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The development of high leverage practices in environmental sustainability-focused service learning courses: applications for higher education

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ABSTRACT

High Leverage Practices (HLPs), as a core set of teaching practices, represent important instructional priorities and provide instructional guidance for students' engagement in practice-based instruction. The goals of this research were to 1) understand how an epistemic community (the people designing and leading courses and programs) viewed the HLP creation process, 2) understand the processes through which the epistemic community actually engaged in the refinement of the HLPS, and 3) identify and present the HLPs created. Data collected across the 2019-2020 academic year included interviews with seven instructors and seven students and four observations of the integration team meetings. First, thematic analysis revealed that the epistemic community members considered the process of creating and refining HLPs central to improving the quality of their instruction. Second, the processes through which the community engaged in HLP refinement included connecting experience and feedback with educational research, identifying the purpose of instructional strategies, sharing practices for instruction, and creating a model for course expansion. Third, the HLPs produced included: 1) eliciting students' initial ideas, 2) informing approaches to problems, and 3) developing informed solutions to address community environmental challenges. This work informs in the literature, especially in applied STEM education, about HLP creation in the context of an epistemic community.

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Introduction

Teachers' success at facilitating students' acquisition of knowledge depends on how they are prepared and supported in creating learning activities conducive to learning. 'High Leverage Practices' (HLPs) (Windschitl, Thompson, and Braaten 2009) or 'core practices' (Grossman, Compton et al. 2009) have comprised such central preparation and support in the field of teacher education. HLPs can

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be thought of as a set of fundamental planning and instructional strategies, routines, and moves. HLPs are ground in important learning goals, literature about how people learn, and evidence from teacher reflections of their impact on student learning (Capobianco, DeLisi, and Radloff 2018; Hlas and Hlas 2012). HLPs can be considered broadly as the important instructional practices that aim to stimulate significant advancements in student thinking across groups and support students' participation in disciplinary pursuits. Further, they may be applied frequently across disciplinary topics and subject matter (Ball and Forzani 2009; Windschitl, Thompson, and Braaten 2009).

A nod to their usability, Maheady et al. (2019) noted that HLPs can be "systematically taught, learned, and implemented by those entering the teaching profession" (2). While HLPs have most often been used to support novice teachers as they learn to teach in the context of teacher education (e.g. Ball et al. 2009; Stroupe and Windschitl 2015), engaging more veteran teachers in professional learning anchored in HLPs is also crucial (e.g. Capobianco, DeLisi, and Radloff 2018).

HLPs hold much potential for impacting applied sustainability education, given that environmental and sustainability education often promote interdisciplinarity and collaboration (De Hooge and van Dam 2019; Salovaara and Soini 2021). For example, De Hooge and van Dam (2019), through their study that examined practices that can leverage students' capacity building, highlighted the important role of practice-based learning in stimulating students' independent thinking, managing academic resources for communities, and addressing topics that are less attractive to others. This study also revealed that both students and community members acknowledged the benefits of their multidisciplinary approach. In their systematic review of effective teaching methods for climate change education, Monroe et al. (2019) found four themes in the environmental education literature: "1) engaging in deliberative discussion, 2) interaction with scientists, 3) addressing misconceptions, and 4) designing and implementing school or community projects" (791).

However, the application of these particular teaching and learning practices in university settings is underexplored, especially in connection to how the iterative development of core practices (i.e. HLPs) can support instructor collaboration and student learning. Researchers more broadly have recently begun to recognize how collaborative work with HLPs can be central to the establishment of communities of educators and stakeholders capable of developing and refining shared knowledge about teaching and learning (Arnold et al. 2021; Campbell et al. 2019; Campbell-Montalvo et al. 2021; Capobianco, DeLisi, and Radloff 2018). Additionally, only limited research has explored the potential role of HLPs in the field of applied sustainability education. Further, at the time of this research, no research could be identified that examined the sociocultural processes of negotiation during which faculty and stakeholders work together to articulate and develop HLPs.

Given this, our previous research examined the conditions (e.g. contextual factors and resources, and the ways that stakeholders collaborated) that supported the establishment of an epistemic community (Campbell-Montalvo et al. 2021). In this research, we intentionally built from our previous work by investigating the development of a set of HLPs with a group of veteran university interdisciplinary science instructors, the epistemic community that emerged in our previous work. This research was part of a larger funded project that sought to further refine and expand the offering of environmental sustainability-focused service learning science courses known as the Environment Corps (E-Corps). In this context, we considered the development of HLPs as a mechanism supportive of our collaborative efforts to propose, distill, and refine fundamentally important instructional practices. Specifically, we focused on the nature of stakeholders' collaborative work in developing HLPs as the anchor within a particular epistemic community (i.e. the people designing and teaching these courses). The present epistemic community includes the people, teams, and units or university actors and community partners involved in developing, refining, and implementing the model of focus in this work.

The research reported here is important, since the associated findings may help environmental education course developers better understand the nuances of developing relevant pedagogical

or instructional approaches, particularly in settings like undergraduate education where instructional aids are sparse. Furthermore, this research also informs theories about how epistemic communities come together to collaborate around instruction within these contexts (i.e. undergraduate environmental and sustainability course settings).

Thus, this research addressed the following research questions:

- How did members of the E-Corps epistemic community view the HLP creation process?
- How did the epistemic community members' collaborative work support the development and refinement of the HLPs?
- What are the important features of the refined HLPs?

We framed our analysis of HLP development in 1) Design Based Implementation Research (DBIR), a framework concerned with continuous program improvement; and 2) epistemic communities, groups of people tasked with creating knowledge and practices to advance shared program goals.

Themes, such as the participants' efforts at creating the HLPs and the iterative process of HLPs development, emerged from the data. Importantly, these themes can inform how the veteran university instructors who comprised the E-Corps epistemic community made sense of the shared effort of articulating E-Corps HLPs and how the process of creating the HLPs over the initial project year unfolded. Ultimately, the development of a set of HLPs was both intended to serve as an anchor around which an epistemic community could rally to purposively explore and improve instruction and a set of resources that could be subsequently used to support the work of course developers at other universities aimed at developing and improving practice-based environmental and sustainability courses. For this, we present and break down the key elements in the actual HLPs designed. We end our discussion by articulating the implications of this work for veteran teachers in higher education, especially those in science education and/or service learning.

Theoretical perspective: DBIR, epistemic community, and HLPs

Design based implementation research (DBIR)

In our earlier work (Arnold et al. 2021), we detail important commitments that ground our project in DBIR. Generally, the approach of the project is guided by the following tenets of DBIR (Fishman et al. 2013):

1. A focus on persistent problems of practice from multiple stakeholders' perspectives;
2. A commitment to iterative, collaborative design;
3. A concern with developing theory and knowledge related to both classroom learning and implementation through systematic inquiry; and
4. A concern with developing capacity for sustaining change in systems (136).

In this research, we pay special attention to the second point. Here, the DBIR perspective takes into account the utility of iteratively focused design research that has traditionally attended to developing practical theory and tools aimed at local innovation in educational settings (Reinking and Bradley 2008). This is coupled with the positioning of practitioners (e.g. instructors) as co-designers of usable tools. These tools are tuned within systems that can support sought-after solutions to important instructional problems. In this research, we discuss the iterative process of how we developed our guiding HLPs in conjunction with the researchers, educators, and administrators overseeing the implementation of the E-Corps model and present those HLPs. Our analysis illuminates how DBIR can unfold in the unique context of HLP creation for applied STEM learning at the undergraduate level.

Epistemic community

Glazer and Peurach (2015) define an epistemic community "as a diverse group of people bound by a common set of *theories*, *codes*, and *tools* that govern interpretation, practice, and communication" (181; emphases added). In this research, *theories*, as cognitive frames of practitioners, are the interpretive or intellectual conceptions used to help practitioners understand, adapt, and develop practice in unpredictable contexts, like in classrooms or in environmental community problem solving. *Codes* are the symbolic ways in which community members communicate their experiences and observations with each other. They are specific ways in which community members transform an experience into a recognizable concept in practice. For example, *pedagogically productive talk*, as one of the codes, can promote participants' collaborative discourse about problems of instructional practices through the reflective interpretation of classroom events (Lefstein, Vedder-Weiss, and Segal 2020). *Tools* are the artifacts that are useful in the transmission of articulated knowledge to support particular ways of engaging in practice. In this research, HLPs that the epistemic community iteratively developed and refined can be considered tools useful for better understanding and implementing *theories*.

High Leverage Practices (HLPs)

Given the complex nature of teaching, teacher educators have focused on learning opportunities and supports for pre-service teachers. This entails moving past merely a focus on teacher knowledge and skills and instead emphasizing application in a range of situations or contexts (Ball and Forzani 2009; Freese 2006; Grossman, Hammerness et al. 2009). Such work grounded in the use of HLPs focused on refining teaching practices in real-world contexts position HLPs as useful instructional supports (Grossman, Compton et al. 2009; Grossman and Dean 2019; Windschitl and Calabrese Barton 2016). Through providing high leverage strategies and techniques that are exercised with sound judgement in context-specific ways (Ball and Forzani 2009; Ford 2008; Zeichner 2012), HLPs assist both pre-service and in-service teachers' development of teaching practices that are supportive of student engagement (Grossman, Hammerness et al. 2009; Lampert and Graziani 2009).

Here, the emphasis is on how HLPs promote student learning (Ball and Forzani 2009; Capobianco, DeLisi, and Radloff 2018). Indeed, HLPs are separated from more general types of teaching practices, since they represent important teaching priorities that, when foregrounded, promote students' acquisition of skills and knowledge and engagement in approximations of disciplinary pursuits (Capobianco, DeLisi, and Radloff 2018; Hlas and Hlas 2012; Windschitl et al. 2012). More specifically, HLPs are conceptualized as practices that can "equip … [teachers] for the fundamental elements of professional work and that are unlikely to be learned on one's own through experience" (Ball and Forzani 2009, 460).

HLPs work best when they include a manageable number of crucial practices that educators can spend enough time with to develop a grasp of each practice (Windschitl and Calabrese Barton 2016). When considering how educators use HLPs, it is important to emphasize the connection between how practices are conceptualized (Ford 2008, 2015; Rouse 2007) and how they are practiced. In the science education literature, practices are those approaches and routines (e.g. argumentation, modeling, investigations, explanations) that support scientists in accomplishing their pursuits of construction and critique (Ford 2008). We see our focus on HLPs as a mechanism supportive of our collaborative efforts to articulate fundamentally important instructional practices that could be used as the anchor for cultivating an epistemic community across and beyond our university context in support of, for example, students in E-Corps' Brownfields Corps developing and refining approaches for cleaning up a local brownfield site. These efforts include eliciting student ideas, as one of the HLPs in the E-Corps, which offers an opportunity to nurture students' approaches to addressing an environmental issue that will be critiqued, added to, and refined over time in the E-Corps courses.

By integrating DBIR, epistemic community, and HLPs, we offer a model of the dialogic processes within the epistemic community through which its members engage in DBIR to create HLPs. This mapping extends the range of existing literature to applied STEM contexts and offers an example of how new pedagogies applicable to new contexts can be created collaboratively.

Methodology

Setting

This qualitative investigation focuses on the E-Corps model, which combines classroom instruction, service learning, and extension outreach to foster a method of community engagement with the aim of benefiting students, faculty, surrounding communities, and the university community itself (Campbell-Montalvo et al. 2021). This model was implemented at a public research university in the New England region of the United States, which newly emphasizes students' experiential learning connected to community environmental needs (Campbell-Montalvo et al. 2021). The model includes three E-Corps courses (i.e. Climate Corps, Brownfields Corps, and Stormwater Corps) and each of these has a shared objective of helping address the lack of needed STEM-related skills found in the New England communities where this research took place (Campbell-Montalvo et al. 2021; Barrett and Hyde 2017; Boyer, Meinzer, and Bilich 2017; Boyer 2013). With some variation, all E-Corps courses run across two semesters in which an initial semester covers natural and social science knowledge and information needed in such community based environmental work. The second semester involves an in-depth community based project focused on helping communities come up with plans to address their environmental needs. Course overviews for the each of E-Corps classes during the 2019-2020 academic year can be seen in Table 1.

Participants

Three STEM education researchers, seven faculty members in the instructor team (i.e. two in Brownfield Corps, two in Climate Corps, and three in Stormwater Corps), and three staff members in the administrator team participated in this research as stakeholders. Participants were 92% white and 8% Asian and 62% men and 38% women. All participants engaged in collaborative work focused on the development of HLPs through instructional and integration team meetings. Importantly, we acknowledge the overrepresentation of white and men participants as a potential limitation of our study. At the same time, we believe value exists in how the HLPs and findings from this research can inform and serve to launch and support similar work in more diverse settings, even as we recognize how differences in how actors work with HLPs are likely to arise in settings with different or more diverse representation.

All instructors from each of the three E-Corps courses were interviewed, and four of the six instructors participated in two rounds of interviews. Additionally, instructors helped identify seven students out of a pool of about ~70 students enrolled in E-Corps courses for purposive sampling (Welman and Kruger 1999). In the end, three students from Brownfield Corps, three students from Climate Corps, and one student from Stormwater Corps were interviewed (Table 2). Informed consent was obtained from all participants in accordance with university Institutional Review Board regulations.

Data collection methods

The initial interview and observation protocols were created and revised by the research team and approved by the university's Institutional Review Board. In our 11 interviews, we used follow-up questions and probes requesting examples and "tell-me-more" prompts to elicit rich

Table 1. Outline for each of the E-Corps courses.

Course	Semester	Learning objectives and course overview (with examples)
Brownfield Corps	Fall 2019	Students in the first semester: • learn about brownfield redevelopment practices (e.g. assessment, clean up, revitalization planning) • consider environmental justice in addressing community environmental challenge • understand relevant laws and regulations for brownfield sites management • identify and describe community's needs • develop community engagement plans for the redevelopment process
	Spring 2020	Students in the second practicum semester: • use what they learned to (re)visit, build on, and finalize an informed solution to the community environmental challenge with brownfield (e.g. develop EPA grant proposal, develop possible solutions or plans for brownfield redevelopment for the towns)
Climate Corps	Fall 2019	Students in the first semester: • analyze and assess the impacts of climate change at a regional, state, and local level (e.g. rise in sea level and its impacts on local community) • understand climate policy and programs at the federal, state, and municipal levels • analyze climate-related problems at the local level (e.g. listen to guest speakers from coastal towns) • consider strategies for mitigating the impacts • consider many perspectives and approaches to the issues (e.g. role playing to the issue)
	Spring 2020	Students in the second practicum semester: • use what they learned to (re)visit, build on, and finalize an informed solution to the community environmental challenge with climate change (e.g. develop relocation plans and cost estimates)
Stormwater Corps	Spring 2020 (Stormwater-Corps started its first semester in Spring 2020)	Students in the first semester with general classes: • connect any prior existing ideas and experiences they may have related to stormwater runoff near their homes or in their communities and the mitigation approaches they have previously seen employed before they learn about more sustainable practices (e.g. low impact development) • learn about the social and political contexts within which residents of the municipalities live so that these are taken into account as stormwater management decision-making depends on the realities (e.g. financial constraints, priorities, livelihoods) • consider many perspectives and approaches to the issues (e.g. role playing to the issue).

Note. The content in this table was reorganized from High Leverage Practices for Environment Corps (E-Corps) Courses (Campbell et al., under review).

data (Bernard 2011). To conduct interviews, we used a semi-structured interview guide that included items asking participants about course experiences, practices, successes, and challenges, with an added focus on their proposals/projects and feelings of support related to E-Corps. We also conducted four observations of meetings between a group of 13 E-Corps stakeholders (i.e. instructors, administrators, and researchers). The observation guide emphasized focusing on university policies, practices, incentives, and relevant factors that supported the E-Corps program and contributed to the successful institutionalization of the program. With participant permission, interviews and observations were audio recorded and transcribed verbatim (see Table 2). Together, these data provide a window into the social processes that occurred across actors during the time in which the HLPs were being developed.

Analysis

To analyze data, two research team members, consulting with a third about key concepts, reviewed all of the data to draft a codebook, established intercoder reliability, and discussed disagreements to arrive at a consensus in order to refine the codebook before it was deployed systematically across the data (Campbell et al. 2013). To establish intercoder reliability, the two

Table 2. Participants, data collection methods and timing, and data sources.

Data Collection Methods	Number	Type of Participants (pseudonyms) and Timing of Data Collection	Data Type
Instructor Interview	5 times with seven instructors	• Two instructors (Penelope and Phaedra) from Brownfield Corps: 1 time in Fall 2019 and 1 time in Spring 2020 • Two instructors (Scott and Elisabeth) from Climate Corps: 1 time in Fall 2019 and 1 time in Spring 2020 • Three instructors (Wes, Dan, and Paul) from Stormwater Corps: 1 time in Spring 2020	Audio, followed by transcription
Student Interview	6 times with seven students	• One student from Brownfield Corps: Fall 2019 • Two students from Climate Corps: Fall 2019 • Two students (as a team) from Brownfield Corps: Spring 2020 • One student from Stormwater Corps: Spring 2020 • One student from Climate Corps: Spring 2020	Audio, followed by transcription
Project Meeting Observation	4 times with thirteen faculty, administrators, etc.	• Seven instructors, three administrators (including Jill and Simon), and three researchers (including Trevor): 2 times in Fall 2019 and 2 times in Spring 2020	Audio, followed by transcription

researchers independently coded the same interview, discussed instances where their coding differed and made minor adjustments to the codebook for consensus and clarity (DeCuir-Gunby, Marshall, and McCulloch 2011; O'Connor and Joffe 2020). This initial coding resulted in a rate of 83% agreement on line-by-line coding on primary codes across the two interviews, which met the common threshold of 80% (Bernard 2011; Krippendorff 2003; Landis and Koch 1977). Finally, one of the two research team members who led the development of the codebook then used it to code the remainder of the data.

Once the data was coded, we used thematic analysis to identify relationships between and processes within themes (Bazeley and Jackson 2013; Braun and Clarke 2006). This consisted of us first exporting, from the qualitative analysis program NVivo, all passages that applied to each code. Then, we reviewed all of the passages relating to each code individually, before meeting as a three-person group to discuss. In these discussions, we identified trends in these passages based on the frequency and/or "keyness" or how closely they pertained to the research questions (Braun and Clarke 2006). Notetaking during this process helped us group these emergent trends into themes. We then pulled examples using participant pseudonyms for privacy to illustrate key points in this article.

Findings

In relation to the first two research questions, two distinct themes emerged from the data. First, regarding how participants considered the group's efforts at creating the HLPs, participants had several specific epistemic conversations about the HLP document and its purpose. Also included were the reasons why they would implement such instruction strategies and how they were grounded in the literature. Second, the process of creating the HLP document was iterative. During several rounds of feedback provided by participants, they discussed specific comments about what was useful or not and how they wanted the HLP document to connect to tangible course elements, practices, and activities they were already doing or were planning to do. During this time, they shared ideas about how the document should be revised to ensure it would make sense to a wide range of practitioners. To speak to the third research question, we present the finalized HLPs, noting that the E-Corps HLP document contained particular elements with a particular community focus, scale, and connections to each course.

University actors' views on HLPs and their purpose

Analysis of the interview and observation data showed that participants considered the process of creating the HLPs as having the following purposes:

- To connect instructor experience/feedback with educational research to craft appropriate HLPs.
- To identify the purpose of the instructional strategies that were currently being used.
- To improve future instruction in single classes and across the E-Corps program.
- To create a model for expanding E-Corps.

Overall, improving the quality of instruction was the most common goal. Consequently, we outline the ways we found stakeholders interacting with each other to reach this common goal.

HLPs creation entailed incorporating educational research

Team members viewed the development of the HLPs as a way to incorporate educational research into broad course planning. In both observations and interviews, participants often engaged in discourse about HLPs themselves, as well as in discourse to develop particular HLPs, both of which were shaped by research. For instance, in a meeting, research team member Trevor[1], drawing on literature, shared the following definition of the HLP, which is related to real-world scenarios and challenges:

> The first HLP, this anchors the High Leverage Practices, there is some educational literature about how learning is a contextual, situated thing…learning as this application of knowledge, and by applying knowledge and ways of doing things, you actually learn that knowledge in a deeper way because you connect it to experiences and you connect it to the world. The first HLP is 'Identify a real-world scenario, a common environmental challenge,' and we've listed some examples.

The discussions about the HLPs suggested that the purpose of creating a document of E-Corps HLPs was to align current instructor experience with educational research to identify evidence-based practices and amplify them. For instance, in a team meeting, research team member Trevor shared an example from science education literature about the importance of having something to solve:

> What we would do is draw on some of those [HLPs] that are already established, educationally sound as practices…in the field of science education we say there's 3 or 4 pillars that we think we can work around. These are larger scale. Some people really collaborate around some very specific practice and some people just back outside and say, 'Here's the pillars'… As an example from the science education literature, researchers have recognized how we need to create authentic problem spaces for students to do work in… science educators have revealed how important it is to have some level of uncertainty for students to work on resolving. In the end, we want them to have a need for any information we share so that they have a context for the application of ideas.

Related to this, Stormwater Corps instructor Paul also noted how previous research had highlighted the importance of the actual problems with which the students engaged:

> We were trying to come up with something like an environmental core class. This comes also from some educational research that talks about the problem that students are engaged in as they learn matters, and thinking about using ideas in context with support from learning also matters, and it's helpful to learners.

More broadly, administrator Simon emphasized how broader fields of study related to community engagement shaped larger course approaches:

> The community outreach and engagement university is a broader perspective umbrella of which service learning was under but I think as a result of that, service learning became more of a community outreach focus and less of a service learning focus and I think with [Brownfield instructor] Penelope's project, there's opportunities to rethink the way service learning might look at a research one and typically through extension of other things.

Thus, participants continuously crafted a shared narrative that educational research was used to define the purpose and rationale for the development of HLPs.

Defining the purpose of teaching and learning strategies

Instructors' comments suggested that they understood that the reason the HLPs were being created was to inform pedagogical decisions. Thus, the HLP document would offer a way to standardize their approaches in pedagogy based on a shared view of important teaching and learning strategies. For instance, the purpose of one HLP, centering the classes around real-world problems, was to deepen students' knowledge and understanding and allow them the opportunity to think critically. Comments about this HLP showed thoughtfulness in how the HLP would be used in instruction. This was reflected in the comments of Stormwater Corps instructor Dan, who stated:

> I think there has to be a certain structure to the initial real-world scenario, certain things within it that will help the students understand. It's not that they don't know and they can't really figure it out, so they have to take some wildest guesses. Then, when they get to the end, their wildest guesses would turn more into reasoned scientific responses.

This view was also aligned to how the research team saw the HLPs, as one of the research team members, Trevor, commented during the project team meeting:

> It also helps students see that you can't just globally apply some science ideas, you have to think with the science ideas in connection to other community concerns or municipality legislation that might influence this… But finding those real-world contexts requires you to do that, and sets up students to feel like they're doing something real.

These quotes offer the participants' views of the purpose of implementing the specific HLP in connection to the importance of the support through HLPs for students' learning.

Further, a member of the university's Center for Teaching and Learning, Jill, described how knowing the purpose of an instructional strategy can make it more effective:

> To give a real concrete example, one of the things that often happens in the K-12 arena is people will pick up instructional strategies, but not understand the reasoning behind when they do it, so they use it inappropriately. One of the things, I think is the big picture, is talking about what is the purpose behind the types of strategy you're using… You've had reasons for why you're using, for instance, a role play.

This quote from an administrator meeting highlights multiple reasons (such as giving context for learning and having a community focus) for developing the HLPs. In a different meeting, Stormwater Corps instructor Wes stated his views, "Mapping what you do in your course to this [the HLPs]" would be an "interesting exercise," further demonstrating how identifying the purpose of the practices was one way in which participants viewed what they were doing. Linking the learning outcomes with instructional activities appeared to be one reason for creating the HLPs as a team.

Improving instruction through shared practice

The team contemplated how creating the HLPs could improve instruction by identifying and reflecting on common strategies. During one meeting, the research team member Trevor outlined the purpose of creating the HLPs, stating:

> The HLPs might create this broader framework where the best practices could come in order to help accomplish the HLPs across time. High Leverage Practices are just things that give us advantages that we might not have if we didn't have them.

Clarifying the purpose of the creation of the HLPs supported instructors to consider improving instruction as a shared goal. This was likewise seen when Stormwater Corps instructor Paul stated, "Thinking about how we can do things together, so not trying to constrain anybody but trying to come up with some common things better, something we can work around."

With the shared goal of improving instruction, instructors shared and reflected on experiences during the course to increase future effectiveness. The strategies that instructors were already using were evaluated and refined after they were initially identified. In the same meeting as when he made his previous comment, Paul asked, "Can we develop some High Leverage Practices that are useful across the E-Corps courses that we say are really important components of doing this kind of work?" This question is evidence of how one important goal was to define strategies that were applicable across multiple classes. Another example is Wes referring to the prioritized strategies, "What I was hoping we could do is see what these [strategies] are… [What] we can do together that we can improve across the courses." In a different team meeting, Jill reminded the group:

> One of the things that will be important as you all move forward is to have a broad framing of where are the places where you do have these commonalities, like the technical writing and that sort of thing, because you can't do tools for everything.

This comment reveals how the group focused on finding common practices that could serve to improve instruction and advance student learning. During the meetings, instructors shared course syllabi and discussed how particular activities did or did not work well. In a conversation about an activity format for students' final presentation, one of the Brownfield Corps' instructors, Penelope, shared the following:

> What happened was last year, we had the Brownfield [Group] come and say, Hey, we want to give money to the students' and because the external money came in, we were like, 'Well, ok, let's do it' in a competition format' and it worked really well. The students were very happy and they really put a lot of energy into the final presentations. And this year, we didn't have the external money … so we decided to sponsor these from our philanthropic minds. It didn't come from the consultants, but it came from the Brownfields [Group] lecture funds. That's how it worked.

Instructors also shared how particular activities worked in the classroom through peer observation. Stormwater Corps instructor Wes observed the role playing activity in Climate Corps classroom. During the discussion for class activities, Wes and Climate Corps instructors Scott and Elisabeth shared their experiences with role playing activity:

> Wes: Role playing though, I think all of it this year, except for maybe one of the reporting out ones, seem to go better this year than they had in the past.
>
> Elisabeth: It was phenomenal.
>
> Scott: That went really, really well.
>
> Wes: It wasn't their lack of ability to interact and work together, it was just something structural maybe.
>
> Elisabeth: Well, no, because the role playing is really an individual [activity]. They just interact in class, but it was the teams. Even though we gave them more time than last year to meet in class, [and told them,] 'any issues come to us, come to us.' Anyway, I guess sometimes you just get different groups of students.

These comments from Brownfield Corps instructor Penelope and conversations between Climate Change and Stormwater Corps instructors reveal how faculty communicated to share quality practices to improve their instruction in connection to the development of the HLPs.

While E-Corps was designed so that instructors had autonomy to teach their classes to meet the objectives of the specific course, comments from the group showed that identifying common strategies helped refine those strategies to be most effective. Identifying strategies that were already in place also saved time and energy, as Wes stated, "Because we are already doing this, and the chances that we are going to change what we are doing right now is close to zero." This comment demonstrates that many of the HLPs are already in place, and the work was to define them and disseminate them across the group rather than to create something new.

A model for expansion

The team discussed how creating the HLPs would be useful for articulating an E-Corps program model for dissemination and implementation to develop more courses and encourage adoption by other universities. During a discussion of the HLPs, research team member Trevor asked for feedback from instructors in order "to make a better model" of the program. In a different meeting, Climate Corps instructor Scott commented, "I do think that the High Leverage Practices will be really useful in trying to move this model for other universities." And, in discussing the creation of the HLP document, administrator Jill commented, "You're going to have tools and resources, both for students and possibly for helping other faculties that are bringing in components of the E-Corps model into the courses." Additionally illustrating how refinement could support expansion, when asked for feedback on the wording of a specific practice, a student in the Fall 2019 Climate Corps said, "If you're trying to use this as a rubric for other schools, they might not have that town hall that they create and they might not have, like the instructors we have, so maybe just putting real-world somewhere." Creating a model also requires effectively communicating exactly what happens in a typical E-Corps class. In a meeting, administrator Jill stated:

> What is the purpose for that role play, and how do you design it in a way to get at that purpose? We're going to be trying to lift that out from what you're doing already, to be able to communicate that to others in respect to the purposefulness of the types of strategies that you're using across the courses.

Accurately defining the HLPs could ease the implementation of a fourth E-Corps class or a similar program at another university. These quotes from instructors, staff members, and students illuminate how they envisioned HLPs being used by others.

Educational research-informed and iterative process of HLPs development

Participants engaged in developing the High Leverage Practices through:

- Sharing of knowledge of the literature on science education and service learning.
- Recursive rounds of open discussion, evaluation, and sharing feedback for revision of the HLPs through a collaborative environment.

Bridging recent literature from K-12 science education, experiential learning, and postsecondary environmental education grounded the work in this current study. Participants engaged in reflection and evaluation of their experiences to provide feedback to improve the drafts of the HLP document.

Use of science education and service learning research to develop HLPs

During the interviews and meetings, participants shared their knowledge of science education and service learning research. Collaborations across departments brought together a significant amount of understanding from various perspectives. This was evident in research team member Trevor's comment at the meeting at the launch of the project:

> This is what we've learned over time in K-12. I'm left trying to leverage a lot of what we've learned over the last… six or seven years now, trying to re-orient our teaching away from just teaching lists of content to now teaching in real-world context.

In the meeting for sharing ideas for understanding the HLPs, Trevor also mentioned:

> For us in science classrooms in K-12, as part of an ambitious science teaching framework we ask students to try to explain something that happens in the world, like how a climate change related phenomenon happens. Through this, students are first asked to start sharing some initial ideas. Next we, as teachers,

> start sharing ideas about how things are connected, like food webs and how these webs play a role in the ocean, so eventually by the teacher introducing a lot of ideas that can be connected to and build on students' ideas as they come up with a complex explanation of the climate related phenomenon…So, I was hoping we could do this by identifying some important instructional priorities as something that we think we could do together across courses.

This example of applying K-12 educational research to environmental higher education was one way in which research was used to create and refine the HLPs and highlights the interdisciplinary nature of the process. Situating learning in a real-world context was discussed multiple times. Trevor continued to describe their choice in a specific issue:

> For us, a community environmental challenge needs to be an event that happens or is happening in time. It matters that you would say, 'We're thinking about the Stormwater issues in Bridgeport.'

This quote demonstrates the instructor's application of current research in the classroom to improve student understanding. In sharing this example, "real-world context" emerged as one of the important elements of the HLPs. Another example of applying interdisciplinary knowledge to the current project is instructors' knowledge of service learning research. When asked the reason for prioritizing one of the HLPs, Brownfield Corps instructor Penelope responded:

> I read that on service learning, and this is something… that reflection is an important part of service learning. I looked up like a rubric of that somebody else had made for service learning and I decided to implement that last semester.

This instructor brought her knowledge of service learning to the development of HLPs. These excerpts demonstrate how constructing the HLPs was informed by and nestled within existing research.

Iterative, collaborative nature of HLP creation process

The process of the HLP creation involved several iterations. A variety of stakeholders evaluated the drafts of the document wherein feedback on the HLPs was elicited through open discussion. During a leader meeting when this was discussed, research team member Trevor described the goal of the HLP creation process as "taking and using any information to make [a] better model that engage[s] students in investigation". Additionally, during a later meeting to revise the developed HLPs, Trevor stated:

> That's the one big thing, just listening and talking to people. The High Leverage Practice is more intense with the instructors. We're on version four. There's already enough input for there to be a version five. We just haven't finished pulling out the information from the interviews that the instructors did last semester to do the revisions of it yet.

This statement demonstrates the iterative nature in creating the HLPs and how feedback was elicited and used to revise the document.

Additionally, when asked for feedback on one particular draft, Brownfield Corps instructor Penelope answered:

> I think you need a lot more detail to make this useful for someone, because there is a lot of nuance that goes into how you engage the communities, how you interact with the communities, how you identify the projects that are suitable for students, because not every project is suitable for a student.

The instructor suggested more details to capture the complexity of each HLP. Feedback like this allowed the research team to make revisions to the wording, organization, and layout of the document. This quote also includes how the instructors helped to prioritize specific practices, like identifying a real-world problem. Asked whether there was an aspect left out of or not needed in the HLP document, Penelope answered, "I think the community aspect is missing here. This is focusing very much on the students. To be successful with these, you also have to have like a one, two, three for the communities as well." Penelope continued:

> Because how are you going to engage [the community]? How are you going to identify the projects? How are you going to have them interact with the students and what are you going to give them in the end and make sure that they actually use it? That's a whole other piece that's completely separate from this.

These comments reflect the instructor's feedback to define and document HLPs in the clearest way possible.

Evaluating classroom experiences during interviews was another aspect of the process. When asked about the HLP that included community, one student answered, "I would keep that because I don't think it's informed by community means. I really liked the community aspect of it. Again, not making it so people like me can't just bulldoze everyone else." When asked for feedback on the HLP document, another student gave specific feedback with a suggestion, "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 in to maybe the science one because the guest speakers are different from the community members as far as I am seeing." Feedback like this enabled the team to refine the document. Instructors also evaluated their experiences in the course during interviews and meetings.

At the same time, when asked about the importance of student reflection in class, two Brownfield Corps instructors shared the following:

> Phaedra: Maybe for next year we can capture their initial and the final ideas like tracking the change.

> Penelope: Yes. We have a reflection that will at the end try and capture this. We had initial reflection, middle reflection, and final reflection for in terms of how they started in the project, how they went, and what happened in the end. We did it in the second semester. We could implement something like this in the first semester as well. I think it might be useful for them to feel that they're making progress.

This conversation demonstrates instructors evaluating their own practice and discussing ideas to improve student outcomes.

Giving and receiving feedback required a collaborative environment. Questioning was one way for participants to give feedback, as demonstrated by Climate Corps instructor Scott in a leader meeting, "Can I interrupt you right there? In my thing it says, 'Real-world challenge or community environmental challenge,' and I'm wondering what the difference is between the two." This example demonstrates a clarifying question as feedback. Additionally, in an earlier leader meeting, Scott asked, "Can I ask something because I'm a little confused. I was trying here to make a list of all the things we do and mark them to those one of six?" The quote shows the instructor's investment in the task of refining the HLPs. In response to this question, Trevor stated:

> We are trying to figure out what we do. What we do instructionally, what we could do together instructionally in terms of getting these practices for preparing people to go out with… To prepare them to work with and solve the problems with the communities. Can we do something that stimulates that in the classroom?

This exchange is one example of the collaborative conversations about best practices for student learning. Developing HLPs required reflection and feedback from instructors and students. Several drafts were created and revised with this feedback and with knowledge of current literature.

Finished product

The final product included E-Corps' refined versions of the main elements of HLPs (Figure 1). The group divided the first part of the HLPs document into three sections by time (i.e. planning, initiating, and throughout the E-Corps experience). Those considerations that needed to happen far ahead of the course starting (such as making sure the course was grounded in a real-world problem) were grouped into *planning*. Actions to take while beginning the course (such as

orienting students to the specific focus of the course) were grouped into *initiating*. Finally, the community-related considerations (such as community involvement) were grouped into the *throughout the E-Corps experience* of the first part of the HLPs document.

The second part of the document (i.e. *engaging High Leverage Practices*) shows the specific practices on which the team decided the courses should focus. Once the course is underway, instructors elicit students' ideas (i.e. *initial phase*), sharing social and natural scientific knowledge and engineering principles to equip students with the tools they need (i.e. *middle phase*), before students apply the knowledge and principles to address real-world problems in the course (i.e. *final phase*).

Two main features of the HLP document as a whole are that it helps:

- Give context for learning.
- Ensure a community focus.

Learning in context

In the instructional planning stage, instructors "identified a complex real-world problem or challenge as meaningful context," which was used as a focus for the class. The process of choosing a specific real-world problem or challenge was discussed at the leader meetings, as Stormwater Corps instructor Paul commented:

> To jump us back into the high-level practices a bit. This came up when Dan and I had a conversation about the initial real-world scenario. I think it would be helpful if there was some guidance that we could have that would identify what elements you need to have in the real-world scenario so that when you start out and you go to the end, there really is some significant change. There has to be some complexity to it.

The choice of the issue was vital because students needed to grapple with it throughout the course, as Paul stated, "I think that's the key on what makes it a good primary problem. What are those elements? So that you don't just come to the end and get the same answers that you had in the very beginning." The topic of real-world environmental problems appeared multiple times in the interviews and meetings.

Introducing the problem, eliciting students' initial ideas, and reflecting on changes in their thinking can occur when they are focused on a real-world issue. Climate Corps instructor Elisabeth shared their strategy:

> One of their first writing assignments for the Climate [Corps] is to find a short, two-page article that has to [do] with sea level rise. Students have to say what they think about the solutions. It just occurred to me that by the end of the course, they are actually coming back to that. So many of them say, 'Oh, build the wall.' But they never say that at the end. I wonder if this would work with Brownfield or Stormwater [Corps as well].

This instructor described how the real-world problem was used to engage students in using their critical thinking skills to come up with solutions related to climate change and its impact (e.g. rise in sea level). The first HLP is "identify a community environmental challenge." When Climate Corps instructor Scott said, "It's not really about solving it as much as it's trying to understand it as part of probably solving it." Elisabeth responded, "What you just said is I think really critical; that it's understanding it, not necessarily solving it." This exchange further demonstrates the significance of the real-world environmental problem. When asked for overall thoughts about the course during their interview, a Climate Corps student answered:

> I would say something that's regarding real-world problems into it, especially I loved how, in this course, we took something that's what we learned about it in class, we learned about white flooding, we learned about municipalities and like, what's going on there. We're doing that exact thing for the next independent study. If you could get a second component to a class, where there's an independent study for it, I think that's wonderful because you're hitting it right with the nail on the head. You're getting the experience

Planning the E-Corps Experience	**Identify a community environmental challenge** (stormwater, climate, or brownfield related) that sets the goal or establishes the focal problem (the "Big Idea") for learning and meeting our professional responsibility to the communities that we serve long-term. This focus is identified by faculty in partnership with communities during course development. It provides a real-world context to elicit ideas in the **Initial Phase: Eliciting initial ideas**, a guide for identifying the topics and instructional techniques used in the **Middle Phase: Informing approaches to problems**, and the focus of the development of informed solutions in the **Final Phase: Developing informed solutions.**
Initiating the E-Corps Experience	**Orient** students and the community to the pursuit of E-Corps focused work (e.g. community assessments, grant proposals) at the outset and throughout the course. This orientation entails acknowledging that resolutions will be developed within contexts of uncertainty—important for students entering professions that address environmental community concerns. Help students and communities understand what they will be doing and begin to see HLPs as essential for achieving their identified pursuit. Make it explicit that the pursuit (**the community environmental challenge**) is their important focus that sets the stage for how solutions are proposed (**Eliciting initial ideas**), informed (**Informing approaches to problems**), finalized (**Developing informed solutions**), and continually negotiated with community (**Involvement and iterative negotiation of solutions with community members**).
Throughout the E-Corps Experience	**Involve and negotiate solutions with community members iteratively**. This process begins early, as instructors work with local stakeholders to identify the community challenge of consequence (in the initial semester this may happen behind the scenes). This continues through instruction as more information about the local community is shared, such as through in-class guest lectures by community members. Finally, community members are invited to help conceptualize and negotiate developing solutions, particularly as part of the practicum semester. This process becomes iterative as each year's group of student-community collaborative projects adds to the Corps collective experience, shedding more light on the types of outcomes that can be achieved.
Engaging High Leverage Practices in the E-Corps Experience	**1. Initial Phase** **Eliciting initial ideas** for addressing the community environmental challenge. Ideally, these initial ideas would be captured so that they could be revisited and improved over time. This will also help students see how their ideas have evolved as connections between their ideas and newly introduced ideas are made as they engage with peers and the instructor(s) around the challenge. **2. Middle Phase** **Informing approaches to problems**. Here, instructors help introduce important science and engineering principles, practices, frameworks, and approaches informed by community needs. These will build upon students' initial ideas for addressing the environmental challenge in context. These are the things that students learn in the course that they may not have considered otherwise. **3. Final Phase** **Developing informed solutions** for addressing the community environmental challenge. Building upon initial ideas, this is where students revisit their initial proposals and strengthen them with what they learned about engaging in the previous 'informing solutions to problems' mid-instruction experiences with peers and instructors.

Figure 1. Final HLP document created by the E-Corps Epistemic Community.

> in the classroom, you know what you're walking into, and then you get to go out and prove it in the real-world. I think that's priceless. This will definitely help me when I graduate.

Community involvement

Given that the course depends on partnering with communities, instructors explicitly integrated community feedback in their reflections included in the HLP document. During a leader meeting, Stormwater Corps instructor Wes described the influence of the community in the courses when it came to the HLP of defining the problem, stating:

> Identification of the [real-world] problem is really coming from the community, right? So, it's defined through the community based on their need. We start from the community and will end with the community. So, basically we hear their problem, we are able to identify their problems and provide the solutions for those.

Students' in-depth project during the second semester for the E-Corps course involved developing plans to address environmental needs for communities. In this, communities played an important role in identifying their environmental needs or challenges (e.g. sharing their environmental projects). So, the team decided that the HLP document needed to include the role of the community.

Additionally, analysis of the interviews with students revealed the importance of community. When asked for thoughts about negotiation with community members, a student in the Climate Corps responded:

> People have lived here longer than you have. You're not just going to come in and change everything up. I really liked the community aspect and the municipal solution aspect of the class.

The student's feedback highlights the importance of community involvement when designing solutions. Another student from Brownfield Corps echoed this when asked about the importance of community members, "I thought it was nice to have because they were very knowledgeable… it was

really great because she just knew everything, she could answer our questions right away." During the course, instructors invited several guest speakers who shared their knowledge or experience in relation to environmental issues (e.g. environmental risk management, remediation technology) or provided insight into the perspective of a local community. Guest speakers from the outside the university were also discussed during the meetings and interviews. For example, asked about her overall thoughts, one student from Brownfield Corps stated, "Definitely one of my favorite parts were guest speakers." When asked for examples of practices in class activities, another student stated:

> Just having other speakers come and you're getting that, not just talking about real-world issues and people being like, 'I am working on this right now and this is what's happening. This is the progress we've made.' [But also] if we need help or something like that, we've had people come in and be like, 'Do you want to intern here?' It's really a cool class…highlighting the real-world community aspect, but having other people come in.

While guest speakers were not necessarily from the town that students were working with, they did provide expert knowledge and act as external resources. This is an example of instructors leveraging their relationships with people outside of the university.

Discussion

We undertook this research to uncover the nature of HLP development and provide an example of the processes undertaken to develop HLPs for environmental sustainability-focused courses in a higher education context. For this, we investigated how epistemic communities work together to develop a core set of practices. The findings revealed themes that can provide important insights to course developers in other universities' contexts, while also providing insights into ways to improve instruction.

Two themes emerged from the data in regard to how participants engaged in the development of HLPs suitable for E-Corps, including how they viewed what they were doing while creating the HLPs and the actual process in which participants engaged to create the HLPs. First, participants considered the creation of the HLPs to be a bridge between educational research and instructor experience to improve instruction and to make explicit the purpose of instructional strategies. The HLPs developed by the E-Corps team within this context were created not only to facilitate their implementation within the E-Corps' university context, but for their use in other university contexts. Second, the process of creating the HLPs required a collaborative space, where instructors apply research from service learning and science education to their classroom practice. Developing the HLPs required several iterations of reflection, feedback and revision. Instructors and students shared how their experiences aligned and misaligned with the drafts of the HLP document. These initial conversations helped participants understand and shape the specific goal of these efforts. This collaborative process again enabled a range of actors to contribute to the process and product, making it most applicable for the E-Corps program.

From the DBIR perspective, researchers have highlighted the necessity for multiple stakeholders to be engaged in collaborative work in the continuous cycle of design, testing, and redesign of teaching and learning approaches (Collins 1992; Fishman et al. 2013; Penuel et al. 2011). In this current research, participants engaged in the development of HLPs suitable for E-Corps through "iterative, collaborative design", which was suggested by Fishman et al. (2013) as one of the approaches to achieve a shared goal of transformation of the educational system. Drafts were shared and revised using feedback from multiple stakeholders (i.e. instructors, administrators, researchers). Our findings extend the research of DBIR by documenting the process of developing an interdisciplinary tool to be used throughout the E-Corps project and across courses within a university. During collaborative work, reflection of how the teaching and learning approaches worked in context plays an important role in refining or changing tools for implementation (Fishman et al. 2013). In this research, practitioners were positioned as co-designers, creating and

refining a tool to fit a specific need. Reinking and Bradley (2008) highlighted formative and contextual approaches for educational innovations through implementing, changing, and improving practices. As revealed in the findings of this research, multiple stakeholders (i.e. instructors, administrators, and researchers) actively shared their understanding of educational research and teaching experiences to negotiate and articulate shared goals (i.e. the HLPs development process). Sharing common goals (e.g. improving instruction and developing HLPs), teaching experience, reflections connected to implementation, self-evaluation, and students' feedback played an important role as resources in stakeholders' collaborative work. Refining the HLPs through several rounds of feedback aligns with DBIR. The iterative process of prioritizing and fine tuning a reasonable number of core practices supports past research on HLPs as well. And, the continued instructional and integration meetings held two times per semester served as a collaborative space for sharing, negotiating, and refining ideas collectively. The collaboration featured in this research is an example of how epistemic communities function to innovate useful tools.

Our findings feature an epistemic community collaborating with shared theories, codes, and tools in order to improve instruction across courses. More specifically, from the epistemic community's perspective (Glazer and Peurach 2015), HLPs can be seen as *theory* as a diverse group of people (i.e. instructors, administrators, researchers) participated in understanding, adapting, and refining it for E-Corps courses. Continued instructional and integration meetings and peer observations can be seen as *code* that allowed participants to share their knowledge and experiences related to particular teaching strategies for HLPs. Resources shared during the meetings can be seen as *tools* that supported instructors' implementation of revised teaching strategies. Lefstein, Vedder-Weiss, and Segal (2020) highlighted the importance of *pedagogically productive talk,* as one of the codes, in epistemic communities of teachers' collaborative work. Pedagogically productive talk is a form of effective talk supporting teachers in a focus on problems of practice and concerns in their classroom. This form of talk helps teachers use "evidence, explanations, and reasons to interpret classroom events and analyze and justify courses of action" (Lefstein, Vedder-Weiss, and Segal 2020, 363). In this research, the conversations during the instructional meetings seemed to be examples of pedagogically productive talk as this discourse provided space for sharing teaching experiences and the use of resources for course improvement. This highlights the importance of collaboration in the development of teachers' practices. Collaborating allowed for collective knowledge to be used to refine the HLPs, thus improving classroom instruction.

In this research, participants agreed about the purpose of the HLPs creation through connecting experience with educational research to craft HLPs, identifying the purpose of teaching strategies, improving instruction, and creating a model for expanding. Hardy and Melville (2018) noted that learning in highly contextualized epistemic communities with resources developed and activated within and through these communities supports success in making sense of particular theories. In connection to the ways participants collaborated for HLPs development, such shared common goals are likely to be more supportive of epistemic community members' collaboration in a particular context. Given what other researchers have found in relation to the nature of epistemic communities, the results of this research provide examples of how DBIR and epistemic communities can be applied. In this, we illuminated the processes of how stakeholders worked together to improve instruction and develop HLPs and provided meaningful insights that others might use in the development of HLPs in other contexts.

We also presented and described the HLP document created through engagement between participants by drawing on data to define its parts. The product can be seen as reflective of both instructors' understandings of the activity they were undertaking in the HLP creation as well as the shared orientation and purpose of the three E-Corps classes as part of the larger E-Corps program. The final product contained one section for planning, two sections focused on framing what is planned in the context of local community problems and in negotiation with community members, and three instructional HLPs that support students in learning about and negotiating authentic environmental community pursuits (Figure 1). The HLPs document

was developed in response to the goal of improving instruction and creating a model that would potentially be useful to others. These crucial practices within our HLPs highlight specific pedagogical decisions that influence student learning. These HLPs offer instructors a chance to improve students' application of knowledge (Grossman, Hammerness et al. 2009; Lampert and Graziani 2009) by providing techniques implemented in specific contexts (Ball and Forzani 2009; Grossman, Hammerness et al. 2009; Zeichner 2012; Ford 2008). The community focus of the HLPs provides an authentic audience for students, increasing their engagement in the task at hand. One thing that became apparent during interviews with faculty during the first year of this project was that in order for them to be useful in other colleges, they must be clear and come with corresponding discussion or training materials to allow other educators to properly understand, digest, and mobilize them within their own university spaces.

Our research adds to the literature on DBIR, epistemic communities, and HLPs in science education, informing approaches that seek to iteratively implement the creation of HLPs and build epistemic communities in various teacher education contexts. We extended research on epistemic communities by uncovering how participants undertook HLP creation. The common understanding of the goal of creating the HLP document is analogous to the theories of an epistemic community. We highlight the codes used by participants as well as articulate how the HLP creation process unfolded. In presenting the HLPs the group arrived at, we share the tool the group created to transmit their HLP knowledge so that it could be taken up within the group and deployed within E-Corps educational settings. Participants understood the purpose of HLP development as a way to integrate current research and classroom experience to improve instruction, which aligns with the literature of HLPs as an approach to prioritizing core practices. The participants understood that refining the strategies used throughout the classes would be an opportunity to further student learning. These practices can be used across disciplines in complex classroom contexts. While the initial epistemic community at the launch of the E-Corps model was limited to a community of practice made up of local actors, the program had ambitions of expanding the local community of practice beyond its single geographic context. The team expected that the development of common theories, codes, and tools would be crucial in governing interpretation, practice, and communication in the realization of an epistemic community outside of the site of the geographic context of the university.

The final HLP document includes a manageable number of crucial practices, communicated in a way that others can implement no matter the discipline. Colleges and universities looking to implement a model like E-Corps must provide time for instructors and stakeholders to collaborate effectively to come to a shared understanding of the goals of the epistemic community. The iterative process requires adequate time for several rounds of revisions to be made. These revisions are important for tuning the HLPs to fit the context.

Conclusion

On one hand, the iterative development of the E-Corps HLPs could serve as a key lever for illuminating a common set of theories, codes, and tools capable of supporting the expansion of E-Corps programming to additional universities and communities, augmenting students' learning opportunity with a real-world environmental problem and community focus. On the other hand, it also illuminates the processes in which epistemic communities might engage as they articulate guiding models (i.e. HLPs) that they will use to shape their work—groups seeking to participate in such model creation (even outside of applied STEM education) might find informative our discussion which deconstructs this process and highlights some its characteristics, which would be useful in supporting successful HLP creation in other contexts.

Future work should seek to understand and assess how these HLPS are implemented and effective in the learning environments for which they were designed. Once multiple-year data about this is gathered, our future work will examine how E-Corps service learning program has

implemented the new HLP approaches. We envisioned how our HLPs and their enactment across the E-Corps courses could result in tools that help support others in geographically dispersed locales orient to, talk about, and engage in a similar practice. And the extension of what we revealed in our study can provide resources for other universities to meet similar objectives of benefiting students, faculty, surrounding communities, and the university community itself. This is particularly useful in addressing the lack of STEM related skills in small towns unable to comply with environmental mandates, or plan for future environmental challenges.

Note

1. All names used throughout are pseudonyms.

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