



# An Undergraduate Agroecology Research Fellows Program Engages Co-learning Through Participatory Action Research

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This paper addresses the role of an Undergraduate Agroecology Research Fellows Program (UARFP) toward a more critical and equity-oriented agroecology pedagogy. As a model rooted in action, Undergraduate Agroecology Research Fellows (UARF) become members of the Agroecology and Livelihoods Collaborative (ALC) Community of Practice (CoP), at the University of Vermont; a transdisciplinary research and education group that engages in community-based participatory action research (PAR). Through this model, UARFs support undergraduate student engagement in an advanced agroecology course, through which a PAR process centered on soil health takes place with regional farms. This triangulated learning format involves in-class and on-farm lab work, alongside the embedded UARF enrichment program, through which agroecological principles are examined via inter- and transdisciplinary educational lenses. *Within this context, the objectives of the pedagogical research presented in this paper were:* 1) *To analyze the ALC-UARFP perceptions of transdisciplinary co-learning through PAR, and 2) extract key lessons learned for critical pedagogy, through this model in action.* Our methodological results illustrate the strength of participatory inquiry to capture stakeholder perspectives, iteratively informing the program's direction, and providing key lessons learned. Parallel to this evaluative strength, the qualitative results suggest that authentic undergraduate engagement in PAR offers great potential for the development of increasingly transformative educational programs. Further, our UARFP model, grounded in reciprocal and transdisciplinary co-learning within an agroecological community of practice, pushes the praxis needle toward a more comprehensive and critical agroecology pedagogy.

**Keywords:** agroecology, undergraduate research, sustainable food systems education, participatory action research, transdisciplinary, co-learning, critical education, pedagogy

## INTRODUCTION

This research responds to the call for new developments in higher education pedagogy that are quick to respond to contemporary issues encompassing socio-cultural, political, economic, and ecological spheres of influence. Sustainable Food Systems Education scholar-educators identify the need for pedagogical studies that engage with this trend to inform and advance the field. Studies that build on recent efforts to effectively and programmatically prepare undergraduates to engage, professionally and civically, with today's grand challenges in food and agriculture, support the growing demand for a culturally competent agricultural workforce. Given this context, we explored innovative agroecology pedagogy involving undergraduate agroecological research embedded within an upper division capstone agroecology course (*PSS 212: Advanced Agroecology*) at the University of Vermont (UVM), the Vermont Land Grant Institution.

Our pedagogical innovation centered on transdisciplinary co-learning through PAR, which is a signature of the ALC. Knowledge co-creation was inherently embedded within this program prototype, blending farmer knowledge with academic knowledge. It recognized the goals of social transformation and communication across differences, which are fundamental to co-learning processes (Lotz-Sisitka et al., 2015; Rice et al., 2020; Utter et al., 2021). A primary aim of the Undergraduate Agroecology Research Fellowship Program (UARFP) was to provide the training in horizontal leadership and the team orientation needed for program participants to successfully engage with this transdisciplinary co-learning format.

To assess our UARFP, a participatory inquiry approach to program development was implemented. The objective of this research was to assess the perceptions of UARFP actors engaged in upper division undergraduate agroecology education, in terms of: 1) their learning and development gains; and 2) the development of a UARFP for advancing agroecology toward a more critical and equity-oriented agroecology pedagogy. The article first examines the relevant literature on the evolution of Sustainable Food Systems Education within the context of higher education institutions to demonstrate a distinct pedagogical shift toward critical and equity-oriented pedagogies for the advancement of the field. In the second section we describe the history and evolution of the PSS 212 course that resulted in the addition of the UARFP. In the subsequent sections, we present methodology for our pedagogical assessment, as well as the results and implications of this approach to developing and assessing agroecology education.

## LITERATURE REVIEW

Early formats for Sustainable Food Systems Education (SFSE) advocated action education, combined with constructivist formats for teaching and learning, as a response to contemporary grand challenges (Lieblein et al., 2000; Francis et al., 2001, 2003, 2009, 2011). Action education formats built on prior discipline-centric agricultural education and centered on integrative problem-based, systems-oriented, and experiential

learning. These learner-centered formats involved multi-disciplinary, team-taught and sequential coursework that utilized agroecological systems-thinking on farms and in communities, often in the format of week-long agricultural intensives (Francis et al., 2001, 2011; Jordan et al., 2005, 2008; Trexler et al., 2006; Moncure and Francis, 2011; Parr and Trexler, 2011; Hilimire et al., 2014). These contexts provided early insight into co-learning, wherein, “farmers, ranchers, consumers, industry, and agency people (served) as co-teachers and co-learners” (Lieblein et al., 2000, p. 218).

By 2003, Francis et al. had defined agroecology as “the ecology of food systems,” providing an interdisciplinary framework for research, education, and action. These early formats provided room to address a breadth of issues, involving the social and ethical dimensions of agricultural development. Lieblein et al. (2007) built on these formats by presenting a metaphorical “dual learning ladder...that leads to responsible and directed action” (p. 37). The framework identifies steps in the learning process that advance from routine skills to purposeful action and involves reflection on ethics and values at play in agroecological research. Galt et al. (2012) similarly argued for a pedagogical shift “away from objectivism and toward approaches that (dealt) specifically with the value-laden nature of agriculture and food systems generally” (p. 46). It was intended for these arrangements to not only attain subject matter knowledge, but also the aptitude to implement this new knowledge.

Circa 2010, SFSE had concentrated its attention on “learning landscapes,” through which core competencies associated with “communicative and systemic learning” could be gained (Francis et al., 2011). Learning landscapes engaged students, scholar-educators, and farmers in open-ended inquiry on farms (Francis et al., 2009, 2011). Francis et al. (2013) began to weave phenomenological educational approaches into these learning landscapes. These approaches referred to the holistic and interdisciplinary methods that involve contextualized visioning and planning for a sustainable future. This led to the work of Francis et al. (2020), which brought forth the notion of transforming farmer stakeholders into co-learners so that they could offer their expertise to university programs. These inquiry formats continued to be problem-solving by nature, as they sought to systematically alleviate challenges through adaptive agroecological co-management that required the use of an array of engaged research skills (Francis et al., 2020). Notably, these early scholar-educators of agroecology purported the essential role of educational action research for combined improvements in both agriculture and agricultural education (Francis et al., 2020).

In the last decade, Land Grant Institution research and teaching formats have experienced a paradigmatic shift to address rapid changes in agricultural and global economic development in the face of global environmental change (Galt et al., 2012). These institutions have attempted to address global environmental change in agriculture through teaching and research, as evidenced by increased numbers of food systems degree programs, professional certificates, and pipeline agri-STEM programs for pre-college youth. Within these novel programs, there is a growing emphasis on the interrelated

domains of justice and sustainability, which coincides with increased public attention and unrest around these issues (Galt et al., 2013; Valley et al., 2020).

Some food systems scholar-educators have increasingly connected sustainability education frameworks with values-oriented pedagogies, which are centered on justice (Galt et al., 2013; Valley et al., 2020). These developments reflect the growing need for a diverse, global agricultural workforce capable of inclusively addressing increasingly complex “wicked problems” in food systems (Parr and Trexler, 2011; Murakami et al., 2017). Murakami et al. (2017) address the role that educators play in bridging pedagogical experiences with these problems to both increase students’ awareness and understanding of the impacts of wicked problems on daily life, and to proactively steer their vocational pathways toward roles that address and abate these grand challenges. They deem that instructors should engage their students in systems-thinking, with broader communities that hold certain value and knowledge systems, and social privileges (Murakami et al., 2017).

Recent works by sustainable food systems scholar-educators in higher education point to “an emerging signature pedagogy” (Valley et al., 2018) that outlines “adaptable learning outcomes” (Ebel et al., 2020) for developing a critical food systems pedagogy. As delineated by Valley et al. (2018), a signature pedagogy is a conceptual model that outlines the fundamental components for educational planning, organization, and execution in a specialized professional field. Scholar-educators whose design reflects this signature pedagogy, embrace phenomenological formats, grounded in experiential learning, and coupled with complex systems analysis, which also look at the political ecology of food systems.

In tandem with SFSE, a Critical Food Systems Education framework was defined by Meek and Tarlau (2016) as a “tripartite” of praxis, policy, and pedagogy, calling for a critical and popular education grounded in the political domain of food systems. It called on agroecology as a field primed for this sort of education approach. This tripartite engages with the Freirean notion of “critical consciousness” (Freire, 1970) and with the “informal education practices that have been central to political mobilization throughout the twentieth century” (Meek and Tarlau, 2016, p. 243).

The political dimensions of sustainable and critical food systems education serve a foundation for the development of competencies associated with conscientious action (Francis et al., 2009, 2020; Moncure and Francis, 2011; Meek and Tarlau, 2016). Such competencies are thought to arise alongside socially constructivist, integrative learning formats involving multiple food systems actors (Francis et al., 2009). In this model, knowledge and skills are acquired from multiple interactions with multiple sources, involving distinct, sometimes opposing, points of view. This occurs within complex agroecological settings that provide opportunities for learners to reflect on concrete issues and positional viewpoints therein (Galt et al., 2012).

In such experiential and integrative cases, learners maintain a locus of control over their learning and development, as complex cognitive, affective, and behavioral dimensions come together to construct new knowledge from meaningful learning

experiences (Valley et al., 2018). Essential for deep, holistic, and transformative levels of learning to occur is the cultivation of “safe space,” within which learners reflect on topics and experiences of profound importance (Lieblein et al., 2007; Galt et al., 2012). Resultant may be what Mezirow (2000, p. 8) described as “constructive discourse” for transforming “our taken-for-granted frames of reference...to make them more inclusive, discriminating, open, emotionally capable of change, and reflective so that they may generate beliefs and opinions that will prove more true or justified to guide action.” In such a way, SFSE moves beyond the cognitive dimension of learning and development to engage with the affective dimension that assists identity development (Lieblein et al., 2007; Jordan et al., 2014; Murakami et al., 2017).

Recent efforts to center equity within SFSE explore critical instructional approaches aimed to link affect with justice, equity, diversity and inclusion topics (Sterling et al., 2p021). The work of Valley et al. (2020) proposes an “equity-competency model” for SFSE, reflecting the importance of fostering “ethical and values-based competencies” shared with other pedagogical justice frameworks. The competency model proposes “declarative and procedural elements” that fall into three “awareness” domains (self, others, and systems of oppression), and one focused on approaches and methods for undoing oppression. This work begins with internal domains of awareness that include values, beliefs, assumptions, and positionality, before moving into intersectionality, social identities, and worldviews. Their application is intended for concrete food systems issues wherein actors collectively take part in cultivating “sustainable, place-based, justice-oriented solutions” (p. 10). Sterling et al. (2p021) recognize a need for sustainable food systems educators to identify and respond skillfully to learners’ responses to equity-centered pedagogies as a means to prevent (re)traumatization.

Such a liberatory approach to SFSE is required to “turn schools into forces for liberation,” and away from the reproduction of “dominant social structures, norms, and career pathways” (Meek and Tarlau, 2016, p. 263). These ideas align with those of Anderson et al. (2019) who note that recent scholarship in the field of agroecology pedagogy is informing critical education praxis in ways that will expand the reach of agroecology and food sovereignty globally. According to Meek and Tarlau (2016), engaging students with topics of food justice and food sovereignty serve as direct links to education grounded in the global politics of food systems. Further, education in agroecology is highlighted for its inherent political engagement in food systems transformation through its focus on power dynamics and its direct engagement with global food movements. According to these scholar-educators, this critical education framework must be connected to “the global movements mobilizing around these issues” (Ibib., p. 245).

Despite the insightful scholarship and innovative educational practices that have advanced sustainable and critical food systems education in recent years, there remains a need to explore the impacts of specific program characteristics on student learning. This need directly links to the recent call for studies that inform and advance the field (Valley et al., 2018; Ebel et al., 2020). Assessment is repeatedly identified as crucial for crafting

and developing courses and programs intended to “prepare graduates for professional responsibilities, roles, and capabilities to address complex problems and contribute to dismantling of structural inequities in food systems” (Valley et al., 2020, p. 12). Galt et al. (2012) suggested that assessment should look at intended outcomes and address notions of success/ limitations to proposed praxis. Jordan et al. (2014) similarly explained that future progress would need to include finding ways to monitor non-cognitive or affective dimensions of learning, such as identity. More recently, Valley et al. (2018) urged scholar-educators “to review, critique and implement the signature pedagogy framework,” as well as the equity-competency model, to develop praxis (p. 1). Ebel et al. (2020) built on this work to define eight skills-based “adaptable learning outcomes” for baccalaureate programs that are intended to inform the design, instruction and assessment of SFSE. Their work illustrates that collective action and advocacy are skills nurtured through communication, practical, and team skills that result from the development of (food) systems-thinking, critical reflection, and capacities for diverse ways of knowing (Ibid.). Detailed studies of undergraduate research experiences in STEM fields show promise for parsing the complex relationships between learning outcomes and program design (Weinberg et al., 2018). This paper seeks to address part of this gap by presenting an analysis of a specific case study grounded in many of the principles of a critical sustainable food systems education.

## THE UNDERGRADUATE AGROECOLOGY RESEARCH FELLOWS PROGRAM

Our case study focuses on the Undergraduate Agroecology Research Fellows Program (UARFP), which is part of the evolution of an upper-division agroecology course (PSS 212: Advanced Agroecology) taught in the Plant and Soil Science department of the University of Vermont, the only land-grant institution in the state. As a model rooted in action, the student undergraduate agroecology research fellows (UARF) become members of the Agroecology and Livelihoods Collaborative Community of Practice (ALC-CoP), at the University of Vermont, which is a transdisciplinary research and education group that engages in community-based participatory action research.

Participatory Action Research (PAR) is an approach that brings together different actors to engage in a collaborative process of research, reflection, and action, and which can also include education (Kindon et al., 2007; Méndez et al., 2017). Most PAR processes aspire for all people involved, including researchers and non-researchers (e.g., farmers, students, community members), to participate in all the stages of the research, and have a voice in defining the research questions, methods, analyses, interpretation, publication, and dissemination. This is not always easy, or the case, and some actors end up only participating in certain stages of the research. PAR processes usually include capacity building and education as part of the process, so it can be adapted to support education in formal settings (Ibid.).

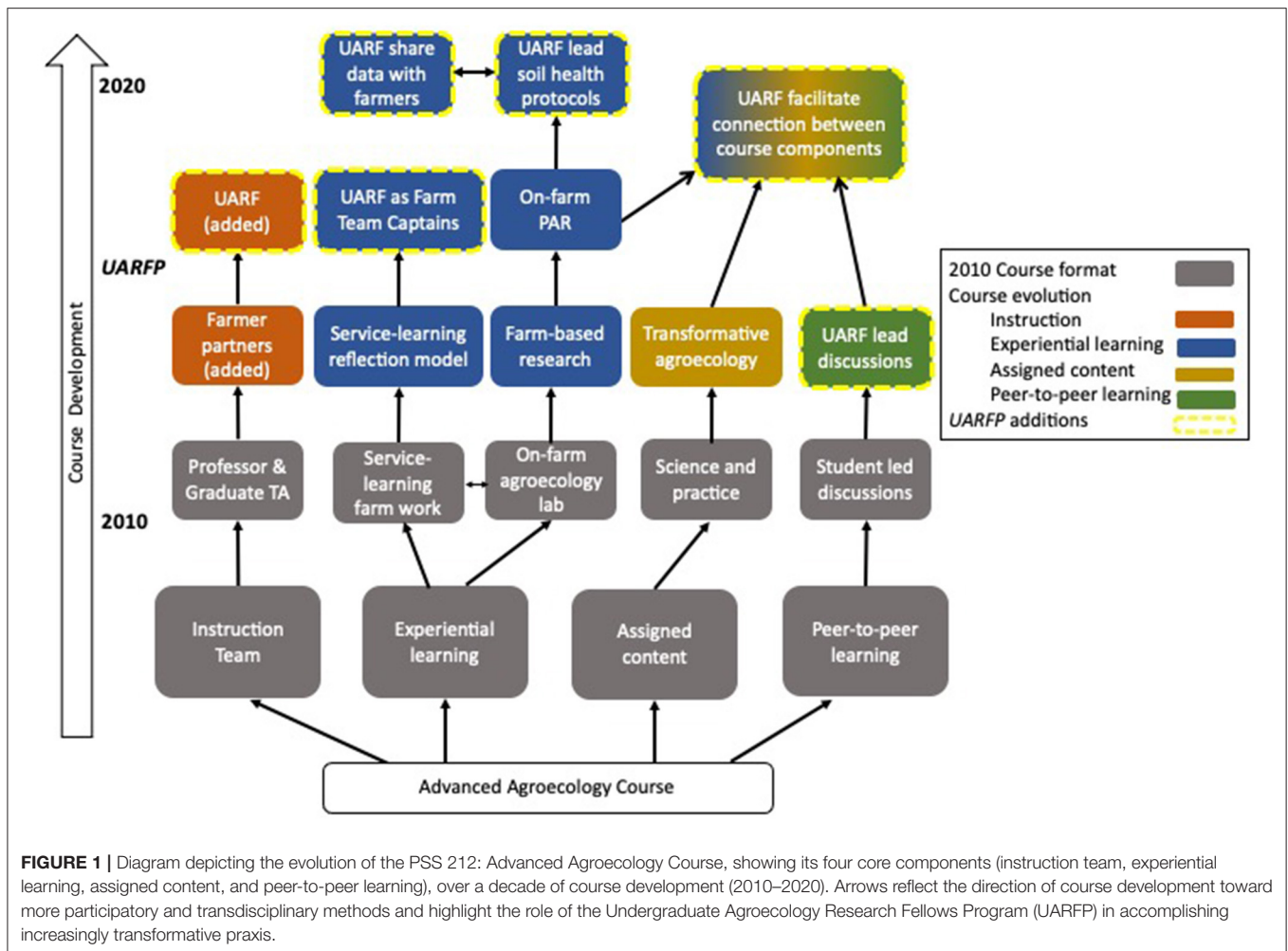
The ALC-CoP is made up mostly of UVM faculty, students and staff that are interested in agroecology and PAR. Traditionally undergraduate student participation has been limited, and the UARFP was an intentional effort to invite selected undergraduate students to be part of the ALC-CoP. There are space and administrative limitations for the ALC-CoP, and a need to maintain it within a manageable size. External partners, such as farmers, are invited for specific events and welcome, but don’t regularly attend the weekly meetings at the university.

The ALC has developed long-term relationships with the farmers that are part of the UARFP, and who also collaborate in other educational and research activities. These relationships started in 2008, with the first iteration of the PSS 212 course, and have expanded to include on-farm research and other courses, by several ALC members, over the years. Some of the criteria to engage farms was that they were aligned with agroecological approaches to agriculture, and that they were not too far away (45 min drive maximum). Several farms came in and out as course partners, mostly depending on farmer interest and needs. For example, for some farms the on-farm service learning was more a burden than a benefit, so they were not a good fit. Farmers generally do not have an official affiliation to the ALC or UVM.

The UARF are invited to become part of the ALC-CoP, which involves weekly meetings, where students were able to interact with faculty, graduate students and staff. These meetings are highly interactive, allowing for the UARF to meet everyone, and participate in activities. In addition, the UARF were asked to present about their experience at the end of the year. The ALC is lead by a team of five people, three of which were involved with the UARFP, and which includes the PSS 212 instructor. The PSS 212 instructor and teaching assistant had weekly meetings with the UARF, and supported them in setting up meetings and logistics related to on-farm research and logistics, as well as farmer interactions.

Over a decade, the PSS 212 course evolved from a Service-Learning Reflection Model to incorporate (PAR, co-facilitated by UARF; see **Figure 1**). In line with PAR principles, the motivations for this evolution included: 1) recognizing that participation in real, hands-on agroecology-related research can yield desirable outcomes for student engagement and learning; and 2) as a response to requests from farmer partners in the course for research that was more useful and relevant to their farms. Existing benefits for both farmers and students were already recognized through service-learning. The potential to go deeper via an ongoing and meaningful research project that would build knowledge over time appealed to both farmers and ALC mentors alike.

The common denominator to early dialogue about this prospect became the overarching interest in soil health, agreed upon by this farmer cohort to be the basis of the whole farm unit. Concrete ideas for soil health inquiry arose, as farmers were concerned with soil biodiversity and fertility for healthy plants and farming systems, and they recognized that they lacked time and resources to do soil monitoring and analyses at regular intervals. They came together with ALC mentors to decide when soil tests would be done, and farmers began to



**FIGURE 1** | Diagram depicting the evolution of the PSS 212: Advanced Agroecology Course, showing its four core components (instruction team, experiential learning, assigned content, and peer-to-peer learning), over a decade of course development (2010–2020). Arrows reflect the direction of course development toward more participatory and transdisciplinary methods and highlight the role of the Undergraduate Agroecology Research Fellows Program (UARFP) in accomplishing increasingly transformative praxis.

set aside spaces on-farm for longitudinal analyses. While clear differences existed between these distinct small-scale farming contexts, soil health was the constant, an integrative long-term research and education project, which took place alongside other tasks (e.g., vegetable weeding/harvesting) that were a core aspect of the existing service-learning environment. Weekly on-farm labs served as spaces for understanding agroecology principles and concepts, and conveyed farmer knowledge to PSS 212 students. Agroecology concepts intermingled with PAR praxis, emphasizing soil health as the central focus of this on-farm research.

In practice, these analyses differed from other forms of agroecological research. This new co-learning format relied on skillful communication for engaged and integrative learning centered on PAR that engaged with the real tension that existed based on differing stakeholder needs. For students, the need to build trusting relationships with farmers, where mistakes were welcomed, contradicted the farmers' need to have accurate data collected by students for agroecological farm management. The farmers recognized that a greater involvement would be needed for this effort to coordinate the training and oversight of UARFs, alongside the lab-based teaching-research teams, to engage with farm preparation, education, and research aspects of

the project. Converting the PSS 212 Course from a basic service-learning course to a Service-learning/PAR practicum required transitioning from a recurring model (students conducting the same on-farm activities each year), to cycles of iterative research. This was a long-term process of pedagogical evolution, in which ALC mentors engaged in different iterations of learning, reflection and adaptation of the curriculum. This initial shift to PAR responded to the idea that the ALC could steward an embedded PAR program supported by UARFs, serving as farm team captains, into the existing PSS 212 course format.

The ALC mentors served as members of the teaching and evaluation team. This involved faculty, staff, and a graduate teaching assistant, who linked the UARFP directly to the PSS 212 course, led the UARFP enrichment program, and collaborated to engage fellows to additional learning opportunities and networks, mostly connected to the ALC. Although the farmers were satisfied with a service learning model that provided on-farm labor during the first 4 weeks of the course, the teaching team felt that it was not providing deep enough reflection and learning for students. For some students the farm work was very disconnected from the course content. PAR provided an opportunity for students to incorporate more intentional reflection about the on-farm work and research, as connected to course agroecology

content. In addition, it provided the UARF the opportunity to engage, hands-on, in a PAR process.

Different cohorts of students/participants were exposed to the evolving content and practice. The transformation of the course happened in parallel and influenced by the evolution of the ALC, which has increasingly sought transdisciplinary, PAR, and a grounding in justice as signature characteristics of their scholarship and practice (Méndez et al., 2016). In this case, we see similar iterations of PAR cycles, including teaching/learning, reflection and adaptation/action, where all actors of the process have been asked to contribute and reflect in order to adapt/act for future cycles of PAR.

We created five UARF positions to work with farm partners, thereby ensuring student participation in the "...institutional and/or organizational connections that facilitate the succession of active participants without losing forward momentum" (Méndez et al., 2017, p. 4). These five students, with studies in environment and/or sustainable agriculture and food systems, arrived at the program with a range of experiences in agroecology. Some held more experience with soils, whereas others had prior experience with farming. The UARF are required to take PSS 212 either previously or at the time when they act as farm team captains. It has worked better for fellows to take the course concurrently with the UARF because course activities are a set part of their schedule, rather than a separate one, and they maintain a closer connection to the course and the students. This can also create some tensions with other students, who may not appreciate other fellow students having a leadership role, but it becomes part of the experience and learning for the fellows to navigate.

The first UARF cohort was selected in May, received training from ALC mentors, participated in farm visits and research design activities over the summer, and acted as farm team captains, the primary farm contact for student teams in the fall. The UARFP provided additional opportunities for the undergraduates to interact with graduate students and ALC mentors through the ALC-CoP. Some attended weekly ALC-CoP meetings that integrated with the content of the transdisciplinary agroecological research shared during the in-class portion of the PSS 212 Course. These extended opportunities for experience beyond the scope of the farm team captain role were malleable with this cohort's range of research interests. They connected their UARFP experiences with additional mentored projects focused on soil health, urban and peri-urban agroecology, Northeastern vineyard production, and rice farming in Vermont, either prior to or alongside the UARFP.

The UARFP enrichment curriculum was designed to provide these undergraduates with a deeper dive into agroecology principles, while supporting the development of various leadership and communication skills (see **Table 1**). A transdisciplinary agroecological framework provides the foundation for the UARFP. This includes an exposure to different knowledge systems and research methodologies that provided students a more diverse and expansive view of agroecological research. The UARFP can be divided into three modules: 1) sustainable leadership building, 2) agroecology knowledge building, and 3) field agroecology skills. These modules respond to three UARFP learning objectives, which

**TABLE 1 |** UARFP enrichment curriculum.

Week	Topic/Theme	Readings and enrichment exercises
<b>Module 1: Leadership, teamwork, and communication</b>		
<b>Guiding question: What is an effective leader?</b>		
1	Introductions	Pair-share and anecdotes
2	Identifying your strengths	Exercise: Clifton StrengthsFinder® assessment
3	Employing practical wisdom	Reading chapter from Practical Wisdom book
4	Structure and organization in research	Reading: From Checklist Manifesto book
5	The art of efficient and well facilitated meetings	Exercise: Meeting facilitation roleplaying
<b>Module 2: Agroecology, transdisciplinarity, and participation</b>		
<b>Guiding question: How can we best apply transdisciplinary methods for sustainable change?</b>		
	Systems thinking: food, policy, and agroecology	Group reflection: Leverage points for systems change
6	Agroecology and transdisciplinary research	Group reflection: How is agroecology unique?
7	Agroecological transformations	Guest speaker: ALC co-director
8	Agroecology and social movements	Guest speaker: ALC co-director
9	Participatory action research	Reading: PAR and agroecology research
<b>Module 3: Soil sampling and analysis</b>		
<b>Guiding question: What is healthy soil?</b>		
10	Soil health indicators	Reading: Chapters—Building Soils for Better Crops
11	Soil sampling protocols	Exercise/Workshop: Joshua Faulkner
12	Soil data collection and analysis	Workshop: TBD
13	Final reflection	Entire learning community

are: 1) to develop leadership and communication skills for conveying knowledge and concepts among multiple audiences and populations, 2) to build foundational knowledge of agroecological concepts and how they are applied within a collaborative research environment, and 3) to cultivate a transdisciplinary lens for addressing issues in the current agrifood system. Core content addressed agroecology, PAR, and transdisciplinarity. Skills acquisition targeted facilitation, research, and analysis (mixed methods), data collection software usage, teamwork, administration, and logistics. While PSS 212 does include PAR, agroecology, and transdisciplinarity as course topics, and are covered using readings, lectures, videos, etc. (see Horner et al., 2021, this issue), fellows gained an expanded and deeper engagement with PAR and agroecology content through the additional curriculum.

## MATERIALS AND METHODS

To analyze the UARFP, we implemented a participatory inquiry approach to study our pedagogical context, which was approved by the UVM IRB. Utilization-focused evaluation (Patton, 1978, 1997, 2008) and case study research (Yin, 2009) were the

two methods we selected and paired for this study, due to their alignment with action-oriented science and evaluation approaches that are viewed as useful for studies in formal higher education settings. Utilization-focused evaluation was selected for its systematic response to the inquiry generated through participatory measures, and for its emphasis on the utility of the evaluation results to support useful action (Patton, 1978, 1997, 2008). It built on the early action science and research traditions that were participatory in nature and valued the utility of knowledge to produce action in education environments (Patton, 1987; Stapp and Wals, 1994; Greenwood and Levin, 1998). These approaches involved closer relationships between evaluator and evaluand wherein possibilities emerged for shared learning as program stakeholders worked together through spirals of evaluation, reflection, and action to achieve program goals (Stapp and Wals, 1994; Greenwood and Levin, 1998). A case study approach was selected because it can cover both a particular phenomenon and the context within which the phenomenon is occurring, through the format of an evaluation study (Yin, 1993). Our case studied the phenomenon of stakeholder engagement in a PAR process centered on soil health within the broader contexts of the PSS 212 Course and the UARFP. These contexts were central to understanding the relationships between the various design and pedagogical components and the program objectives related to transdisciplinary co-learning. Yin (1993) described how positions within research contexts limit the objective distance between the researcher and the phenomena of study. The scholar-educator perspective that came with our internal roles in this context provided multiple entryways for conducting qualitative research methods. As reflected in **Table 2**. UARFP Data Collection, UARFs and Farmers were exposed to multiple modes of reflection and assessment as part of this ongoing PAR process (see **Table 2**).

In line with the ideas of Patton (1990), our qualitative assessment was formative in nature, aligning with the theory of change processes common for program development. It informed the extent to which we were meeting our goals, and it highlighted the nuanced ways in which our novel program went about achieving our learning and development objectives. Three kinds of qualitative research methods were used for this context. These methods included: 1) participant observation; 2) in-depth, open-ended interviews, and 3) written documents, including written reflections and program archives (Patton, 1987). *Participant observation* centered on program activities in our triangulated learning spaces (on-farm, in-class, and enrichment) and gave special attention to participant behavior and stakeholder perspectives. *Interviews* with key stakeholder groups included purposeful and homogenous samples to describe subgroups in depth. Along with review of UARF *reflective essays*, *program archives*, and *course planning documents*, these data served to triangulate with interview and focus group transcriptions for an inductive analysis. Data collected were compiled and organized using selective coding strategies into major themes, through a grounded theory approach to content analysis (Patton, 1987; Yin, 1993; Maxwell, 1996). These case study methods, outlined by Yin (1993), and compatible with utilization-focused evaluation methods, enabled us to build

**TABLE 2** | UARFP data collection.

Research participants	Data collected	Fall 2018	Spring 2019
UARFs (five undergraduate student research fellows)	<i>Curricular work samples*</i>	Five <i>reflective essays</i> and <i>transdisciplinary lab reports*</i>	
	Document review	Farmer dinner notes	PSS seminar presentation
	<i>Interviews*</i> (individual and group)	Five <i>individual interviews</i> and one <i>focus group*</i>	One <i>focus group*</i>
	<i>Facilitated reflection meetings*</i>	One <i>facilitated reflection meeting*</i>	One <i>facilitated reflection meeting*</i>
	Participant observation	Soil health training (summer) Farmer dinner (fall and spring)	
	Participant observation	Agroecology enrichment meetings (weekly)	Agroecology enrichment meetings (Weekly agroecology enrichment meetings)
Farmers (five farmers representing PSS 212 course on-farm labs)	<i>Individual interviews*</i>	One <i>individual interview*</i> per farmer (5 farmers)	
	Participant observation	<i>Farmer dinner*</i>	
	Document review	Farmer dinner notes	

\*Reflection and assessment italicized.

program theory from the socially constructed reality unique to the program's context. We looked for patterns that emerged from the data, from which program theory could be established, and we employed member checks with key stakeholders to guarantee the validity of our findings (Yin, 2009). We further developed a database that held the evidence and served as a way of distinguishing the data from the research findings, a means to make certain the reliability of this research (Ibid.). These methods helped us to gather appropriate qualitative data to inform our program's development.

## RESULTS

In this section, we discuss the learning and development impacts of the UARFP through the two primary perspectives relevant to the scope of this paper: students and farmers. First, we report the students' perspectives on the UARFP through two core themes that emerged through our grounded theory approach to content analysis: 1) community of practice orientation and 2) PAR principles and praxis. The students' holistic reflections on their affective experience with the UARFP

add context to this analysis. Second, we present farmers' perspectives, including appreciation of co-learning, identification of contradictions between course format and PAR praxis, and suggestions for future course iterations. These lessons infer that stakeholder engagement in transdisciplinary co-learning through PAR advanced UARF agroecological knowledge and skill acquisition and informed UARFP development. In addition, horizontal knowledge sharing through reflexive praxes, grounded in an authentic agroecological PAR context, met programmatic learning objectives in multiple meaningful ways.

## Students

### Community of Practice Orientation

UARF horizontal Leadership was understood to be a complex and crucial aspect of this UARFP typology. The UARFs engaged with multiple, integrated peer leadership roles while serving as farm team captains. Leadership roles involved in-class, student-led discussions; on-farm lab work; and PAR leadership as ALC-CoP members. The leadership role in the PSS 212 course involved a great deal of time and energy investment and served as a site for deep levels of learning and engagement. PAR leadership was needed to navigate on-farm soil testing, data analysis, and sharing results with ALC mentors and farmers. UARFs were required, as stated by one, to “integrate them all,” referring to the complexity of the leadership role and related responsibilities that included accountability to communicate effectively with farmers and researchers, facilitation responding to group power dynamics among students, and organizational skills involving management of time and research materials.

Trying to sort out the complexity of this role inspired the creation of an egg graphic that the UARFs developed for a final presentation of their work at a departmental seminar (see **Figure 2**). Coined “the egg,” this graphic reflected the complex framework of the UARFP, defined as consisting of multiple, interconnected layers. Many facets of the program, e.g., soil study, fit into multiple layers. The bulk of their UARF dialogue revolved around sorting out this complexity, which, at times, overshadowed discussion of specific, tangible, and hands-on research and education topics that needed to be addressed. The UARFs indicated that rapid personal growth and development were required to meet these complex needs, pushing them to face their vulnerabilities and build confidence collectively. Through their reliance on their peer network, UARFs ultimately felt empowered to engage with this complexity, connecting classroom and field-based learning on farms with weekly UARF agroecology enrichment activities (see **Table 1**).

The UARF cohort spoke of their team orientation centered on leadership, which involved a combination of accountability, transparency, and camaraderie, woven together within this UARFP format. UARFs became attentive to their leadership styles through a combination of assessment, interaction, and observation addressed through weekly agroecology enrichment meetings that encouraged strengths-based approaches to leadership. Camaraderie was a term used to describe the “tight knit support network” that they strived to provide for one another in the context of fellowship topics and tasks. Together, they learned to communicate and organize themselves and

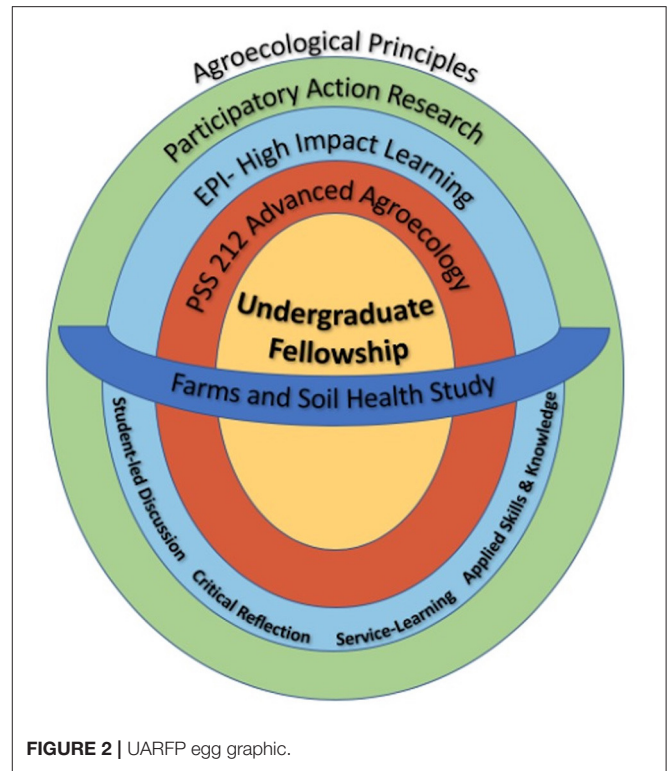


FIGURE 2 | UARFP egg graphic.

others, including those perceived to be “superior,” holding higher positions within academia. Two of these students ascribed perceptions associated with gender, speaking openly about how their placement among a group of female-identifying “fellas” reinforced their sense of place within the program, and their confidence as researchers. Both students described feeling underrepresented and undervalued in previous research settings and attributed their newfound confidence as researchers to the horizontal knowledge sharing network that valued their contributions.

Building from this enrichment experience, UARFs utilized reflective practice with their lab groups that led to inquiry and attendant learning pathways. One UARF described moments of “deep learning” wherein they were “prompted or internally inspired to ask more questions.” In addition, integrating classroom and on-farm experiences generated new questions and allowed teams to discuss their reactions to what was being learned through the course, and to identify emergent questions through dialogue. Aligning with agroecological principles centered on knowledge co-creation, hierarchies of seniority and experience were leveled within the classroom. UARFs reported feeling that all forms of knowledge were recognized and valued, and all voices were heard.

Classroom-based farm team engagement centered on Student-Led Discussions, which UARFs viewed as concrete opportunities to engage with controversial equity and diversity issues. Food justice and sovereignty topics were covered in class and offered talking points for an on-farm lab. This gave students opportunities to explore how racial tensions and the urban-rural divide are manifested within Vermont agriculture, connecting



on-farm learning to class content. UARFs noted that inquiry, dialogue, and reflection were essential to understanding the transdisciplinary complexity associated with this field.

One element of the course that was designed to deepen students' connection to farmers was on-farm interviews. All UARFs placed high value on a lab designed to develop research interview skills. Interview questions were developed to center on farmer livelihoods as part of an interdisciplinary lab report. Interviews were also an important part of the PAR process. To see agroecology put into practice in terms of the livelihoods concept was a powerful and positive experience for the fellows.

Differing UARF experiences on farms were linked to patterns of communication while facilitating lab group activities. These differences were attributed to distinct farm needs and patterns of farmer behavior. They also reflected widely varied student group dynamics on farms—from effective group communication while addressing challenges, to difficult interpersonal and leadership dynamics. This variability led to concerns among UARFs that the lack of interaction with farmers could reflect poorly on the farm team captain. This experience was reflected in the following UARF statement: *“The hardest stuff that would keep me up at night wasn't if I did the soil test right.”* Rather, she was concerned with how day-to-day affected the group. While farmer engagement was unique to each farm, and ranged from little attention aimed at the lab group to explicit lab group instruction, hearing farmer perspectives on agroecology was highly valued by all farm team captains. In all, such differences allowed for rich dialogue that enabled UARFs to put organizational and communication skills into practice throughout the course.

The farm team captain role enabled deep learning via assuming a researcher role within the PAR project. This role involved communicating results with farmers and institutional stakeholders. It also inspired additional senior capstone experiences and influenced UARF thinking about graduate study. Toward the semester's end, UARFs presented farmer partners with soils and qualitative data along with a farm map. The research conversations that ensued were meaningful and empowering opportunities to concretize learning about the importance of relationships within PAR processes. This event prefigured spring UARFP engagement that involved greater autonomy and choice. Spring activities included additional work on farms, continued documentation of research data and programmatic feedback, collaboration with graduate students, and research presentations. Students created living documents, including data management, for future UARFs in subsequent program iterations. Research deliverables served as baseline data for the ongoing PAR project. Presentation of this research took place at both the UVM Student Research Conference and the PSS spring seminar series. UARFs shared their insights with PSS faculty into the ways in which this research opportunity differed from other undergraduate research experiences, describing PAR as comprehensive transdisciplinary inquiry, a process well-aligned with the contemporary research needs of the PSS department.

Three of the five students connected the UARFP with senior research studies. Two connected it to their capstones through the Environmental Studies program. One of these was completed

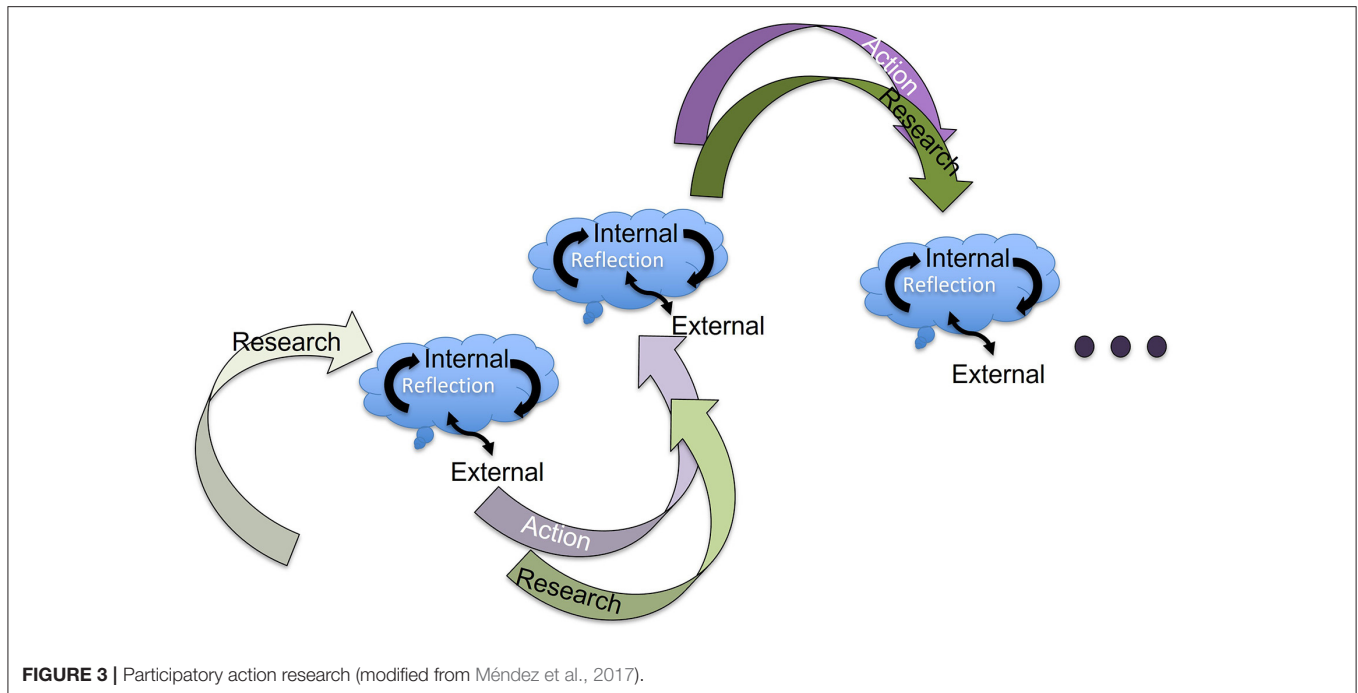
alongside an urban and peri-urban agroecology project that was formed and supported by the ALC. The third UARF completed an agricultural thesis for the Honors College. Their research was presented for feedback from the ALC, cultivating interactions with graduate students and researchers within the CoP context. Ultimately, it was noted by one fellow that this experience was *“an ideal culmination of (her) ENVIS undergraduate career,”* and *“like a trial run”* for graduate school, with structure in the beginning evolving toward greater levels of responsibility to own their work. The UARFP experience was collectively described as an excellent reference for future studies, as it refined their professional intentions and directions.

UARF reflection highlighted the crucial mentorship role played by the ALC-CoP in transdisciplinary co-learning through PAR. As stated by multiple UARFs, these mentors *“genuinely care”* and *“are passionate about”* the impacts of their work within agricultural communities. They agreed that a shared values-orientation, grounded to great extent in respect for farmers' identities and livelihoods, guides this work. In a written capstone reflection, one UARF described how *“each member of the ALC brings valuable skill sets to the collaborative workspace.”* This variety was deemed extremely important for their research training—from instruction on soil sampling and related data collection taught through UVM Extension, to the reflective practices and facilitation training led by the agroecology enrichment program leaders, to farmer communications support from the ALC leadership team, and the *“close mentorship”* received from the graduate teaching assistant. They collectively perceived that the teaching team *“came together”* and *“welcomed”* them into the ALC-CoP.

Review of the data from our final UARF focus group revealed multiple references to taking time to pause and reflect on gratitude and appreciation for this fellowship opportunity. When prompted to reflect on the UARF experience, *“humbling”* was a word that came to mind for one. The opportunity to learn about relationships to land and commitments to action fueled her response. For another, *“letting go of fear”* in the face of this learning experience was supported by the lack of a dichotomous success/failure lens toward the educational experience. A third shared her experience with moments of *“confidence”* and *“vulnerability”* as she described how this range of affect allowed her to navigate between her leading and learning roles. The fourth described it as *“equally rewarding as it was time and energy demanding.”* She reiterated the *“unexpected roadblocks”* that arose as multiple moving parts of the program unfolded. The fifth described it as *“unique,”* consisting of *“so many layers, and a very real and human opportunity that can't really compare to any amount of research methods classes or literature.”* She went on to say that the UARFP *“allowed us to show up with heart.”* Holistically, they enthusiastically praised the *humane* quality that they attributed to the program model.

### PAR Principles and Praxis

This UARF cohort became familiar with the multiple stages of PAR, through which reflective practice informs action and research (see **Figure 3**). As stated by an UARF, *“the cyclical PAR model gave me opportunities to try research methods to*



**FIGURE 3** | Participatory action research (modified from Méndez et al., 2017).

gather data, to recover from mistakes, and to communicate results to move forward within a research process.” From pre-reflection, through to research, action, and further project reflection—in which partners’ needs and expectations were valued—UARFs experienced how PAR is a form of community-engaged research. One UARF stated that this PAR experience “affirmed (their) sentiment that research and activism shouldn’t be separate and that they can be united.” Another UARF was drawn to explore notions of empowerment and inclusion within the PAR framework. She “considered her own identity and privilege as a student of agroecology” and decided to review research on female peasant farmer empowerment. Her studies helped her contextualize PAR and horizontal communication in experiences different from her own. For others, this experience helped (them) grasp research priorities and recognize how much time and energy goes into these types of projects. And, as summarized by a fourth UARF, “your research is not just for you.” Through the PAR principle of reciprocity, she acknowledged the importance of thanking project partners and giving back to communities, which illuminated the potential for PAR to provide long-term benefits for project partners.

Building on their nuanced understanding of PAR as a complex process with long-term impacts, this UARF cohort engaged in transdisciplinary co-learning through PAR, within the ALC-CoP knowledge co-creation framework. Engaging in a process of agroecological praxis, UARFs linked agroecology principles of soil health and knowledge co-creation within an applied, practical context. Their experiences with PAR enabled values-orientated learning alongside the development of valuable skill sets. In comparing their experience with prior research endeavors, one UARF “solidified” her thoughts about how her values play into research dynamics. As stated by another, “PAR

understands the unique needs of each player... (it) creates flexibility.” Another student noted that within the PAR process, the participating farmers’ body of knowledge “has the same value as peer-reviewed literature.” They collectively indicated that they let go of preconceived notions of learning through their interactions with the farmers and the ALC mentors. Establishing relationships with farmer partners and observing farmer livelihoods allowed students to engage in co-learning and apply the agroecological principle of knowledge co-creation.

While UARFs collectively described PAR as complex and challenging to understand, their familiarity with PAR was complemented by their engagement with the ALC-CoP. As viewed broadly by this cohort, transdisciplinary agroecological, and participatory research relationships were redefined, which inspired curiosity regarding both research processes and their impacts on people and global food systems. Interview data brought forth their shared understanding that PAR “crosses lines between academia and actual life,” supporting individual and community livelihoods, and the livelihoods of agroecology scholars who rely on publications to survive in the land-grant environment. Through reflective writing, an UARF cited ALC scholars, Fernandez and Méndez (2018), who described communities and farmers as “protagonists” with autonomy via “shared ownership in the research process.” Overall, UARFs collectively believed that the fellowship was unique in its ability to convey PAR principles and applications.

The PAR principle of reciprocity was reflected in the horizontal relationships cultivated by UARFs, which relied on effective communication and the valuing of diverse perspectives within the learning environment. This research typology differed from their prior research experiences

that supported a researcher-subject relationship, and it provided greater opportunities for building agroecological and research skills through transdisciplinary research partnerships. This included the highly valued opportunity to hear directly from farmers about their perceptions of researchers and research processes. Students' prior research experiences were described as "more isolating," whereas, the UARFP created an interactive communication network that built on their unique individual programmatic experiences, combined with shared workloads and verbal processing of feelings and challenges that arose during the research process.

The horizontal and collaborative UARFP environment, deemed professional, welcoming, and conducive to learning, allowed for "learning from mistakes" over fear-based performance metrics. Having this "room for mistakes" supported steady progress, rather than a "return to the drawing board" when research verged from the expected. This space further built trust among students, farmers, and ALC mentors, providing impetus for skills development. Overcoming fear, doubt, and guilt associated with soil sampling and analysis errors were key to engaging in PAR. The PAR format that involved encouragement from their cohort and from the ALC mentors, assisted fellows in undertaking soil resampling for precision. As stated by one fellow, "mistakes are imperative parts of the research process." The group further acknowledged the need for patience and a willingness to spend more time engaging with processes that accomplish applied research goals. These acknowledgments highlighted imperfection as a critical part of both the PAR process and undergraduate learning within PAR. While mistakes were moments of obvious tensions in the research process, UARFs also reflected on the deeper tensions that underlie notions of student success in higher education. Through this reflection, they challenged their expectations of themselves based on what they had been trained to do to succeed within the academy. As these notions were questioned, new formats for educational leadership took the place of previous narratives and norms. The UARFP placed a unique emphasis on personal growth alongside the development of valuable skill sets via integrative experiences, connecting academia with agricultural practice and personal reflections.

## Farmers

### Transdisciplinary Co-learning in Agroecology

The farmers had high levels of education, including advanced degrees, and considerable experience working with undergraduate students. Five of the seven farmers representing the five farms have held, or currently hold, formal faculty, and/or staff positions within an academic institution of higher learning, and one of them held more than one position at multiple institutions. Notably, one of the partner farms for the course is the UVM Catamount Farm, with two employees working directly with farmer training and land management systems affiliated with the university. Of these two farmers, one held an advanced degree through the UVM Plant and Soil Science Department and had previously

been a cooperative member of another farm partnering with the course.

While these farmer associations with institutions of higher learning were unique to this context, they allowed the farmers to enter into the course arrangement with much more certainty than might be exhibited by a typical farmer who engaged in agricultural research with UVM faculty. As stated by the farmer who had lectured at UVM and had previously participated in ALC teaching and research, "When [students] come on the farm, I really feel that is my venue for teaching and learning with them." He highlighted the reciprocal nature of learning by adding, "I learn from them too. We had one student this past time who was a hemp specialist. We started growing hemp and I learned a lot because I had never grown it before." He further noted that students with prior farming experience shared their stories informally with the group, indicating yet another reciprocal format for knowledge sharing among the lab group members. Reciprocal learning was highly valued and emphasized by multiple farmers in interviews. Farmers also expressed deep value for the authenticity and experiential nature of their farm learning environments for teaching about agroecology.

Embedding a PAR project within the course further enabled co-learning. The perceived importance of this project centered on soil health was articulated through the farmer interviews, as noted by the following farmer statement, "It is the basis of all agriculture. It is the most fundamental thing for students to understand." Reiterated by multiple farmers, soil testing provides useful longitudinal data that informs land management. One of the farmers shared how soil health indicators were collected for their farm over the course of many years, and soil test results enabled them to keep track of fertilizer and compost applications. She indicated that she would like to share this information with students over time, to link natural science concepts with land management. Describing an objective of the relationship between service-learning and the soil health PAR project from her perspective, another farmer shared their farm's aim to provide students with opportunities to link agroecological and business management systems that took place aboveground, with the soil health taking place underground. This observation reflected the way in which the service component, combined with PAR, further enabled students to view organizational skills of farmers and the efficiencies that go into farm management. Concern was expressed by a farmer who realized that the data collected by this UARFP cohort/ PSS 212 class would not provide immediately available information for use with the class, yet she recognized that future cohorts would benefit from this work. She offered to engage students in data interpretation and in a discussion about how the data would inform her farm management decisions. She further recognized how this project could be linked to the farmers' responsibility to complete nutrient management plans for the state. She explained that the revamped water quality policy implemented under Vermont's "Required Agricultural Practices" could inform this PAR project. Two additional farmers concurred that most farms in the project already have multiple datasets from prior years, and one of these farmers proposed that students could use the data to construct a management plan for their fields. Even as farmers recognized their own expertise, they were

eager to integrate complementary expertise from the ALC-CoP to support this PAR project.

### UARFP Development

Farmers partnering with PSS 212 had engaged with multiple prior iterations of the course that applied a service-learning reflection model. This format intentionally linked “meaningful service to academic learning, personal growth and civic responsibility” so that students develop “critical literacy and independent thinking necessary for successful engagement with present-day society” (Murphy, 2010, p. 39–40). The work-service component engaged learning through observation and sensory engagement with a working landscape, enabling a “systems-orientation” to the interrelated natural and social systems of the farm. On a day early in the semester designated for participatory mapping, one farmer engaged students in a process of developing farm management strategies “*in real time*.” The farm had just acquired new land, and so the farmer explained, “*We didn’t end up doing mapping like it is typically laid out... We had just acquired this new land, so we did this walk of the new land.*” With weekly returns to the farm, he noted that students observed change over time, such as noting the regrowth of grasses for pasture and the movement of animals by humans, that they may not have observed with a single visit. From there, farm labor became the service provided in exchange for learning. For those interested in farming as a profession, service-learning was described by one farmer as “*good practice for being crew leader on farm.*” However, farmers noted broadly that time was a core challenge associated with service-learning. As stated by one, there was “*no time to train*” students, so “*tasks must be simple, yet embedded within the broader systems, where observation allows them to make meaning out of how the work plays into these land management systems.*” He went on to say that while the students wielded shovels and rakes, they were encouraged to observe systems components.

Farmers addressed pedagogical complications that coincide with doing authentic PAR on-farm with one class cohort at a time, particularly when the perceived range of students’ knowledge and skill were so vast. For one, farmers were unsure about how meaningful and/or educational PAR was for students. There were expressed concerns by multiple farmers around the utility of the experience for student learning, given the issue of time and varying levels of student interest in the topic. With reference to research process skills (i.e., data collection and interpretation), it was noted that the farmers needed to be heavily involved in this work because the perceived levels of skill among students varied widely, regardless of the lab focus (e.g., mapping, scientific methods, understanding PAR, or rudimentary hands-on farm skills). Therefore, farmers were not convinced that they should depend on students for research, nor that this was the best route to connect with them. In one farm case example, the farmers designed a scientific approach to study organic matter with the students to further their teaching about soil health. They developed an intricate plan to look at organic matter, through the addition of wood chips to sandy soil, only to realize that there would be little to no reliance on students to help with any part of the project. This brought

forth the realization that they needed to be clear with themselves about what the students were capable of, in terms of both time and skill. This led to the broad realization that they needed to consider what to expect from a class on their farm (e.g., looking at crop yields over time), and how this realization should play into their scientific inquiry and associated methods for engaging students. Despite these complications, data from farmer interviews illustrated their intent to provide meaningful educational experiences with and for students, their curiosity about how to engage them more effectively in learning about soil health, and their commitment to greater involvement in these research and education processes that differed from other forms of agroecological research. Ultimately, they indicated that they worked to find balance between providing students with direction and trusting in the PAR process, and the coordinated skills of the teaching-research teams were perceived by farmers to be critical to engage students with farm preparation, education, and research aspects of the project.

Multiple farmers presented their ideas for advancing agroecology education in partnership with their farms. A farmer referred to student learning in terms of “*education of mind and heart*,” and voiced his genuine curiosity to learn about what students “*reap*” from the course. He explained that there is a final lab session dedicated to wrapping up the lab course component but emphasized that it “*does not represent the entire context of the course.*” To strengthen the farmers’ educator role, the following five UARFP provisions were suggested by farmer partners: 1) Create “*guideposts*” throughout the course that would tie course information (e.g., syllabus) more fully into the farm environment; 2) Provide information about students’ perceived on-farm learning and development based on evaluative feedback; 3) Develop agroecology curricula that engages students with their farms over multiple semesters; 4) Develop the PSS 212 course curriculum to address Vermont’s water quality policy focused on agricultural practices; and 5) Provide farmers and students with examples of additional land management cases centered on soil health for comparison with this on-farm PAR project. These suggestions reinforced the collective idea from the farmers that we need to strengthen the relational nature of teaching-learning processes, in part by recognizing and celebrating the reciprocal nature of this work.

## DISCUSSION

### Community of Practice Orientation

Communities of practice theory states that social practices “are formed through pursuing any kind of enterprise over time” (Farnsworth et al., 2016, p. 2) with “self-organization as a defining feature” (Nicklin et al., 2021, p., 71). Nicklin et al. (2021) point out that “communities of practice can be an effective means to spread and create knowledge” (p. 70). The values orientation of the ALC-CoP is defined by its commitment to transdisciplinary, participatory, and action-oriented approaches to agroecological research and education (Méndez et al., 2017). Such approaches align with agroecological principles that “support transitions toward economic, social, and ecological sustainability” (Caswell et al., 2021, p. 1). Together, these commitments to agroecology

principles and participatory research praxis guide the work of the ALC-CoP in the transition to sustainable food systems.

UARFs deemed the ALC-CoP “safe space” for exploring transdisciplinary perspectives that fueled learning and operationalized meaningful research. High value was placed on the mentorship and expertise that emerged from this supportive and community-oriented learning environment. As stated by Galt et al. (2012), safe space is essential for transformative learning in SFSE. In our case, UARF impressions of ownership and empowerment in the learning process stimulated personal, professional, and civic action and direction. The “safe space” of the enrichment program further provided room for UARFs to explore connection, compassion, and courage, through dialogue focused on shared leadership and problem solving. It helped them to overcome fear, doubt, and guilt associated with soil sampling and analysis errors. It also involved encouragement from their peer cohort, while ALC mentors assisted fellows in undertaking soil resampling for precision. Ultimately, this format led to renewed research identities that were attributed to the horizontal knowledge sharing network of the ALC-CoP that valued their contributions. In line with the integrative and experiential characteristics of a sustainable food systems signature pedagogy (Valley et al., 2018), our case made space for UARF to gain new knowledge through engagement with the multiple cognitive, affective, and behavioral dimensions of their research and education experiences.

Our results indicate that a researcher identity developed in correlation with UARF positionality within the ALC-CoP and its situated context within the University of Vermont. The UARFP model aligns with the ideas of Hunter et al. (2006) who discussed the function of undergraduate research “in students’ cognitive, personal, and professional development.” Like ours, their model centered on socially constructivist learning that involved “student-centered and situated learning...in a community of practice” (p. 38). Both approaches relied on facilitated reflective practice by an “expert other” to create socially constructed meaning frames. Our PAR approach was distinct in the ways that shared expertise and knowledge co-creation occurred among UARF, ALC mentors, and farmers. Dialogue centered on leadership and communication, grounded in PAR, brought forth a shared sense of authorized place within our research domain, while UARF confidence grew within our enrichment context. Such “epistemological development” leads to ways of knowing that are internally directed and are part of the professional socialization process (Hunter et al., 2006, p. 39).

One of the aspects that has allowed this program to be successful is to select the right types of farmers and farms. Many of the farmers we have worked with over the years have some experience in education and are college educated. A few have worked at UVM as instructors or staff. Although this is helpful, it does not seem necessary. Being a rural state, Vermont provides ample opportunity to choose different types of farms (i.e., dairy, vegetable, diversified). However, the reality is that it would be hard for a large dairy operation to be able to host students, as would be the case for a large, highly mechanized farm in the Midwest of the U.S. The UARFP model has worked well with small to medium scale diversified farms, including some with

cattle, chickens and pigs. The smaller scale of the farm also aligns with farmers that are interested in supporting agroecology education and have a high demand for labor. From the service-learning perspective, this is most easily applied to vegetable farming that requires manual labor, although one of the farm partners involved students in rotational grazing of cattle and managing the pig herd. We can envision small-scale farms, both private or run by an organization or institution, being interested in collaborating with this type of course and the UARFP. We also see this model working in a variety of locations, ranging from rural areas to urban settings, as long as smaller diversified farms are present. One important logistical aspect is that for farms to be visited twice a week, during 3-h lab periods, they cannot be too far away. Our limit was always no longer than a 45-min drive in our department van, and even those posed a time challenge. This can be dealt with in creative ways, but it is an important issue to consider when assessing the feasibility of this program in other colleges or universities. In terms of the background of the students, we have many who come to the course with farming experience, especially from the Agroecology, Environmental Studies and Food Systems majors. Again, this is easy to do in Vermont, if desired, and many students from diverse backgrounds take advantage of the many opportunities available. However, it cannot be a requirement, and all of our farm partners have accepted that the groups will have a range of experiences. This diversity also makes the role of the UARF more important, as they become mentors especially for students with no experience.

Farmer partners had long been involved with the PSS 212 course, through their historical ALC-CoP affiliations, and multiple teaching and research collaborations. We believe that the timing and objectives of this iteration of course evolution, which involved UARFs serving as farm team captains for the first time, led farmers to share their holistic course development perspectives with us, rather than centering their interview responses more directly on their perspectives of the UARFP. However, through the yearlong UARFP, involving numerous and varied interactions between farmers, UARF, and ALC mentors, it became clear that farmers valued the research, communications, and leadership contributions of the UARF for bridging their farms with the classroom, and for their role in stewarding the combined course and UARFP. Although the farmers did not directly say they valued the new UARFP, we perceived an appreciation for the higher level of coordination and depth that was brought by the UARF. The farmer perspectives strengthen our analysis, illustrating the effective role of the ALC-CoP to engage PAR actors in knowledge co-creation processes that involve transdisciplinary co-learning on farms.

## Transdisciplinary Co-learning Through PAR

Knowledge co-creation is a key agroecology principle (FAO, 2018; Wezel et al., 2020). It is inherently embedded within this program prototype, blending farmer knowledge with academic knowledge for transdisciplinary co-learning. The FAO (2018) points to education to play a central role in knowledge co-creation processes. While the FAO names exemplary farmer-to-farmer exchanges to illustrate this principle, we believe that transdisciplinary exchanges among academics, farmers, and

students associated with agricultural research in higher education create ripe contexts for advancing agroecological praxis. Within these contexts, co-learning is a pedagogical approach that places emphasis on collective goals and the processes engaged to achieve them. These include group accountability for teaching and learning, as well as group processing of learning materials (Lotz-Sisitka et al., 2015; Rice et al., 2020). With social transformation and communication across difference a primary aim of co-learning, such formats reject the individualistic learning modes of traditional educational formats (Ibid., p245). These educational formats place the responsibility for learning in the space of the learner and encourage capacities for lifelong learning and responsible action. Our program effectively responds to the call by Francis et al. (2020) to sufficiently orient and train the UARFPs to successfully engage in transdisciplinary co-learning through on-farm PAR.

PAR intrinsically involves co-learning, since it is “a form of knowledge co-creation that involves two or more actors in a collaborative and intentional process” that “results in insights and solutions that would not otherwise be reached independently” (Utter et al., 2021). Our PAR actors took part in the co-learning approaches that are reflective of a “transformative education in agroecology” (Francis et al., 2020). This educational format folds farmers’ expertise into the university teaching and research setting through their active participation with the ALC-CoP. In addition, our on-farm soil health inquiry engaged UARFP actors with agroecological research skills, alongside the reflective and observational skills of PAR. This work involved a situated systems analysis with the potential to inform land management. To further this work, we can lean on the ideas of Francis et al. (2009, 2020), who engaged students in visioning and planning processes alongside farmers, through phenomenological open-ended and inquiry-based approaches to agricultural problem-solving. Additionally, our work aligned with Wezel et al. (2020), who linked students’ understandings of agroecosystem-level, principles-based change, with higher-order thinking that considers the principles at play in food systems-level, transformational change. This sort of educational engagement will be particularly important as we aim to provide additional opportunities for PAR actors to engage with food systems concepts centered in political economy, namely those that converge with issues of equity and justice. Facilitated engagement with these topics, may lead to what Jordan et al. (2005, 2008) described as socially constructivist practice that acts toward worldview transformation, and which may lead to “pro-environmental civic behavior” for “problem-solving relevant to sustainable agricultural development.”

## UARFP Development

The UARFP is situated in action education which, according to Lieblein et al. (2004), provides a set of methods for learning about the complexity of farming and food systems, and provides students with insight into the field of agroecology, and what it means to be an agroecologist. We built on earlier co-learning formats described by Francis et al. (2001, 2020), as we combined a depth of farmer and researcher expertise through PAR. This expertise connected our transdisciplinary co-learning

community with an agroecology enrichment program within the context of the ALC-CoP. This comprehensive set of knowledge and skill led to socially constructed, transdisciplinary co-learning. Like other sustainable food systems scholar-educators, our enrichment format engaged social values associated with sustainability and justice issues to explore our context within the broader framework of global agricultural economic development and global environmental change (Galt et al., 2012, 2013; Valley et al., 2020). Social constructivism guided the process, wherein communication and reflection were key and facilitation by experts crucial for co-learning processes. This theoretical orientation aligns with liberation and critical education theory, providing an agroecological values-orientation that is useful for guiding students’ awareness toward topics of global sustainable agricultural development. Soil health and knowledge co-creation principles of agroecology melded together for transformational learning, as evidenced by the ways in which preconceived notions of formal learning shifted and power dynamics were flattened. These results border the efforts of Valley et al. (2020), who defined an “equity-competency model” for SFSE that utilizes learning spaces to guide students through internal and external awareness domains toward the goal of justice-oriented problem-solving in place.

To align the UARFP more fully with critical education frameworks and approaches for transitions to sustainable agriculture and food systems, we turn to the Critical Food Systems Education framework (Meek and Tarlau, 2016) and to recent scholarship on agroecology pedagogy grounded in social movements (Meek et al., 2017; McCune and Sanchez, 2019). Aligning our work to theirs will allow us to move the UARFP “beyond agroecology as a science and set of practices, to agroecology as a political project” (Meek and Tarlau, 2016, p. 246). The Critical Food Systems Education tripartite of policy, pedagogy, and praxis recognizes that engaging learners with the interrelated ecological and political economic forces occurring in agriculture and food systems, through the lens of social movements, are key for agroecology education (Meek and Tarlau, 2016; Anderson et al., 2019). This work aligns with the recent scholarship, grounded in the organizational work of those involved in social movements in the United States, Mesoamerica and the Caribbean, for fostering consciousness and advancing skills (Meek et al., 2017; McCune and Sanchez, 2019). Anderson et al. (2019) have termed these educational praxes “Learning for Transformation” in agroecology. We can shape our UARFP, grounded in PAR, to engage with such praxes—to cultivate the activist-oriented “transgressive subjectivities” needed for food systems change (Meek and Tarlau, 2016, p. 242).

As we infuse the UARFP with critical- and equity-oriented educational frameworks, we can consider pedagogical approaches that engage values and ethical development for the purpose of transformative learning (Galt et al., 2013; Valley et al., 2020). Topics of empowerment and inclusion within the PAR framework, notions of identity and privilege within the land-grant context, and a response to individual academic inquiry that explored feminist agroecology arose through our UARFP context. These topics were key for engagement with socially constructivist pedagogical methods for case-level experiential agroecology

education. To build on this work, we can respond to the call from Trevilla-Espinal et al. (2021) to further integrate feminist theory into agroecology education and practice. Morales (2021) summarizes this call by stating that feminist agroecologists “must cultivate what we promote in the field, to nurture polycultures, mutualisms, knowledge dialogues, social organization, and horizontal learning in our own minds and institutions” (p. 956). Combined with reflexivity, this integration could push forth explorations of researcher and gender identities in science that arose through this cohort’s UARFP experience. While this exploration was unique to this cohort, it provides evidence that we can be more intentional about crafting curriculum that engages the intra- and inter-personal fields of identity development with social equity, diversity, and justice topics.

Our paper echoes the findings of Murakami et al. (2017), who suggest that affective learning is an aspect of agroecology and sustainable food systems education that warrants deeper consideration. Our work should build on that of Valley et al. (2020), who apply “equity-competency” approaches to their work, exploring the role of the affective domain in teaching, learning, and research for agricultural and food systems transformation. For example, we could develop a reflective assessment tool for equity-competency based on the ideas of Post (2019), who suggested that we utilize reflective practice to understand the relationships between notions of interdependence, compassion, resiliency, and empowerment, which inform program development for sustainability. To do this, we can build on our recent pedagogical work focused on the PSS 212 course (see Horner et al., 2021, this issue), which revealed relationships between topics of equity and justice and transformative learning in agroecology. Using a Most Significant Change technique that drew upon students’ course reflections, themes of empowerment, social justice, systems thinking, relationship building, and transdisciplinary learning surfaced. To further explore the intra- and inter-personal domains that explore values, beliefs, assumptions, positionality, and intersectionality, and to engage with the frameworks’ methods for undoing oppression, we propose infusing contemplative pedagogies into our curricular efforts. These pedagogies weave contemplative insight and action into the realm of education. The need for transforming social systems, and the relationships between the contemplative mind and societal conditions, are at the center of works by contemporary contemplative scholar-practitioners (Barbezat and Bush, 2014; Litfin, 2016; Eaton et al., 2017). We intend to steer teaching and learning in agroecology toward contemplative approaches that are more deeply grounded in equity and justice. This work builds on transdisciplinary learning formats seeking to deconstruct traditional educational paradigms. Utilization-focused assessment and evaluation tools show great promise for assessing this work within the “safe spaces” cultivated by the UARFP.

## Limitations

Our comprehensive qualitative research was not conclusive for all UARFP typologies since our model represents one case in one locale. On the other hand, our utilization-focused case study provided a solid understanding of what the UARFP, centered on

PAR, accomplished in terms of learning outcomes and program objectives. We captured stakeholder perspectives based on our shift from a service-learning reflection model to an on-farm soil health PAR process within the context of the PSS 212 course. These perspectives served as assessment measures to determine our capacity to meet programmatic learning objectives and to inform program direction. As a result of examining these evaluative data for this special issue on critical- and equity-oriented pedagogy innovations for sustainable food systems education, we learned that the most meaningful and relevant co-learning occurred among participants of this UARF cohort, and to a lesser extent between farmers and ALC mentors tasked with program development. We considered the mentor perspectives captured through this research beyond the scope of this paper. However, our research results are reflective of the role that this type of program can play for advancing SFSE toward more critical- and equity-oriented educational endeavors in land-grant institutions through participatory, co-learning processes. Further, our research demonstrates the utility of this case study research mode, infused with participatory, utilization-focused evaluation, for assessing novel agroecology education programs.

## CONCLUSIONS

Affective learning is an aspect of agroecology and sustainable food systems education that warrants deeper consideration. We viewed its importance for learning and development through the positionality of the UARF within the ALC-CoP. The “safe space” for fellows stimulated enrichment learning and engagement with meaningful research, which led to notions of transformation that emerged from reflections involving a combination of cognitive, affective, and behavioral domains. To explore the role of the affective domain in education and research for transitions to sustainable food systems, we propose infusing contemplative insight and action into our curricular development efforts. This effort is complementary to current approaches and provides additional opportunities for agroecology education to further engage with issues of equity and justice. To this end, critical education for food systems and sustainability frameworks can support the development of our UARFP to engage the intra- and inter-personal fields of personal learning and identity development more fully. As we infuse the program with critical pedagogical approaches, centered on topics that include global food sovereignty, agroecological feminism, and social movements, and combine them with contemplative pedagogies, we aim to further engage the values and ethical dimensions of student development, for the purpose of transformative learning that leads to action.

Engaging PAR actors in knowledge co-creation for the purposes of understanding and shaping the political forces affecting agriculture and food systems is crucial for transitions to sustainable food systems. Within our context, PAR distinctly merged UARFP leadership and farmers’ expertise together into

university education for transdisciplinary agroecological co-learning and curricular development. UARFP actors engaged agroecological research skills, alongside the reflective and observational skills of PAR. Explorations of transdisciplinary perspectives resulting from these experiences occurred through dialogue centered on PAR and led to increased UARF confidence and transformed research identities. This educational format is well-positioned to engage PAR actors in facilitated problem-solving that addresses a range of localized and broad food systems issues. In combination with critical educational frameworks for sustainability in food systems, PAR can serve to push the agroecological praxis needle toward more transformative methods that link education, research, and action.

Land grant institutions of higher learning create ripe contexts for advancing agroecological praxis through co-learning approaches guided by collective processes and goals. These socially constructivist approaches are foundational for transformative agroecology education praxis. The ALC-CoP, affiliated with the University of Vermont, engages agroecology principles and participatory research praxis in the transition to sustainable food systems. Utilization-focused evaluation methods are well-suited to explore the impacts of these praxes to acquire insight into co-learning alongside development of transdisciplinary educational formats that seek to deconstruct traditional educational paradigms.

## DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without organization or institution being undue reservation.

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## ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Research Protections Office, University of Vermont. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

## AUTHOR CONTRIBUTIONS

VM, MC, VI, JF, NC, KN, and CH: study conception and design, interpretation of results, and draft manuscript preparation. KN: data collection and data analysis. All authors reviewed the results and approved the final version of the manuscript.

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