the complexity of and potential solutions for environmental issues. Students collaborate in small groups, read relevant articles, engage with guest lecturers from both the private and public sector, and are supported by instructors with expertise specific to the class focus. Additionally, the practical, social, and economic nuances of the real-world cases are foregrounded in the classroom semester to help ensure that usable solutions to community problems emerge (Arnold et al., 2021). In the two-course sequence, students' ability to solve complex community challenges develops in connection with the instructors' use of HLPs in the first semester and sets the stage for students' work in the second semester.

As part of the grant funding the E-Corps program, faculty members from across these courses collaborated in developing and refining the HLPs that could be used in the courses to build students' capabilities to address environmental concerns. The program was initiated in 2016 and the data was collected over the course of three academic years, from Fall 2019 to Spring 2022. Both the Brownfield and Climate Corps start during the fall semester with the second semester in the spring, while the Stormwater Corps starts in the spring semester with the second semester courses happening the following fall. The course periods and the data collection process can be seen in [Figure 1](#).

Participants

All seven instructors from various disciplines who offered the three E-Corps courses (i.e. two in the Brownfield Corps, two in the Climate Corps, and three in Stormwater Corps) participated in data

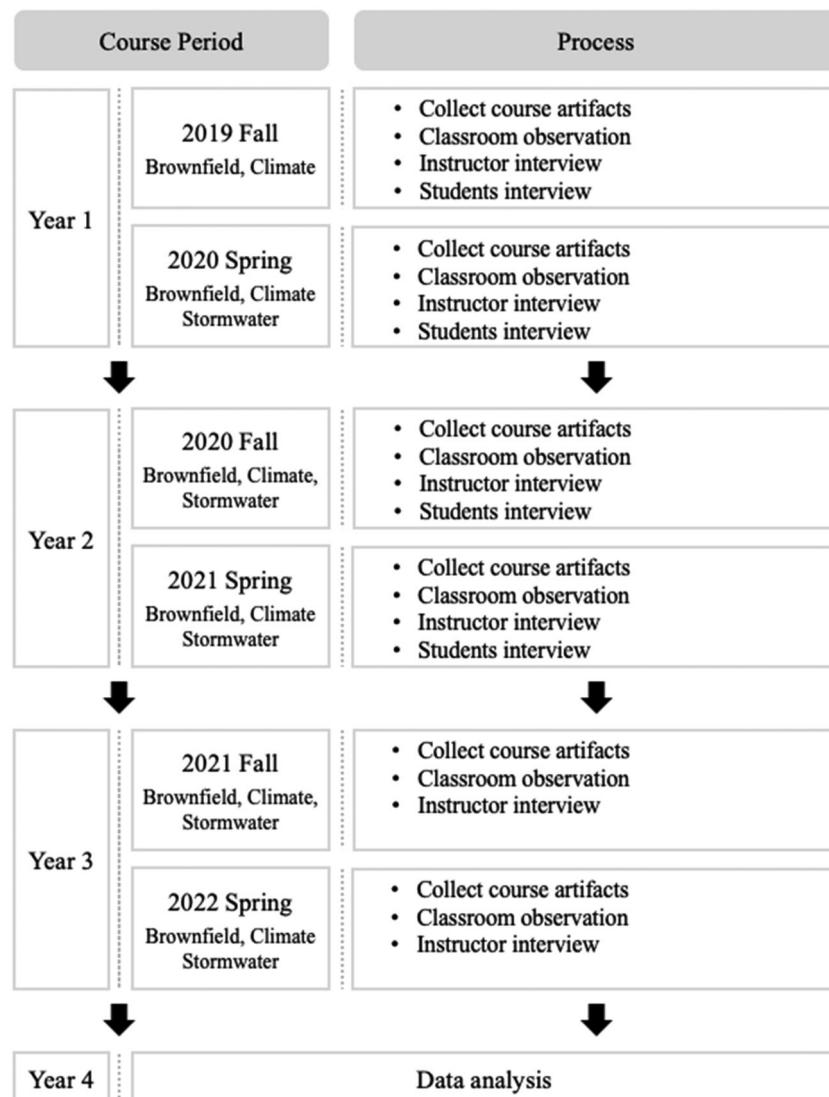


Figure 1. Course period and data collection process.

Table 2. The number of instructors and total student enrollment for each of the E-Corps courses.

E-Corps Courses	Fall 2019	Spring 2020	Fall 2020	Spring 2021	Fall 2021	Spring 2022
Brownfield Corps (two instructors)	23 students	11 students (5 projects)	30 students	13 students (9 projects)	32 students	11 students (7 projects)
Climate Corps (two instructors)	21 students	12 students (3 projects)	24 students	9 students (7 projects)	23 students	14 students (5 projects)
Stormwater Corps (three instructors)		9 students	4 students (4 projects)	14 students	7 students	23 students (6 projects)

collection through sharing artifacts, permitting course observations, participating in interviews, and supporting recruitment of student interviewees. During the three academic years, there were 280 students enrolled in the E-Corps courses (Table 2). In some instances, students enrolled in multiple courses (e.g. Brownfield and Stormwater). Each semester, students from a diverse range of majors (e.g. economics, biology, chemical engineering) enrolled in E-Corps courses. The majority of students enrolled were undergraduate juniors and seniors. Among the students who took E-Corps courses, with instructors' help in identifying students, we used purposive sampling (Welman & Kruger, 1999) to identify student participants willing to share their experiences related to the HLPs. In sum, nineteen students were interviewed during the first two academic years. In accordance with the university's Institutional Review Board, informed consent was obtained from all participants prior to data collection. One of the authors of this study is an instructor for the Brownfield Corps, while another is an instructor for the Climate Corps. The other authors participated in large group meetings focused on course preparation and institutionalization during across the entire research period. More specific details about the number of instructors for each of the E-Corps courses and the number of students enrolled in each semester can be found in Table 2.

Data collection

The data for analysis was collected through four methods: classroom observations, instructor interviews, student interviews, and course artifacts (e.g. syllabus, course assignments, students' final proposal, and presentation examples). With the exception of the Stormwater Corps during its first semester (i.e. Spring 2020), which was observed three times, we conducted two classroom observations for each of the E-Corps courses every semester during the three academic years of the study. Of the 35 classroom observations, because of the Covid pandemic, 17 classes were held virtually while 18 classes were held in-person. One member of the research team was responsible for conducting observations, taking 'what happened notes' (Bailey & Bailey, 2017) to document what happened, what and who was involved, and where and how the activities occurred within the course. At the end of each semester, interviews were conducted by one of three team members with both instructors and students. We interviewed all instructors for each of the E-Corps courses as instructional teams. We also interviewed at least one student from each of the courses in the first two semesters and interviewed two students from each course in the next two semesters. With participants' permission, interviews were audio recorded and transcribed for analysis. The protocols created and revised by the research team were approved by the university's Institutional Review Board and used for the observations and interviews.

As described in the participations section, all seven instructors agreed to participate in data collection and to support recruitment of student interviewees. Instructors suggested one or two students for each of the courses and all of the 19 invited students agreed to participate in an interview. Informed consent from all participants were obtained before observations and interviews were completed. As secondary resources for analysis, we also collected artifacts (e.g. course materials including syllabi and hand-outs, or artifacts emerging from student activities) from the instructors. The details of the data collection methods, type of participants or data sources, and method of recording the data can be seen in Table 3.

Data analysis

In this study, we focused on HLPs previously identified including 1) eliciting students' initial ideas, 2) informing approaches to problems, and 3) developing informed solutions (Campbell et al., 2023; Park

Table 3. Data collection methods, type of participants or data sources, and method of recording.

Data collection method	Type of participants or data sources	Number	Method of recording
Classroom Observation	Two Brownfield observations each semester (Fall 2019-Spring 2022)	35 times (17 online, 18 in-person)	Fieldnotes
	Two Climate observations each semester (Fall 2019-Spring 2022)		
	Three Stormwater observations in one semester (Spring 2020),		
	Two Stormwater observations each semester (Fall 2020-Spring 2022)		
Instructor Interview	One-time interview with all instructors for each course in each semester (Fall 2019-Spring 2022)	17 times with 7 instructors	Audio recordings, transcription
Student Interviews	One Brownfield student: Fall 2019	18 times with 19 students	Audio recordings, transcription
	Two Climate students: Fall 2019		
	Two Brownfield students (as a team): Spring 2020		
	One Climate students: Spring 2020		
	One Stormwater student: Spring 2020		
	Two Brownfield students: Fall 2020		
	Two Climate students: Fall 2020		
	Two Stormwater students: Fall 2020		
	Two Brownfield students: Spring 2021		
	Two Climate students: Spring 2021		
Artifacts	Two Stormwater students: Spring 2021	20+	Paper and electronic copies
	Course syllabus, activity descriptions, hand-outs, student project write-ups, student final presentation slides, etc.		

et al., 2022) as a unit of analysis to understand how E-Corps instructors used HLPs and tools to support students' engagement in learning.

To analyze the observation fieldnotes, interview transcripts, and artifacts, we used an adapted version of Groenewald's (2004) phase strategy. In this, initial *a priori* codes were developed from the constructs of the HLPs (Park et al., 2022) and used to identify units of meaning within the data. In connection to the research questions, the units of meaning are the statements or actions identified from the fieldnotes or interview transcripts that were thought to reveal the characteristics of instructors' use of the HLPs or their use of tools during HLP use. After identifying the units of meaning, three researchers discussed the their meaning within a classroom context in which they were found.

Beyond the initial *a priori* codes, additional codes were created based on the constant comparison method (Glaser & Strauss, 1967; Strauss & Corbin, 1990) as additional important units of meaning arose that could not be coded with the initial codes (Appendix A, Table A1). Three researchers independently coded the interview transcripts and discussed disagreements on the codes and refined the codebook. Initial coding results were used to calculate intercoder reliability (ICR), and an average ICR value of 0.82 across the three researchers was obtained—an acceptable agreement value between coders (Bernard, 2011; Krippendorff, 2003; Landis & Koch, 1977). One of the three researchers then used the same codebook to organize the classroom observation fieldnotes and artifacts.

Next, the units of meaning initially identified were reviewed and clustered based on their meanings within the context (Groenewald, 2004). The clustered 'units of meaning' were combined and represented the initial overarching themes (Braun & Clarke, 2006). In the next stage of analysis, a descriptive narrative for each of the courses was created to reveal the patterns of instructors' use of the HLPs. For this, we worked to develop coherent, logical, and concise stories across the themes to create descriptive narratives as a foundation for further argument (Braun & Clarke, 2006). In the final stage, we revisited the research questions to synthesize across cases (i.e. courses and semesters, Stake, 2006). To ensure accuracy of understanding in relation to the units of meaning that emerged as part of our data analysis, we recursively revisited the raw data sources (e.g. fieldnotes, transcription, audio recording, and other artifacts) when/if ambiguity or disagreements related to the meaning of a particular unit of meaning arose.

Findings

Two themes relating to the research questions are seen in the organization, clustering, and analysis of data. First, we identified the ways instructors used HLPs in their courses. Second, we were able to see how instructors used tools (e.g. real-world scenarios, group discussions, guest lectures, roleplaying, and

Table 4. Instructors' use of HLPs and related tools.

HLPs	Instructors' Use of HLPs	Tools for HLPs
HLP 1. Eliciting Students' Initial Ideas	<ul style="list-style-type: none"> • Connecting environmental issues to human activity • Asking questions to identify and share students' prior knowledge related to the issue • Encouraging students to share initial suggestions or possible solutions to issue based on prior knowledge 	<ul style="list-style-type: none"> • Real-world scenarios • Guest lecture • Group discussion • Assignments designed with intention
HLP 2. Informing Approaches to Problems	<ul style="list-style-type: none"> • Providing relevant information in problem solving context • Providing opportunities to see various perspectives on the issues • Encouraging students to use a professional assessment or analysis software (e.g. GIS software in Stormwater Corps, online mapping tool in Brownfield Corps) 	<ul style="list-style-type: none"> • Roleplaying • Guest lecture • Direct connection to the relevant resources
HLP 3. Developing Informed Solutions	<ul style="list-style-type: none"> • Supporting collaborative work with communities • Encouraging students to connect what they do and communities' needs 	<ul style="list-style-type: none"> • Group project • Peer assessment • Presentation to the community

presentations to the community). While the HLPs were each found across the courses, the identified tools were used in similar and different ways depending on the teaching and learning contexts.

Instructors' use of HLPs and related tools

Through the HLPs, students developed possible solutions to the communities' environmental challenges. HLP 1, Eliciting Students' Initial Ideas, mainly occurred in the first semester. HLP 2, Informing Approaches to Problems, happened throughout the first and second semesters. HLP 3, Developing Informed Solutions, was mainly observed in the second semester in terms of developing and finalizing students' learning outcomes. This aligns with the stated purpose of the second semester of the E-Corps courses as being to complete the group project. Overall characteristics of instructors' use of HLPs and identified tools for HLPs can be seen in **Table 4**, with further details provided in the following sections.

HLP 1: Eliciting students' initial ideas

The first HLP was used to help instructors and students see initial ideas as assets that can be built upon and shared as part of addressing the communities' environmental challenges. This is also useful for helping students see how their ideas evolve over time (Park et al., 2022). There were several ways instructors used this HLP to support students' learning: providing real, local examples, the use of questioning, and brainstorming possible solutions.

First, instructors made connections between environmental issues and their societal and environmental impacts. Through examples familiar to or experienced by students, instructors provided opportunities to think about why and how the issues happened and how they might be resolved. For instance, the following excerpt of fieldnotes from classroom observation in Spring 2020 for Stormwater Corps demonstrates how instructors used a low-stakes handout to guide students to elicit their initial ideas about the issue. The handout described a local flood caused by stormwater runoff that happened several years ago with relevant information. Note how the handout explicitly asks students to come up with options for addressing the problem:

It positions students to solve this problem: 'You have been hired by the [city name] to study this problem and come up with recommendation for solving it'. The document contains four questions to support discussion of possible solutions:

1. Based on the information provided above, what options can you come up with to address the flooding problem in this watershed? Try to come up with multiple approaches.
2. What constraints (political, social, economic, physical) do you think there might be on any of the options you identified above?

3. What additional information would you like to have about this watershed to help you make recommendations amongst the various options identified above?
4. Who (in town and beyond) would you like to talk to as you develop your plan for this problem?

Students were divided into two groups (four in one and three in other) and they discussed possible options for solving the problem and to answer the questions ... During the discussion, students shared stories they experienced in their town or heard from other cities as examples. Each student shared their own understanding and ideas about the issues.

Second, instructors often asked students questions to help them identify and share their prior knowledge related to an issue. Fieldnote excerpts from the Stormwater Corps in Spring 2020, both during and after the group discussion, revealed how instructors asked questions to clarify students' thoughts. Through this questioning process, instructors went further to share additional examples (e.g. how other cities work to support residents' participation in activities to prevent flooding, suggestion to create a newsletter) or offer advice that students might not have considered (e.g. use historical aspects to get more financial support or funds, contact town and community organizations to do something).

Another example of how instructors' questioning played an important role in eliciting students' ideas can be seen in the following fieldnote excerpt from Climate Corps in Fall 2019. This instance included a roleplaying activity:

During the discussion, each student tried to convince others based on evidence from the known facts and their own experiences. The questions students asked requested clearer evidence and often pointed out how others' opinions could be inaccurate. During the activity, instructors also participated by asking questions ... The questions from instructors provided broader aspects or diverse perspectives that students did not initially focus on. Instructor questions sounded like simple questions, but played an important role as guidance for the classroom activity.

Third, instructors also asked students to suggest an initial solution to the issue based on prior knowledge. Through the development of possible options to address environmental challenges, students were able to consider what they already knew and what additional information or resources might be needed. Further, instructors used students' initial ideas to guide the rest of the course in ways that provided more meaningful learning opportunities. An example of how this happened can be seen in a fieldnote excerpt from an observation of Stormwater Corps in Spring 2020:

The activity sharing what students have initially offered as solutions looks like it provides meaningful information to the instructors about what and how students actually understand stormwater issues, as it gives pictures of students' initial understanding. The instructor collected the completed worksheet on which students had filled out answers to the questions. The instructor mentioned that they gathered this worksheet back to compare and see how students' understanding of the water-related issue changed over the course. This might be the way to let students notice the importance of comparing their initial and final understanding about the topic.

Triangulated across observation, interview, and artifact data, eliciting students' initial ideas were used at the beginning of the first semester for all three E-Corps courses to understand students' prior knowledge and guide coursework that followed. This provided students a chance to see how their initial ideas evolved over time.

Tools. Instructors used four main tools to elicit students' initial ideas: real-world scenarios, guest lecture, group discussion, and intentionally designed assignments. First, instructors used real-world scenarios to support students' sense-making of the environmental challenges that communities experience. Specifically, instructors identified community challenges during their course preparation through gathering information about what has historically happened to towns or searching recently published articles. This information was used to create a real-world scenario as a starting point for students' learning. Interviewee Charles (all names used throughout are pseudonyms), a student who took both Climate and Stormwater Corps in 2019 and 2020, shared how real-world scenarios helped him learn during the courses:

I think both of [the instructors] did a very good job of relaying real-world examples to us. I know my stormwater class did it a lot, as well as my sea-level rise one [Climate Corps] talking about how these different cities are impacted. I know in my sea-level rise class we talk not only about [local] towns and the politics in them or personal experiences the professors had with them ... The issue of sea-level rise is so important, but you have to understand it in the context that it's not just happening in one city. It's happening in hundreds of cities along the coast.

This quote provides an example of how instructors supported learning with authentic examples by providing students contextual understanding.

Secondly, guest lectures were used for sharing information about environmental challenges. Guest lecturers were not only invited from the community but also invited from other academic areas across campus to share the most recent research related to the issues identified. For example, Climate Corps had guest speakers discuss the implications and outcomes of low-impact development plans. More specifically, fieldnotes from observation showed that the Associate Director of the state Sea Grant organization was invited as a guest lecturer and shared the impacts of storms with high winds and flooding to a coastal town, and discussed possible solutions. Likewise, Brownfield Corps instructor Phaedra described in interview, 'We had some lectures, we gave the students the overview and background of environmental pollution, what is the development. And then, guest lecture[r]s come into the course to talk about their field and how they plan what they do essentially in their careers'.

Thirdly, instructors used group discussion to support students in sharing ideas about the issues. An example of how student discussions were organized can be seen in the fieldnote from the classroom observation of Climate Corps in Fall 2020:

This group discussion of a particular case of a coastal storm and flood disaster seems to allow students to think about and share possible reasons coastal residents decided to leave or stay. This activity was conducted before the instructor's guest lecturer, the Associate Director of the [local] Sea Grant, provided a specific explanation about the issues. The sequence [group discussion followed by guest lecture] helped to bring forward students' initial thoughts.

Importantly, the order of the discussion followed by the guest lecture enabled students to develop initial thoughts with which the lecture followed up.

Lastly, instructors intentionally designed assignments to effectively elicit students' ideas. As an example, according to the syllabus, assignments in Climate Corps included searching a current news article on climate change, discussing potential management options, and summarizing students' opinions about different adaptation strategies (Figure 2).

In addition, instructors combined assignments and tools (e.g. discussion and guest lecture) to elicit students' ideas. For example, one of the assignments for Climate Corps asked students to connect their thoughts to what they learned from the guest lecture, 'Write a two-page, double spaced essay on: What were your reactions and takeaways from the guest lecture? What are your thoughts on hurricanes and

Week 3 September 16, 2021 Instructor [REDACTED]

- Sea level rise (continued); Environmental Solutions (Gray to Green Continuum)
- Sea level rise viewers
- Role Playing Exercise Discussion – everyone will have **one minute** to introduce their role playing character and position. (Consider forming alliances!)

Assignment for Week 3 Due 09/21/21

Find a current news article pertaining to sea level rise in the United States. Provide article title/author/source. Summarize the article in a paragraph. Explain in detail the **impacts** of sea level rise. Discuss potential management options and your opinions on different adaptation strategies. Come up with 3 questions that this article leads you to ask and why are you asking these? Write a 2 page, double spaced paper for this assignment. Submit pdf or word doc to [REDACTED].

Figure 2. Screenshot of the syllabus for climate corps.

evacuation? Under what circumstances would you evacuate or not evacuate your residence?' Similarly talking about the combination of assignments and tools to elicit ideas, student Anna from Climate Corps in Fall 2020, described in interview how particular tools were used in important ways within the class to elicit student ideas:

We started having assignments too, and those assignments were similar to the other assignments I was telling you about where there is some openness of how you go about it and what you want to talk about, and the solutions or ideas that you want to propose. That was great. Then, in the class, especially with the guest speakers, sometimes, we'd have something where we'd go into breakout rooms or we pop ideas in the chat and we could go about it that way. I'd say that the main way that they ask for ideas was through the assignments or in class if we had a guest speaker.

Anna indicated that the assignments, guest speakers, and group discussions were important to her learning in the class.

HLP 2: Informing approaches to problems

The second HLP was used to help students consider relevant information and various ideas, perspectives, and strategies to address community environmental challenges. First, instructors provided students with relevant, practical information in a problem-solving context. In other words, the information (e.g. remediation techniques for brownfields or green infrastructures for stormwater issues) that could be used to address the environmental challenges was introduced alongside the advantages and disadvantages of its applications. For instance, during an interview, Charles described the courses helped him to understand and respond to the issues:

I think the model of each course, especially [Climate Corps], tried to impart on us was that the only thing you can really do is be an informed consultant. You have to allow both the community to determine their own future, but you also have to be informed enough to give the pros and cons of every option. I think that the uncertainty of it, especially with the sea-level rise class, they try to make us understand that you can't plan for everything. The best thing you can do is lay out all the information and move on from there, using the ideas or model you operate under to try to understand where these different people are coming from.

He noted that the advantages and disadvantages of various solutions were important, but he also shared that the community would be making the final decision.

As another example, a student from Fall 2020 Stormwater Corps, Peter, shared how the site visits helped him better understand matters as he was guided by instructors to be more informed of issues and consider possible solutions. In addition to understanding how relevant techniques or solutions can be applied, students were engaged in learning opportunities to think about what issues remained and what might still need to be considered:

We all, as a group, went to the town and met at the location. Then we walked around, looked at the different sites, and talked about the pros and cons with the instructors [asking], 'Okay what kind practice would be best here?' We had some insights in mind that they would tell us if that would be good or 'Oh, that wouldn't work'. Then there would also be other sites that maybe we didn't notice when looking at online imagery and all that, and we'd be able to see those sites would work, then we could include them into our presentation.

Seeing the site in-person helped students understand the specific problem in the local context and provided an authentic backdrop for useful techniques.

Second, instructors provided students opportunities to see various perspectives on the issues. As noted earlier, Charles mentioned how important it was for students to be knowledgeable about the concern they were addressing—he described how the instructors used roleplaying to have students consider different perspectives as they took on the roles of community members with different positions:

I think to tackle that uncertainty, they'd use the [town] council model of having us all talk in very different ways than many of us think. I would say most people in that class have the same model of thinking around sea-level rise. Making us challenge ourselves and our beliefs to really address that a classroom setting is not how most politics or towns operate. It is a very contentious, varied opinion setting. I think that can only be done by making us go out of our comfort zone and take on personas that were very different from our own.

In another case, Laura, who took Climate Corps in Fall 2019, likewise described how the roleplaying activity helped her to understand various perspectives:

The fact that I was able to take this course is really cool because I want to get involved in more politics and political things when I get older. It really helps to show me what goes into that especially with this last thing we just did, this roleplaying exercise ... I just am about the climate, about a lot of things and so my character that I had to play was [less-so]. It really helped me get into the headspace and buckle down and understand where other people are coming from. I think it's going to help me especially with Thanksgiving break talking to relatives. I think it's going to help me a lot to take a step back and think of their perspectives more, which I thought was important especially since I want to go into public office. I think it's important to have that perspective.

Laura described how the roleplaying activity was an opportunity to see something from another person's view, which she believed would help her both in her future career trajectory and in her own personal life.

In addition, other activities, such as guest lectures by faculty members from other departments or community members (e.g. town planner, researcher, revitalization expert, or environmental consultant), provided students with practical learning experiences to see examples of the relevant techniques and actual community problems from someone actively working in the field. Here, Kathy, a Brownfield Corps student in Fall 2019, shared her thoughts on guest speakers:

I also like the guest speakers. We had those almost every single class. It was nice to hear from people who are actually out there working on the stuff we're learning about ... I think me and everyone else, we really like the guest speakers. I guess that wouldn't be required for a class like this, but I almost think it would be nice to put that into maybe the science one, because the guest speakers are different from the community members as far as I am seeing.

Guest speakers shared authentic experiences on topics relevant to the class in which students found real, usable meaning. Kathy went as far as to say, 'Definitely one of my favorite parts of the class were guest speakers'.

Third, instructors encouraged students to use professional assessment or analysis software, such as GIS software in Stormwater Corps and an online mapping tool in Brownfield Corps, as part of developing possible solutions. For instance, Charles shared how the use of software helped him to address environmental challenges:

The Climate Corps instructors offered a lot of technical skills. Specifically, in the internship class, they had people who were offering to teach us ArcGIS skills on stormwater maps ... I feel like by the end, I was really able to see where I did come from in my understanding of stormwater infrastructure and sea-level rise. All the skills they taught me, beforehand, I wouldn't have been able to even comprehend what they were ... In the stormwater class, we did rapid GIS assessments on our high schools. We also used programs that allowed us to look at watersheds and how they come together, implementation of rain gardens in different places on campus, understanding how to measure roof runoff. There was another one where we tried to understand the impact from putting green infrastructures on certain buildings and how that would affect their overall contribution to stormwater ... Simply their teaching, by the end, I'm able to use different methods, different software to arrive at the conclusion. I think they gave us the tools and the framework to allow us to do these things, instead of giving us like, 'Oh, you could do this' and trying to see where we could.

These technical skills were an important part of students' development of potential solutions.

Tools. The tools instructors used to inform approaches to problems include roleplaying, guest lecture, and direct connection to the relevant resources. First, the roleplaying activity was used to foster students' understanding of various perspectives related to the environmental issue. Specifically, instructors tried to help students think critically by considering varied and particular points of view. Providing further detail, in an interview, Climate Corps instructor Scott described how they implemented roleplaying in Fall 2019 in an effort to help students understand where different interested parties were coming from:

The overall thing that we're trying to achieve is to make the students think for themselves, rather than telling them. What we try and do is to give them some things to think about and then put them in a position where they have to incorporate that into the exercise that they're doing. For example, in the roleplaying exercise, they took what we had taught them at the beginning of the semester to the middle of the

semester, and incorporated that into their testimony into the questioning [in the roleplaying activity], and they did an outstanding job staying in character. We have some students who are rabid environmentalists, and we put them in [positions generally less directly supportive of environmental mandates]. One of the other comments we've gotten from a number of students was this sort of exercise helped them understand how it's important to look at somebody else's point of view, and ... that just because you have a different point of view doesn't mean that you're a bad person or that you're wrong.

Second, guest lectures were a tool used for informing approaches to problems (i.e. HLP 2), even as they were also used for eliciting initial ideas (i.e. HLP 1). Guest lecturers were invited not only from other departments and disciplines across campus, but also from outside the university. The topical range of expertise of community guest lecturers was relatively wide. As detailed earlier, guest lecturers provided more in-depth information or knowledge about particular topics, especially when the instructors' expertise in a particular area might be limited. For example, Climate Corps instructor Elisabeth mentioned how guest lectures helped them to support students' learning about environmental and climate justice:

We're going to bring in a speaker to talk about environmental justice and climate justice because this group responded so well to discussions throughout. What we did is we gave students a few definitions of 'Here's environmental justice, here's climate justice'. Then we had some questions and we put students into breakout rooms. I think we were learning from them from their perspectives, and I think they did a really nice job.

As additional evidence for this, Fall 2020 classroom observation fieldnotes in Brownfield Corps indicate how guest lecturers shared resources for students' understanding the history of particular brownfield area:

The guest lecturer who deconstructed and redeveloped the sites (e.g. residential areas and facilities) for many years as an Economic Development Director provided resources (e.g. photos and stories) and explained how this area has been changed from farms, wetlands in the 1850s to industrial use, and he explained how the Mosquito Epidemic did impact the area and people's life ... The guest lecturer explained the ways in which they redeveloped the community area with his own experiences in the program as a community member and as an expert.

This excerpt exemplifies how the invited guest lecturers afforded students more opportunities to understand the community's perspectives in relation to real-scenarios, along with the historical developments of particular sites and how happenings had impacts down the road that needed to be considered.

Third, instructors provided students with a direct connection to relevant resources. More specifically, students were able to access the resources that informed their approach to solving problems. For example, students visited the actual sites for investigation to see the specific problems of communities or to see examples of the applications of relevant techniques, like the use of rain gardens to mitigate stormwater runoff. Additionally, community involvement and interactions helped students address real-world challenges by being more informed about local needs and relevant expertise and perspectives. The fieldnotes from the observation for students' independent study in Spring 2021 in Brownfield Corps provide additional insight into the importance of directly connecting students to relevant resources in communities:

Instructor supported student to have resources (e.g. software using guide, articles from the local newspaper and related information or website) that might be useful for students working on the project, and to make connection between community members and student by sharing contact information of community coordinator of the town office and resident that can help student have locally relevant information and additional support from the field experts. This seems like an example of HLPs which indicate that instructors supports with informing approaches to problems and providing information as much as possible and as needed, while also helping students better understand how to use information to address the problem.

These instructional strategies were used not only to promote their informed approaches (i.e. HLP 2) but also to support students' development of informed solutions (i.e. HLP 3), which we turn to next, as part of the two-course sequence for each E-Corps course.

HLP 3: Developing informed solutions

Instructors implemented HLP 3 as they helped students develop informed solutions through supporting collaborative work with communities, guiding students to apply what they learned to meet

communities' needs. For instance, student group projects focused on identifying environmental problems, assessing current contamination status of sites, devising redevelopment plans for a contaminated area, providing the newest information to the community, and providing suggestions for revitalization or low-impact redevelopment. Final project foci and outcomes depended on students' interests and communities' needs.

This was well evidenced in Brownfield Corps, where students developed Environmental Protection Agency [EPA] grant proposals with instructor and guest lecturer support during the first semester. Proposals were submitted to the EPA for consideration after having first been presented in class to a panel of judges consisting of two instructors and two environmental experts external to the university to solicit comments and advice. Brownfield Corps instructor Phaedra described how the projects unfolded throughout the course during the interview in Spring 2020:

We actually do the real-life project starting from semester one. The students interact with the municipal official ... They are developing their grants so they definitely need a lot of information from the town to do that ... The town officials come to the class at least once or usually twice per semester or we visit the town. The rest of the communication happens through email or through call.

During interview, student Jeff provided additional details from the student perspective about how this played out in Brownfield Corps during the Fall 2020 semester:

Our specific project was dealing with a cleanup grant for a local mill building. It is in an Opportunity Zone, so the city really wants to redevelop that area to stimulate the economy, make it safer for residents and the environment—which is a really big aspect of this that was hammered into our brains by the instructors. I liked that we had a specific project, and it wasn't just some random assignment. This local cleanup grant was cool because I got to visit the site, I got to take pictures of the site, and walking around, you could just tell there was a need for this ... We got to work with local officials in those smaller group meetings and they explained to us really what the problems were, what the obstacles were, why things like this take so long, and I really enjoyed that.

For the students' group project, instructors prioritized the ways in which students addressed the needs of the community, as they tasked students with applying knowledge and skills to the situation. During the Fall 2019 interview, instructor Scott shared an example of why the communities' needs are an important part of group projects, by saying, '[In one community the students are] doing a beach resilience plan to deal with sea-level rise for the town border. In another city, they did a neighborhood vulnerability assessment to determine what's going to happen to that neighborhood if sea level rises ... One community wanted to get involved in the community rating system'. In relation to this, he also described how he wanted to connect communities' needs to students' group projects:

The important part from my perspective is that we want to have projects that the municipalities can actually use, [and not just] from a planning perspective. I wish I had a nickel for every plan that was done and stuck on a shelf and never looked at again. What we're trying to do is to do real world things that the students do, that the municipalities can use in their everyday operations, and what they would normally do.

This interview excerpt reveals how students' group projects were closely tied to the needs of communities. This also foreshadowed how the proposed solutions as part of the group projects were shared with communities.

More specifically, at the end of the semester, students presented their project to the community they served. Most of the towns had significant interests in collaboratively working with students and having practical outcomes (e.g. revitalization, redevelopment, or renovation plans to manage their environmental challenges). Fieldnotes from Fall 2020 Stormwater Corps—the internship semester for this class—captured how many interested parties participated in the student final presentation meetings, such as the town's land use planner, parks and recreation director, director of the public works, project management specialist, chair of the planning and zoning commission, civil engineer, and even the first selectman¹. As shown in the fieldnote excerpt, conversation between students and interested community parties during the final presentation provided useful feedback to both students and the community.

Comments from town Interested Party 1, I am most excited about, besides their functions, the educational aspects with some infrastructure. Some of the options students presented (e.g. rain garden and riprap channel) were actually considered before to solve the runoff problems at the lower part of Town Hall. But, we

didn't know whether these other infrastructures could coexist. I feel this might be really nice to showcase as a sort of management.

In response, students mentioned they had one concern with placing something in this spot because of the erosion and the runoff. And the type of grass, low fertility, high compaction area issues should be considered.

Interested Party 2 from the town, Looking at the past, some of the ideas of putting rain gardens at the edge of the parking lot were considered. I didn't know about the concept of how the catch basin would work over rolling snow nor about how flows and streams get flooding into the main load.

In response, students explained some details about how they went to the site and investigated.

As documented in our fieldnotes, at the end of the presentation, participants from the town expressed satisfaction and appreciated what students and instructors provided as a resource for them to solve the problem. They also pointed out how the presentation and the information would be a great resource to make decisions in addressing this issue.

Tools. For students to develop informed solutions (i.e. HLP 3), instructors used three tools including the format of students' group projects, peer assessment, and presentations to the community. First, the format of students' projects allowed them to address community needs in that the deliverable of the project was to contain a written report. Specifically, the final outcomes of the project were diverse as they included site assessments, revitalization or redevelopment plans, providing the most recent updates to the community related to the environmental challenges, and others. These project outcomes were aligned to the community's needs (e.g. instructors contacted towns for course preparation and interactions between students and the community during the project further served to make sure the community needs were central in projects). Related to this, one of the Stormwater Corps instructors, Dan, described during the interviews in Fall 2020, how community involvement was around what the students' group projects were arranged:

I think the interaction is the biggest one ... We had [the project focus] filtered in the towns a little bit more during the process as a whole. We talked to the towns in the beginning of the process, we asked them for what's going on in town, for recommendations. Then, at the end, we show them [students'] completed work ... Intervention in the middle there, after the students who've been out to visit, to have a follow-up question and answer session where they can ask more questions about their site, and start to talk about the ideas that they have for that site before they get into their final project preparation.

Second, for group projects, instructors used the tool of peer assessment to support students' effective collaboration and management of group work. Instructors encouraged students to be cooperative with each other and responsible for the project. This peer assessment helped instructors work on the course management (e.g. grading fairly and improving participation). Bridging disciplines, Stormwater Corps instructors even adopted a peer evaluation tool from Brownfield Corps as it worked well in keeping students accountable to each other and group project management.

Third, through the final presentations, the outcomes of the group projects were presented to the community at the end of the course. As previously revealed, many interested parties from the community were captivated by student projects and participated in the final presentations. For example, Jeff shared his experience with the final presentation as follows:

I think we were fully supported. I know that we got really good feedback from not only our professors but when my group did the presentation. There was good feedback from the judges ... They saw that we worked really hard and it feels nice when people that are professionals notice when you've done the work that was required of you and more, which we definitely did.

This excerpt demonstrates how having opportunities to present their work and hear feedback from the community provided students with more authentic learning experiences in the service-learning context.

Discussion

We examined undergraduate instructors' HLP implementation in environmental service learning. For this, interviews, observations, and artifacts (e.g. syllabus, hand-outs) were analyzed to illuminate the specific

ways HLPs were carried out in three courses (i.e. Brownfield, Climate, and Stormwater Corps), including the use of specific tools (e.g. use of real-world scenarios, group discussions, guest lectures, roleplaying, and presentation to the community). Instructional strategies for the HLPs were seen during the classroom observations and discussed in instructor and student interviews, highlighting how students' learning opportunities during the E-Corps course were designed for the linkage between students' learning and ensuring community partners' benefit.

These findings provide important new insights into how HLPs and tools that support their implementation can serve as building blocks of mutually beneficial service learning, because they engage students in meaningful and authentic environmental learning. The core practices and tools were implemented in three distinct environmental service-learning courses across disciplines. This supports the notion that specific instructional practices can be used in a variety of contexts in undergraduate environmental education, rather than reliance on discipline-specific practices. Henderson et al. (2017) call for this alliance between STEM disciplines in order to improve undergraduate teaching and learning for all. More specifically, learning engagement can occur within an individual discipline, but might be facilitated by core practices that are key practices across relevant and related disciplines. As a core set of practices, HLPs can increase the effectiveness of instructors' teaching and students' learning (Windschitl et al., 2012). Specific ways of using HLPs and tools revealed in this study provide instructors with examples of teaching strategies, especially in connection to service learning focused on addressing environmental challenges. Although HLPs identified in this study focused on specific content and contexts (i.e. Brownfield, Climate, Stormwater Corps), we believe our HLPs might also be useful beyond a focus on this content and these contexts for interrogating broader disciplinary foci and extended ranges of contexts in higher education and service learning settings.

Teaching is challenging, and teaching about multidimensional, multi-scalar environmental issues in the context of a university-community partnership adds another layer of difficulty. While existing literature has highlighted the challenges of teaching about environmental issues (e.g. Monroe et al., 2019; NAAEE, 2019), this study focuses on the practices and tools as a set of strategies that are highly useful across diverse contexts of environmental service learning. Educational approaches to support students' understanding of the complex nature of environmental issues are important, because they connect students' learning to problem-solving in real-world contexts.

Related to this, researchers have also previously recommended that learning opportunities be provided through interdisciplinary peer-based or problem-based group work, collaboration with communities or interested community parties, and engagement in professional practices in real-world contexts (De Hooge & van Dam, 2019; Salovaara & Soini, 2021), all of which are foundational to the HLPs and tools investigated in this research. Given the challenges of educational approaches to environmental issues, our findings reveal how educators can work with and on HLPs to support student engagement in the context of environmental service-learning courses.

Specifically, the three HLPs, 1) Eliciting Students' Initial Ideas, 2) Informing Approaches to Problems, and 3) Developing Informed Solutions, played a role as the supportive anchor in guiding instructors' instructional approaches and their use of tools. Real-world scenarios, guest lectures, group discussions, and intentionally designed assignments were used to elicit students' initial ideas (i.e. HLP 1). Roleplaying, guest lectures, and direct connection to relevant resources were used to inform approaches to problems (i.e. HLP 2), and group projects, peer assessments, and presentations to the community were used for developing informed solutions (i.e., HLP 3). HLPs can be used to activate students' prior knowledge, to help students understand important principles, approaches, and practices in related disciplines, and to support students in suggesting possible solutions to community environmental issues (Campbell-Montalvo et al., 2021; Gray et al., 2022; Park et al., 2022; Windschitl & Calabrese Barton, 2016). What was shared in the findings about instructors' and students' teaching and learning experiences illuminated how HLPs and tools effectively supported educators and learners within the environmental service-learning context.

What has been revealed in this study provides insights into the educational approach for environmental service learning to benefit both the students and community partners. Previously, researchers highlighted the mutually beneficial nature of service learning in general (Bringle & Hatcher, 1996; Salam et al., 2019). Consequently, the findings of this study revealed that the collaborative and supportive

relationship between the institution, students, and communities can certainly stimulate student learning and meet real-world community needs in support of environmental progress. These relationships with communities provided students practical interactions with and useful feedback from the community.

Further, course activities provided students opportunities to apply what they learned to address issues in the real-world contexts. Moreover, it was revealed that students valued the learning and experiences they were afforded, while communities were also supported in meaningful ways. This is aligned with the complementary aims for service learning that other researchers have highlighted (Meyer et al., 2016; Olberding & Hacker, 2016). Finally and importantly, this research also adds to the literature related to the needs of communities as part of service learning, and the lack of research investigating community-university partnerships (Butin, 2003; Cooke et al., 2023; Cruz & Giles, 2000).

Limitations of this work resides in how student interviews were conducted with only a portion of the students participating in the courses, something that we recognized could potentially limit the representation of all students' opinions and experiences. However, efforts were made to mitigate this limitation by analyzing other data from instructor interviews, classroom observations, and associated artifacts. Another limitation is that we were unable to collect a more diverse and extensive set of data on the effects of service learning with HLPs on communities, from their perspectives. Consequently, we believe future research should focus on the perspectives of community partners in community-university partnerships. As such our work has already begun in this area.

Conclusion

Our previous work includes the conditions for the establishment of collaboration around instructional approaches, the development and implementation of HLPs, and community-university relationships in association with the E-Corps model (Campbell et al., 2023; Campbell-Montalvo et al., 2021; Cooke et al., 2023; Park et al., 2022, Park et al., 2023). Building on our previous work, we believe an application of this research resides in how the HLPs and accompanying tools we have identified can be thoughtfully adapted for new contexts. More specifically, through this research we have identified a set of HLPs (i.e. Eliciting Students' Initial Ideas, Informing Approaches to Problems, and Developing Informed Solutions) and tools (e.g. real-world scenario, community involvement, and group projects) that support students' engagement in applied environmental education. Throughout the implementation of HLPs, instructors used various strategies, such as making connections between environmental issue and their impacts and asking questions to identify students' prior knowledge. Further, different types of tools were used in diverse ways, such as guest lectures, group discussions, assignments, role-playing, direct connection to relevant resources, and presentations to the community. These tools were dynamically organized based on instructors' decision-making to align with the classroom and learning context and pursuits.

Weaving together the educational practices and community involvement, these HLPs and tools engage students in real-world environmental challenges experienced by communities, while also providing benefits to partnering communities. For those both new to and experienced with this type of work, the results of this study offer specific suggestions for HLP implementation in service-learning contexts. Specifically, the sets of HLPs and tools from this study can be used in teaching and learning focused on community-involved environmental projects in higher education settings. For example, real-world scenarios can be used to elicit students' initial ideas in community-involved projects to address topics such as stormwater runoff, as was the case in one of our course, or other pressing environmental challenges like food security/food sovereignty. Instructors can provide students opportunities to see various perspectives or provide direct connections to relevant resources capable of informing varied approaches to problem solving, while taking into account varied community perspectives related to these pressing environmental issues. As well, the E-Corps model offers a two-semester approach for engaging students in service-learning projects alongside community partners anxious to support the next generation of learners, while concurrently meeting the demands of environmental challenges faced by communities. Relatedly, in our future research, we plan to focus on understanding the institutionalization of the E-Corps model in which the HLPs and tools are embedded to provide additional resources and strategies for other institutions interested in similar work.

Note

1. A town's chief elected official under the mayor-council form of government used in some U.S. areas.

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About the authors

Dr. Byung-Yeol Park is a Research Professor at Dankook University in Korea. His research focuses on science and earth science teachers' curriculum strategies, standards-based curriculum implementation, and students' engagement in science learning through systems thinking and modeling activities. He also explores environmental education(EE) and education for sustainable development(ESD), sustainability-focused service learning, and teacher leadership within the teacher professional network.

Dr. Rebecca Campbell-Montalvo is an Assistant Professor of Medical Anthropology in the Social Medicine section of the Department of Emergency Medicine, Morsani College of Medicine at the University of South Florida, where she directs the Advancing Quality and Uniform Access through the Social Sciences (AQUASS) research lab. She holds a joint appointment at the U.S. Department of Veterans Affairs as a Social Science Analyst. She is a trained cultural anthropologist whose research focuses on understanding and improving how a range of people are served by institutions, including healthcare and schools. Her new book is titled The Latinization of Indigenous Students (Lexington, 2023).

Dr. Todd Campbell is the Department Head of Curriculum and Instruction and a Professor of Science Education. He is focused on cultivating imaginative and equitable representations of ST EM activity. In formal science learning environments this means collaborating with preservice and in-service teachers and leaders to interrogate and reimagine just and thriving futures. In informal learning environments this means focusing on iterative design of informal learning spaces and STEM identity research.

Hannah Cooke is a doctoral student in Curriculum and Instruction at the University of Connecticut. Her research interests include critical, antiracist science education. Her former role as a high school science teacher and facilitator of the school's Green Team led her to grapple with the role science educators play in advancing environmental and racial justice.

Chester Arnold is an Extension Educator Emeritus at the University of Connecticut. He is the co-founder and former Director of the Center for Land Use Education and Research (CLEAR). Chet's areas of interest and research include stormwater management, watershed management, ST EM education, and land use change and its impacts on natural systems. He has an M.S. in Marine Environmental Sciences.

Dr. Marisa Chrysochoou is a Professor and Head of the Department of Civil and Environmental Engineering at the University of Connecticut. Dr. Chrysochoou's general research area is environmental geochemistry, with a focus on site remediation and redevelopment, characterization and reuse of industrial waste and construction materials. Dr. Chrysochoou serves as the Director of the EPA Region 1 Technical Assistance for Brownfields (TAB) Program.

Dr. Peter Diplock is the Associate Vice-Provost for the University of Connecticut's Center for Excellence in Teaching and Learning (CETL), a role he has occupied since 2012. Peter provides thought leadership for developing new and innovative academic programs and elevating teaching and learning outcomes. He earned his Bachelor's degree in Economics from the University of Western Ontario, and his M.B.A. and Ph.D. in Management from the University of Massachusetts.

ORCID

Byung-Yeol Park  <http://orcid.org/0000-0002-7474-9693>
 Rebecca Campbell-Montalvo  <http://orcid.org/0000-0003-2671-8056>
 Todd Campbell  <http://orcid.org/0000-0001-6844-5303>
 Hannah Cooke  <http://orcid.org/0000-0003-2527-2873>
 Chester Arnold  <http://orcid.org/0000-0001-8533-5931>
 Maria Chrysochoou  <http://orcid.org/0000-0002-2592-925X>
 Peter Diplock  <http://orcid.org/0000-0003-1423-2083>

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Appendix A

Table A1. Initial codes for data analysis.

Constructs	Codes		Themes
Students E-Corps Classroom Experiences	1	1.0	General or overall thoughts
		1.1	Community environmental challenge
		1.2	Student group work (how it actually went)
		1.3	Community members or (guest) experts involvement and iterative negotiation of solutions with
High Leverage Practices	2	2.0	Initial Phase: Eliciting initial ideas
		2.1	Middle Phase: Informing approaches to problems
		2.2	Final Phase: Developing informed solutions
Others	3	3.0	Other important/interesting things to note

Here's the short summary detailing either your own or your group's main research activities, including how the research reported in this paper relates to wider projects or issues:

We examined the implementation of high leverage practices in environmental service-learning courses. These practices included: eliciting initial ideas, informing approaches to problems, and developing informed solutions. Interviews, observations, and artifact analysis of data from 2019 to 2022 showed 1) specific moment-to-moment instructional moves as tools when enacting HLPs (e.g. questioning, making connection between environmental issues and impacts), and 2) the range of instructional tools used (e.g. group discussions, roleplaying). This supports the notion that specific instructional practices can be used in a variety of contexts in undergraduate environmental education, rather than only discipline-specific practices, advancing work on how interdisciplinary STEM alliances can work (Henderson et al., 2017). We also advance work suggesting that learning opportunities be provided through interdisciplinary problem-based group work, collaboration with communities, etc. (De Hooge & van Dam, 2019; Salovaara & Soini, 2021), by revealing how educators can work with and on HLPs to support student engagement.