# Critical and equity-oriented pedagogical innovations in sustainable food systems education

Edited by
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Critical and equity-oriented pedagogical innovations in sustainable food systems education

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Co-design of Adaptable Learning Outcomes for Sustainable Food Systems Undergraduate Education

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Higher education institutions are increasingly offering Sustainable Food Systems (SFS) degree programs in response to societal demand for training a professional food systems workforce. As a relatively young field, there is a need for clearly articulated learning outcomes (LOs) for SFS education to define student learning through degree programs, design new programs, and evaluate and modify existing programs. New and established SFS programs are often fragmented over multiple academic departments which impedes the development of a coherent and holistic curriculum for approaching the complexity of food topics. Here, we address these needs through the co-creation of adaptable LOs for Baccalaureate degree-level SFS programs which are aligned to a SFS Signature Pedagogy and based on outcomes-based education toward contributing to a solid conceptual basis for SFS education. The SFS Signature Pedagogy is a framework that can be applied to develop students' systemic capacities, including holistic, and pluralistic ways of understanding sustainability challenges, multi-, inter- and trans-disciplinarity, experiential learning, and collective action projects. Our co-design of LOs was based on qualitative content analysis of existing LOs of established SFS programs, a cross-sectional survey with SFS educators and refinement of LOs from feedback in an expert panel. This process resulted in the eight adaptable LOs: (1) systems thinking, (2) critical reflection, (3) diverse ways of knowing, (4) practical application, (5) multi-context communication, (6) teamwork, (7) collective action, and, (8) advocacy for SFS. We anticipate the adaptable LOs proposed here to be applicable for diverse student communities and geographic respectively cultural contexts as well as to provide insight for sustainability-related academic programs toward developing professionals equipped with skills and capacities to address complex challenges.

Keywords: sustainable food systems professionals, curriculum development (education), curriculum assessment, collective action, systems thinking and application, co-design, outcome-based education (OBE), sustainable food systems education

INTRODUCTION

Overview of Sustainable Food Systems (SFS) Education

One of the greatest societal challenges of our times is to nourish a growing population with healthy food procured in ways that support environmental and human well-being (Tilman and Clark, 2014; Mason and Lang, 2017). While food nourishes us, food systems are a leading driver of environmental degradation (Meybeck and Gitz, 2017) and global change (Willett et al., 2019). Diet-related health conditions present one of the greatest global burdens of disease (Swinburn et al., 2019) and inequities persist from farm to table (Breggin and Myers, 2013). Several planetary boundaries of environmental thresholds recognized as safe operating spaces for humanity have already been crossed including a dramatic rate of biodiversity loss and notable changes to the global nitrogen cycle (Steffen et al., 2015). The environmental challenges associated with food systems are depleting the natural resource base upon which food and well-being depend (Foley et al., 2005; Francis et al., 2008; Gerber et al., 2013; Steffen et al., 2015). Malnutrition including obesity, undernutrition, and their coexistence, impacts every country and is a leading cause of death globally (Afshin et al., 2019). Concurrently, interacting political, market, and population factors create inequity and other food justice issues (Breggin and Myers, 2013). Climate change exacerbates these food system challenges (Willett et al., 2019). Addressing the complexity of these interconnected challenges requires engaged professionals equipped with skills beyond conventional disciplinary training in food, nutrition, and agriculture, which often approach each issue separately (Valley et al., 2018). Additionally, food system studies take into account the unique relationship between food and the human experience from a variety of perspectives lending an interdisciplinary aspect to this field that differs from more disciplinary approaches taken by food-related areas of study (Almerico, 2014).

In response to societal demand for more interdisciplinary programs, higher education institutions, including private and public colleges, universities, and polytechnics, are increasingly offering sustainable food systems (SFS) and similar degree programs. However, despite the need for enhanced interdisciplinarity in programs and classes, many courses of interdisciplinary programs remain housed in traditionally defined disciplinary departments (Cargill, 2005). In addition, there is often an expectation of faculty to develop new courses and programs that are interdisciplinary with little institutional resources or support. This lack of resource support for the design of interdisciplinary programs and courses contributes to structural and economic "siloing" of SFS and similar programs, which precludes the creation of programs that facilitate education across disciplines (Hamada et al., 2015). To overcome resource limitations as well as to strengthen the field of SFS education based on a solid conceptual basis, collaborations across SFS programs to develop curriculum is critical.

While differing in their curriculum, SFS programs are characterized by an underlying conceptual framework to build students' systemic capacities that complement disciplinary training in food and agriculture topics (Jordan et al., 2014). These systemic capacities include deep reflection, rich observation and model-making, future visioning and design, and responsible participation (Jordan et al., 2014). More recently, a SFS Education Signature Pedagogy (SFSESP) has been identified to advance SFS education by providing a guiding framework to develop and evaluate curriculum of SFS programs (Valley et al., 2018).

To transform frameworks such as the SFSESP into curricula that meet societal and professional needs, outcome-based education (OBE) has been advanced over the past five decades (Harden, 2001, 2002). The establishment of clearly articulated program learning outcomes (LOs) is an essential requirement for OBE (Spady, 1994). While LOs presently exist in numerous SFS programs, they differ in number, approach, emphasis, and style (see **Appendix 1** for examples). It is also unclear to what extent these LOs align with the SFSESP, especially since most programs evolved independently from this framework. Thus, we identified the need for LOs aligned to the SFSESP as building blocks for the development and assessment of SFS curricula. The purpose of this paper is to draw from an OBE model to co-design and propose a set of LOs for Baccalaureate degree-level SFS programs aligned to the SFSESP that can be adopted and modified in diverse educational and institutional contexts. The LOs presented here are intended to adaptable to diverse geographic and cultural contexts and for akin programs including Food Networks, Urban Food Systems, Ocean Food Systems, Food Studies, Sustainable Food and Farming, Agricultural and Food Systems, certain Agroecology programs, Community Food Systems, Sustainable Community Development, Indigenous Food-Energy-Water Systems, Eco-Gastronomy, certain Nutrition, Gastronomy, and Food Culture programs, Food Systems Management, Food Security, Food Sovereignty, Hunger Studies, as well as several Environmental, and Sustainability Studies programs.

The co-design of adaptable LOs for SFS undergraduate curricula was led by faculty ($n = 6$) and staff ($n = 3$) of three SFS programs in North America (Montana State University, University of Minnesota, and University of British Columbia). It proceeded in the following steps: a qualitative content analysis of the LOs of selected SFS programs; a survey on SFS LOs with SFS educators; and an internal review panel ($n = 8$) for the final refinement of the LOs aligned to the SFSESP.

Sustainable Food Systems Signature Pedagogy

A signature pedagogy serves as a framework in which future practitioners of a specific field are educated for their profession (Shulman, 2005; Gurung et al., 2009). It is applied across higher education institutions to align programs based on philosophies of education such as experiential and social constructivist learning (Kolb, 1984; Palincsar, 1998), and more specifically Lieblein et al. (2007) dual learning ladder toward responsible action and transformative food systems education (Galt et al., 2013), teaching practices, and LOs. Educators and students can benefit from a clearly articulated signature pedagogy of a specific field by understanding its pedagogical foundations

as well as accepted methodological approaches for developing professional capacities (Valley et al., 2018). A leading framework for organizing a signature pedagogy is based on three structural levels: (1) surface structure of visible operational acts of teaching and learning; (2) deep structure of the essential theories, concepts, and capacities for professional practice in a field, and (3) the implicit structure, comprising the set of professional attitudes, values, and dispositions of a field (Shulman, 2005).

The SFS Signature Pedagogy was developed by SFS educators from four different institutions in the US and Canada and first presented to the public in 2017 in the journal article "An emerging signature pedagogy for sustainable food systems education" (Valley et al., 2018). The article has been cited 33 times between March 2017 and July 2020. The framework was also presented at five scholarly conferences since 2017. Each component of the SFSESP exists at one of the three structural levels of a signature pedagogy (Shulman, 2005) and interacts with each other. The surface level of learning contexts and activities of the SFS Signature Pedagogy caters to multiple learning styles essential for designing inclusive curriculum which accounts for students' educational, cultural, and social background and experience (Smith, 2002). This includes contexts from classrooms to laboratory and community settings, and from individual assignments to co-producing solutions. This range of context and activities provides opportunities for students to adapt to different settings.

The deep structure of the SFS Signature Pedagogy proposed by Valley et al. (2018) consists of four principal elements:

1. Pedagogy of systemic thinking: to develop the ability to understand food systems through holistic and pluralistic approaches. Systemic thinking requires the capacity to identify the boundaries, components, and interactions within a system, as well as how different stakeholders value, define, and experience systems.
2. Pedagogy of experiential learning: to build a particular form of professionalism, here defined as capacities for thought, performance, and action with integrity (Shulman, 2005). This pedagogy is primarily based on experiential learning that features integrated engagement of "heart, head, and hands"; this 3-fold integration of engagement is considered essential to building capacity for thought and action with integrity in ethical and moral terms.
3. Pedagogy of multi-, inter-, and trans-disciplinary learning: to develop capacities to participate in the process of understanding complex situations with diverse academic stakeholders and other social actors in the food system.
4. Pedagogy of open-ended case inquiry: to develop the capacity for dealing with the uncertainty and dynamism that are characteristic of complex issues and opportunities in SFS. In particular, such inquiry aims to develop one of the most crucial aspects of SFS professionalism, namely, the ability to make judgments under uncertainty.

The implicit structure of the SFS Signature Pedagogy consists of three elements:

1. Collective Action: acknowledging the limitations of singular, uncoordinated efforts to instigate systemic change in a complex system.
2. Critical Reflection: requiring a habit of mind that recognizes historical and current power differentials within society and their resulting uneven distribution of benefits and harms related to food systems.
3. Seeking Balance: recognizing the tensions and trade-offs inherent to any intervention in a complex system, and being mindful of the potential negative consequences associated with maximizing for any one outcome in food systems (Valley et al., 2018).

Outcome-Based Education

Outcome-based Education (OBE) develops a curriculum around an explicit set of program learning outcomes (LOs) identified as critical for all students to achieve by the end of their experiences in a program (Spady, 1994; Harden, 2002). Prior to the emergence of OBE, statements regarding students' learning expectations were generally not included in program documents. Early proponents of OBE in higher education were in the medical field and argued that language clarifying student learning expectations is a catalyst to keep up with changing societal needs (Jessup, 2002). As a learning-centered curriculum approach, OBE focuses on what students know and can do, as compared to a teacher-centered model emphasizing what is presented (Tam, 2014). By aligning courses with clearly stated measurable LOs, OBE improves curriculum consistency and strengthens curriculum accountability (Spady, 1994).

Program LOs are fundamental for OBE. Some authors define them as what students know, are able to do, or are like after college education as a result of specific teaching and learning experiences (Killen, 2000; Tam, 2014). Contemporary definitions emphasize that LOs should be precise and measurable and achievable for all students during college (Spady, 1994; Hartel and Foegeding, 2004). The most frequently used definition is Spady (1994), who defines LOs as "the ability to demonstrate learning that matters." Accordingly, LOs (framed using action verbs) are not values, beliefs, or states of mind, neither approaches, means, strategies, or processes but skills, knowledge and professional attitudes. Educators can apply LOs to guide curriculum mapping, curriculum design, instruction, and assessment (Spady, 1994; Harden, 2002; Hartel and Foegeding, 2004; Frank and Danoff, 2007). Proponents of OBE highlight that the use of LOs provides students and the professional sector transparent and clear expectations about a program (Harden, 2002; Tam, 2014).

There is sometimes confusion between the term LO and the partially overlapping (depending on the school of thought and authors of each framework) concepts of learning objectives and student competencies. Hartel and Foegeding (2004) clarify that learning objectives are general statements about the larger goals of a course or program, while LOs describe specific student skills. Competencies are statements that broadly indicate the desired skills of students after graduating. Different from PLOs, competencies are acquired by students or graduates, rather than by the program and its instructors (Morcke et al., 2013).

Although there are underlying differences between outcome- and competency-based education frameworks, when referring to the point of graduation, similar descriptors can be used for LOs and competencies (Cumming et al., 2007), although achieving a single competency may require a graduate to meet several LOs. The organic incorporation of the SFSESP in SFS curricula we expect from the use of LOs would also be accomplishable using a competency-based education framework. We opted for OBE as a vehicle to implement the SFSESP because it is currently more common in higher education curriculum design and assessment than competency-based approaches.

While various SFS programs have developed LOs (**Appendix 1**), implementable LOs are needed to provide foundational building blocks for the improvement of existing SFS programs and for allowing new programs to have a foundation from which to draw. A set of shared and adaptable LOs contributes to strengthening the way SFS curriculum is developed and assessed. Clearly defined LOs also allow employers and food system stakeholders to better understand the attitudes, skills, and knowledge of a growing professional workforce with a SFS degree.

METHODS

We developed the adaptable LOs for sustainable food systems (SFS) undergraduate curricula in three steps: (1) qualitative content analysis of the LOs of selected SFS programs, (2) cross-sectional online surveying of SFS education experts (faculty and graduate students), and (3) final framing of adaptable LOs based on an expert panel and iteration.

Content Analysis of SFS Program Learning Outcomes

We analyzed the LOs of undergraduate SFS programs in the U.S. and Canada which were selected on the basis of the following criteria: (1) the program name includes the term "food systems"; (2) SFS is available as a major or minor at undergraduate (BSc or equivalent) level; (3) the program has explicit LOs framed in the context of outcomes-based education (Spady, 1994), (4) the LOs are published by the respective institution. A total of 43 undergraduate SFS programs were evaluated for the aforementioned criteria and the following five programs were selected as they best met this existence of published LOs in OBE style.

- Sustainable Food and Bioenergy Systems, Montana State University
- Food Systems, University of Minnesota Twin Cities
- Land and Food Systems, University of British Columbia
- Sustainable Agriculture and Food Systems, University of California Davis
- Sustainable Agriculture and Food Systems, University of Rhode Island

For the five selected SFS undergraduate programs, we carried out a content analysis of the published LOs to identify the skills, knowledge, and attitudes that students are expected to acquire

and develop during their degree programs (Kuckartz, 2014). While we used a qualitative approach to content analysis, we quantified the results of this analysis including the prevalence of specific themes. Our content analysis was led by the following research question: *What are common and overlapping student skills, attitudes, and knowledge determination relevant to the students' ability to examine and address complex food systems challenges in undergraduate sustainable food systems program Learning Outcomes?* The coding process was facilitated by the qualitative software NVivo 12 and conducted in two steps: (1) An initial directed content analysis based on predetermined key variables as preliminary coding categories, and (2) a refined analysis using coding themes that emerged during the first step (Leech and Onwuegbuzie, 2011; Saldaña, 2015). In both steps, we split the LOs into meaning units (Kuckartz, 2014) and coded each unit. Occasionally, one meaning unit was coded to multiple themes.

The coding scheme for the initial process consisted of the four deep and three implicit components of the SFSESP (see Introduction). Any content that could not be categorized with the initial scheme was categorized as "Other." We calculated the frequency of meaning units as a percentage of total meaning units to identify extensive or underrepresented codes (**Appendix 2**).

In the second step, we grouped meaning units into categories and coded them along these categories. "Collective action" and "Critical reflection" were identified as extensive categories, and we established subcategories. "Self-reflection" was considered underrepresented and became a subcategory of "Critical reflection." The category "Open-ended case inquiry" was renamed to "Food system assessment." The same occurred with "Experiential learning" which was renamed to "Practical skills." We merged the categories "Food system assessment" and "Collective action" under the title "Civic engagement" since they shared over 30% of meaning units. The remaining uncategorized meaning units were coded to determine whether they represented a new category or subcategory of one already existing code. They were divided into "Communication skills" (two subcategories), "Attitudes," and "Knowledge." After coding, we identified 46 condensed meaning units grouped into eight categories, three of which were divided into subcategories. Six categories were related to skills, one to knowledge, and one to attitudes (**Appendix 3**).

Surveys to Identify Priority Adaptable SFS Program Learning Outcomes

We conducted surveys with SFS educators in Canada and the United States to identify priority LOs for SFS undergraduate programs. The surveyed educators have disciplinary and interdisciplinary expertise in various aspects of SFS and in interacting with stakeholders. A cross-sectional online survey was administered in two steps. First, educators associated with a SFS education project led by members of this paper were surveyed ($n = 31$; 25 faculty, 1 post-doc, and 5 graduate students; 28 responses). Second, we reached out to experienced SFS instructors outside the project-scope, teaching at 14 different institutes of higher education in North America ($n = 37$; all faculty; 17 responses). The survey responses were voluntary and

anonymous. Upon completion, a $15 gift card was provided as an incentive for participation in the survey that was provided to educators outside of the project team.

For the questionnaire, all 46 meaning units obtained in the content analysis were framed as LOs. Their style was aligned to the recommendation of Hartel and Foegeding (2004), meeting the criteria of being specific, measurable, achievable for all students, realistic, and time-bound. In our understanding, specific and measurable mean that LOs are assessable and provide a guideline for the development of assignments to objectively measure the students' mastering of these LOs. Consequently, our LOs involve skills expressed by an action verb such as "demonstrates" or "analyzes." We avoid verbs like "understands" or "appreciates," which could not be objectively assessed. We intended to be as specific as possible with the framing of our LOs given the interdisciplinary nature of SFSE. "Achievable for all students" means for us that meeting a certain LO does not privilege a specific group of students or discriminate against another one. Finally, "realistic" and "time-bound" LOs are, in our understanding, achievable based on what a SFS curriculum offers to students and the regular duration of the respective program. Thus, mastering a LO refers to what can be expected from an undergraduate student after graduation. It does not mean perfection.

All LO suggestions in our surveys began with "Upon graduating, students will be able to," followed by an action verb. For example, the meaning unit "Systems approach" was framed "Analyze complex problems using a systems approach." On three occasions, one meaning unit was presented in optional versions differing in terms of style and emphasis. The questionnaire involved multiple-choice questions and a Likert-scale ranking. In the latter section, participants were asked to rate the significance of each LO on a scale from 0 (not relevant for SFS curricula) to 10 (indispensable). The multiple-choice questions served to select one prevailing theme per LO. Therefore, the categories and subcategories from the qualitative analysis were converted into survey questions and the corresponding meaning units were the choice options. Example:

Question: "Please select the most appropriate framing of a learning outcome about systems thinking!"

- Answer (Option 1): "The student analyzes complex problems using a systems approach."
- Answer (Option 2): "Using a systems approach, the student compares and assesses alternative models for food system change."

Final Framing of Adaptable Program Learning Outcomes

In this step, an internal project panel comprised of eight instructors in the fields of SFS, education, agriculture, food, and nutrition, all authors of this article, interpreted the survey results, selecting those options with the highest approval rate and synthesizing certain content where the approval for different options was equal. The panel framed the final set of LOs as building blocks for the substantial systemic capacities that we hope our graduates will develop. This occurred through

a focus-group workshop followed by a series of iteration through correspondence and conference calls. In this context, we integrated the LOs "Food system assessment" into "Collective action," "Self-reflection" into "Critical reflection." We renamed "Research skills" to "Diverse ways of knowing," "Communication skills" to "Multi-context communication," and "Professional attitude" to "Advocacy." Due to our emphasis on developing student skills such as collective action (Valley et al., 2018), we decided to process "Knowledge" as a requirement for achieving our LOs but to exclude it as an independent LO. We restructured the sequence of the LOs and shared a draft set of LOs with all project team members. After integrating their feedback, we determined the final set of adaptable LOs for SFS education. We assigned a short name to each LO and aligned the LOs to the deep and in implicit components of the SFSESP (Table 1).

RESULTS

Overview of Adaptable SFS Program Learning Outcomes

The final set of adaptable Sustainable Food System Program LOs derived from the study process involving content analysis, surveys of SFS education experts (see results in Appendix 4), and the final framing of adaptable LOs, is presented in Figure 1. In section Description of Individual Adaptable SFS Program Learning Outcomes, the eight LOs are described in detail focusing on their relevance for SFS programs along with teaching approaches and techniques for supporting these LOs (resumed in Table 1). For a detailed description of recommended pedagogical techniques and strategies for supporting our LOs, please see Appendix 5.

Description of Individual Adaptable SFS Program Learning Outcomes

LO 1 Analyze Food Systems Using a Transdisciplinary Approach Guided by Sustainability Principles

Analyzing and addressing the food challenges of our times requires systems thinking that takes into consideration all the parts, relationships, and interactions from food production to consumption and waste. Systems thinking is grounded in the principles of holism and pluralism (Valley et al., 2018) and draws from socio-ecological theory. Holism refers to a focus on the relationships and interactions between the components of a system to understand the whole as well as to consider the contextual factors that surround an issue or desired outcome. Pluralism refers to explicit engagement and valuing of multiple perspectives when characterizing a system (Reynolds and Holwell, 2010; Williams and Hummelbrunner, 2010). Food systems thinking further draws from a socio-ecological approach that examines the ecological, socio-economic, cultural, and human health dynamics pertaining to food (Ahmed et al., 2017, 2019; Mason and Lang, 2017; Ahmed and Byker Shanks, 2019). Food systems thinking is, therefore, transdisciplinary, involving what is between different disciplines, across, and beyond them. Its goal is the understanding of the present

TABLE 1 | Adaptable Program Learning Outcomes for Sustainable Food Systems Education, their alignment with the SFSESP Framework, and teaching activities for supporting these LOs.

Learning outcome #	1	2	3	4	5	6	7	8
Short name	Systems thinking	Critical reflection	Diverse ways of knowing	Practical skills	Multi-context communication	Team skills	Collective action	Advocacy
Alignment with SFSESP level	Deep structure	Implicit structure	Deep structure	Deep structure	Deep structure	Deep structure	Implicit structure	Implicit structure
Closest alignment with SFSESP components	Systems thinking; Multi-, inter-, and trans-disciplinarity	Critical reflection; Seek balance	Multi-, inter-, and trans-disciplinarity; Open-ended case inquiry	Experiential learning	Multi-, inter-, and trans-disciplinarity; Experiential learning	Multi-, inter-, and trans-disciplinarity; Experiential learning	Collective action; Seek balance	Collective action
Suggested teaching activities (see Appendix 5 for details).	Case Studies; Concept Mapping; In-depth Multi-day Field Courses; Power Mapping; Rich Pictures	Case Studies; Concept Mapping; Critical Reading; Debates; Deep-learning Classroom Activities; In-depth Multi-day Field Courses; Interactive Group Techniques; Power Mapping; Rich Pictures; Student-centered Guest Lecturing	Case Studies; Conversational Method of Gathering Indigenous Knowledge; Debates; Farm-based Authentic Research Modules in Sustainability Sciences	Case Studies; Experiential Learning; Internships; Roleplays; Service Learning	Critical Reading; DEAL (Describe, Examine, Articulate Learning); Deep-learning Classroom Activities; Electronic Media Communication and Literacy Training; One-to-one Relational Meetings; Participatory Writing	Capstone Projects; Experiential Learning; Farm-based Authentic Research Modules in Sustainability Sciences; Interactive Group Techniques; Internships; Public Narrative; Service-learning	Capstone Projects; Case Studies; Community-based participatory action research; Deep-learning Classroom Activities; Public Narrative; Service-learning	Capstone Projects; Community-based participatory action research; Community Arts Projects; Community-engaged Teaching and Learning; Power Mapping; Service-learning

world (Nicolescu, 2014). Also, systems thinking is not limited to Western scientific methods but informed by insights from the multiple perspectives and sensibilities of those affected by a food system (Klein, 2013). When analysis is guided by systems thinking, it reflects the multiple values and conceptions of sustainability, particularly its complex social dimensions related to equity, sovereignty, and justice (Bacon et al., 2012). We define such an analysis as a qualitative account of a food system (Moragues-Faus and Marceau, 2019), that portrays key elements, events, relationships, forces, ideas, and values in the food system in question.

Systems thinking is a means to understand a food-system situation broadly including its complexity and divergent perspectives of participants and their histories. Given the complex and "wicked" nature of food system problems, well-considered initiatives for food systems change must take a holistic view grounded in systems thinking as their point of departure or run risks of failure. "Wicked" problems are characterized by heterogeneity, non-linearity, interdependence, and self-organization (Finegood, 2011). As such, systems thinking considers how to collectively address complex food problems where the environment interacts with socio-economic, cultural, and human health factors in infinite permutations.

Although many analytical methods can be applied to investigate food systems in the classroom, few of these are explicitly transdisciplinary or reflective of the multiple dimensions of sustainability. Images and symbols, rather than verbal accounts, are often effective tools to depict the qualitative essence of a food system (Cadieux et al., 2016). In such a model, the account should describe the activities and agencies of both human and non-human actors and their interplay, and the essential dynamics and tensions that animate the food system situation, particularly as relating to sustainability challenges. The account should also be a "tale told in many voices," to capture the divergent views of people that have different understandings and stakes in a situation. We advocate that by the end of their programs, students will be able to articulate transdisciplinarity via the use of visual representations of complex systems. For example, "rich pictures" (See Glossary in **Appendix 5** for further information) is a mechanism for learning about complex problems by drawing detailed representations of them (Avison et al., 1992). Inventories such as concept or power maps (Glossary) also enhance systems thinking. Socio-environmental case studies (Glossary) are an excellent way to apply systems thinking in real scenarios.

FIGURE 1 | The Eight adaptable Program Learning Outcomes for Sustainable Food Systems Education and their interconnection.
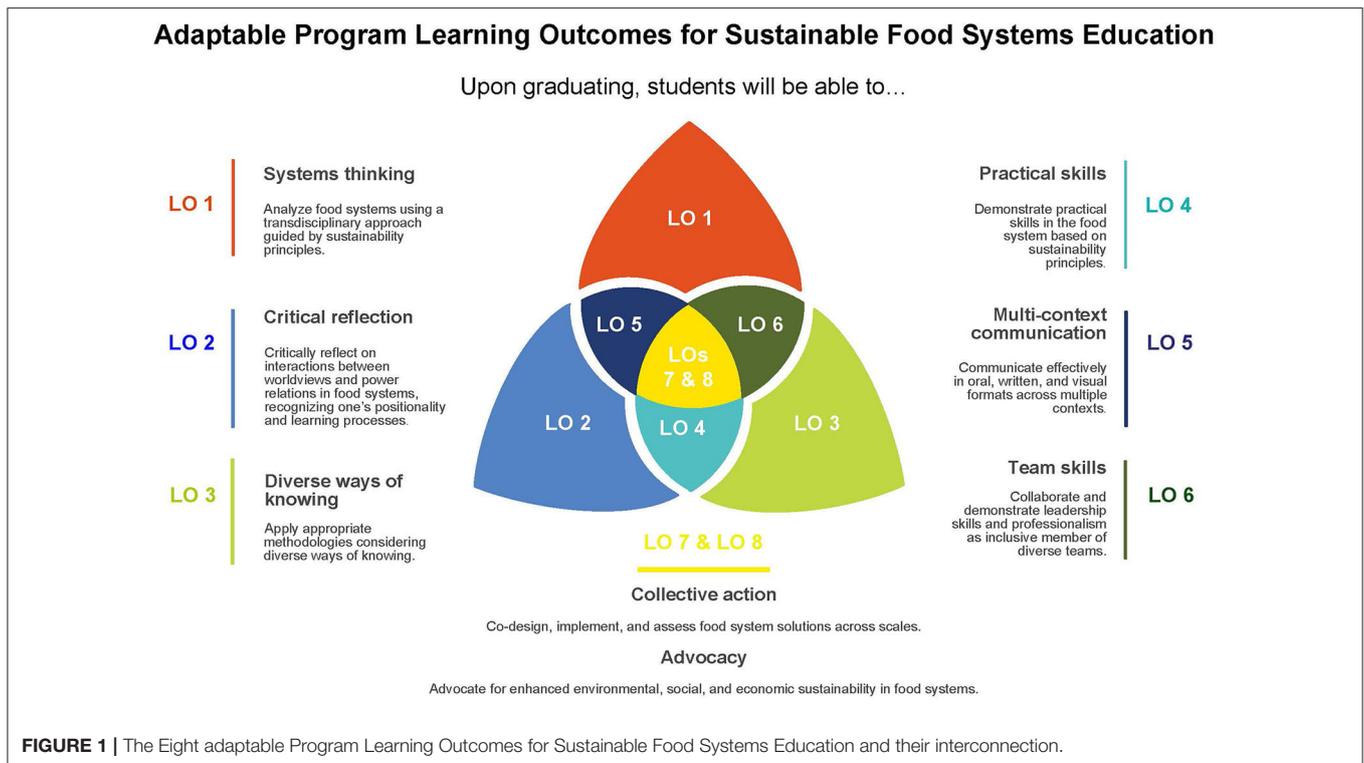
LO 2 Critically Reflect on Interactions Between Worldviews and Power Relations in Food Systems, Recognizing One's Positionality, and Learning Processes

While LO 1 is about how information is processed in SFSE, LO 2 deals with the nature and the use of this information. We consider critical reflection as a skill that allows students to develop reasoned solutions to complex problems when the needed information and evidence are unavailable, or when there is no one single resolution, a characteristic of most food systems issues (Perry et al., 2018). Further, critical reflection requires developing a habit of mind that continuously questioning one's taken-for-granted assumptions and beliefs, one's positionality, and their cumulative impact on what one values and how one acts. Further, critical reflection requires an outward orientation toward recognizing and questioning external power relations in food systems and their influence on distribution, representation, and recognition. We draw upon Mezirow (2000, 2003) transformative learning theory as an essential building block for developing an understanding of the nature of reason and associated methods, logic. Considering the social dimension of learning, we agree with Kreber (2006) that reflection must be responsive to broad social and cultural imperatives to allow critical reflection leading to action. Furthermore, we underpin our understanding of critical reflection on Andreotti et al. (2018) framing of problematic and harmful patterns of hegemony, ethnocentrism, ahistoricism, depoliticization, salvationism, uncomplicated solutions, and

paternalism that permeate the food system and society broadly (Allen et al., 2003; Born and Purcell, 2006; Levkoe et al., 2016).

Critical reflection is related to the process of learning and embodies the ability not only to know content, but also to understand that knowledge is both socially constructed (and consequently strongly influenced by power relations in- and outside the food systems), and based on one's own experiences and assumptions (Lieblein et al., 2004; Roy et al., 2019). When students understand how their socioeconomic status, experiences, and (cultural, religious, and family) backgrounds shape their learning, they are better equipped to think critically and arrive at thoughtful solutions to sustainability issues.

The capacity of students to bring about positive food systems change is hinged on the depth of their ability to apply critical reflection skills following, and during, their education. Historically, most SFS academic and degree programs in the U.S. have arisen out of production-based programs such as agronomy, horticulture, or plant science. Yet the food systems issues addressed in these programs are larger in their scope, context, and stakeholder base, requiring students to learn across multiple disciplines. Most importantly, for students to be engaged in effective collective action, they must have the right tools in their toolbox and know how to select or modify these heuristics. When faced with a new issue or problem, the exploration of multiple perspectives, ways of knowing, and their assumptions, will result in more effective outcomes. Critical reflection skills help students sort through multiple perspectives and arrive at reasoned solutions that bring voices of all actors to the table. It encourages students to question how knowing occurs, where

knowledge and power reside as well as how knowledge is constructed and evaluated (Valley et al., 2018). Eventually, critical reflection is a requirement for shifting unequal power relations in the food system and the students' lives.

By the end of their programs, students should be able to validate their attainment of this LO via writing pieces that demonstrate reasoned and supported arguments for often divergent perspectives on an issue. In SFS education, rather than instructors conveying information through traditional lectures, readings, and discussions, it is common for them to instead serve as guides to help students understand the complexity of issues via structured interpretation and reflection on experiences and their learning process (Lieblein et al., 2004). Courses that involve action and participatory learning and that move beyond a lecture-in-the-field allow for the development of critical reflection skills through exposure to diverse viewpoints. Pedagogical strategies to enhance LO 2 include a wide range of community engagement activities such as in-depth multi-day field courses, service-learning, and power-mapping (See Glossary in **Appendix 5** for further information). Where community engagement is not possible, students can gain insights through case studies, debates, and student-centered guest lectures, diverse types of deep-learning classroom activities, interactive group techniques, and the subsequent integration of learned information in a "rich picture" or concept map (Glossary). Tools such as the DEAL model (Glossary) guide students through the process of critical reflection via writing. The "Iceberg Exercise," where students are encouraged to distinguish between the visual part of a complex problem, and its underlying roots (Crosby and Bryson, 2014) is an example of practicing and assessing both, LO 1 and LO 2.

LO 3 Apply Appropriate Methodologies Considering Diverse Ways of Knowing

Examining and making decisions with regards to the food system requires an evidence-based approach that considers diverse perspectives and synthesizes the totality of available knowledge sets. LO 3 is therefore, essential for SFS programs. It implies that students select an appropriate methodology for analyzing a determined problem, that this selection considers diverse ways of knowing (including those not based on Western science), and that the student is able to conduct this analysis based on the selected methodology. Specifically, diverse ways of knowing include academic, humanistic, and non-academic notions of "evidence" applied across the ecological, socio-economic, cultural, and human health dimensions of food systems. This approach requires the inclusion of perspectives at all levels of the food system from those involved in production, distribution, processing, packaging, consumption, and waste to those involved in associated education, healthcare, and policy (Valley et al., 2018). Conventional research is strongly underpinned by the epistemology of positivism. In conventional research, the application of appropriate methodologies encompasses the processes of inquiry, data collection, analysis, synthesis, and dissemination that facilitate problem-solving and critical thinking (Ritchie and Rigano, 1996). However, SFS programs facilitate research approaches tailored to the needs and interests of stakeholders of a food system that include, but

go beyond, classical academic methods. For example, drawing from indigenous paradigms, appropriate methodologies further relate to the set of beliefs and ethics, that guide action and relationships including the way knowledge is acquired and information is presented (Wilson, 2001). Methodologies that consider diverse ways of knowing can be qualitative, quantitative, participatory, or mixed methods, and include, but are not limited to, experiments and trials, surveys and questionnaires, interviews, case studies, participant observation, conversation, ceremony, and storytelling (Wilson, 2009; Kovach, 2010; Creswell and Creswell, 2017). Activities that directly teach students research methodologies have been shown to foster intellectual and professional development including scientific literacy skills, career interest, and self-confidence (Hunter et al., 2007; Derting and Ebert-May, 2010; Brownell et al., 2015; Staub et al., 2016).

Independent from the diverse knowledge sets available and appropriate for analyzing a specific food system, we encourage students to apply an evidence-based approach to decide about possible interventions. By taking into account the totality of available evidence from diverse sources and types of information, food system leaders can more effectively design solutions that support sustainability while considering trade-offs with minimal unintended consequences (Stoy et al., 2018). Also, an evidence-based approach calls for students to consider their positionality, implicit biases, and preconceived assumptions as expressed in LO 2. Activities that may increase self-awareness and positionality can arise from collective processes of learning that engage with diverse ways of knowing (Tochon, 2010; Anderson et al., 2019b). Consequently, students may be more disposed to support and work toward decolonizing the food system. Decolonizing the food system points to the contemporary food system crisis arising from a globalized, modern-industrial food system built upon the hegemony of anthropocentric, imperialist, Euro/Western-centric, capitalist, and modernist ontologies, and refers to 'commons-based alternatives often rooted in non-anthropocentric cosmologies, agroecological farming methods, less androcentric land-tenure, and generally congenial relations to non-human nature (International Assessment of Agricultural Knowledge, Science and Technology for Development, 2009; Figueroa-Helland et al., 2018). As multiple scholars call for education to directly address its complicity with maintaining the food system (Napier, 2010; Meek and Tarlau, 2016; Anderson et al., 2019b) contends that experiences with otherness provide new paradigms for living and science.

It is expected that exposing SFS students to such new paradigms for living and science, their capacity to assess food system challenges and to develop concerted solutions increases. Curriculum activities about applying appropriate research methodologies require educators to critically analyze the ways in which they prepare students to ask questions, think across disciplines, test possible solutions, collaborate with a diverse range of stakeholders, facilitate community engagement, and synthesize evidence (Ahmed et al., 2017). The premise is a critical self-reflection of the instructors on their own positionality, which should be shared with the students. To sensitize students on the impact of epistemology on research results and the subjectivity of evidence, having students performing research using theoretical

lenses with different epistemologies (for example, positivism, political economy, and feminism) in their fieldwork can be a powerful experience (Galt et al., 2013). Primary research in the undergraduate classroom (Hunter et al., 2007; Derting and Ebert-May, 2010; Brownell et al., 2015; Linn et al., 2015; Ahmed et al., 2017) is a typical way to train students to apply appropriate methodologies. For example, Farm-based Authentic Research Modules in Sustainability Sciences or FARMS (See Glossary in **Appendix 5** for further information) incorporates primary research into course curricula based on input from diverse local agricultural stakeholders (Ahmed et al., 2017). Another curriculum activity to train the selection and application of appropriate research methodologies is to guide students to employ ethnographic techniques such as participant observation and the conversational method of gathering knowledge built upon an indigenous relational tradition (Glossary) (Kovach, 2010). Socio-environmental case studies and debates (Glossary) that facilitate students to reflect on their positionality and that of food system stakeholders are further curriculum activities to support LO 3.

LO 4 Demonstrate Practical Skills in the Food System Based on Sustainability Principles

Understanding food, from production to consumption, and the actors involved in the system requires the development of diverse practical skills, which are developed through hands-on approaches to deepen knowledge or solve problems within the food system. Students in SFS programs must be able to draw upon skills from multiple disciplines including food, agriculture, natural resources, and human sciences (Clark et al., 2013; Hilimire et al., 2014) to better understand the logistical aspects of those dimensions. Given the magnitude of practical skills required from food system professionals, SFS students cannot achieve proficiency in all potential sectors. A balanced SFS program should provide insight into diverse activities such as farming, culinary, processing, nutrition education, application of the scientific method, lab-based skills, and indigenous ways of knowing to research, policy advocacy, entrepreneurship, management, leadership, and communication. Existing SFS programs have faced challenges in structuring curricula that address such activities while offering students a feasible graduation timeframe.

Developing practical skills is essential to answer questions and solve real-world problems related to the interconnected challenges of changing environmental, social, economic, and health conditions in SFS. Students particularly need to critically engage with practical skills to know when to apply specific skills to certain issues or problems to support the economic, environmental, and social components of sustainability (Parr et al., 2007; Clark et al., 2011). For example, students can hold romantic or naïve assumptions regarding food production. Through immersion in farming activities such as planting, weeding, harvesting, and selling, students may contextualize alternative farming practices to their unique challenges and opportunities. Given that SFS require a multitude of practical skills, students need to know how to draw upon other resources to gain skills they do not already possess. Immersive experiences

allow students to move beyond forming ideals to embodied experience where they can better understand decisions in the food systems from a logistical perspective. Experiential learning (See Glossary in **Appendix 5** for further information) provides a framework for students to practice skill-building (Lieblein et al., 2004; Parr and Trexler, 2011). These experiences are typically external but can be introduced in classroom settings, for example, in the form of problem-based case studies or roleplays (Glossary). Ideally, experiential learning also means interacting with and learning from professionals in the respective areas as in the case of internships (Glossary).

LO 5 Communicate Effectively in Oral, Written, and Visual Formats Across Multiple Contexts

Oral, written, and visual communication skills are essential for most undergraduate programs. More unique to SFS programs is the ability to effectively communicate ideas clearly and concisely using multiple modalities in cross-cultural contexts to diverse, both professional and lay, audiences. It is not enough to simply have an idea to transform food systems—one must be able to effectively communicate ideas to varied audiences across contexts for knowledge dissemination, debate, and to stimulate change or action (van Ginkel et al., 2015). This means that SFS students should be able to articulate or present food system issues clearly and in a way that is appropriate for the respective target audience. Depending on what is communicated, the process of writing, speaking, and creating visual representations always fosters one or more of the other LOs (Trumbo, 1999; Prain and Hand, 2016).

Effective oral, written, and visual communication skills are critical for a SFS workforce who has the capacity to effect change including through mobilizing stakeholders in the food system (Trumbo, 1999; Chan, 2011; van Ginkel et al., 2015). The development of communication skills should be emphasized in SFS programs to demonstrate the achievement of other LOs and competencies such as systems thinking and critical analysis [5]. Effective communication is further of relevance for training a SFS workforce capable of demonstrating leadership, stimulating action, and presenting a professional identity across different sectors of the food system as well as being capable to effectively share stories, build relationships, and synthesize feedback from stakeholders (Nisbet and Scheufele, 2009; Reynolds et al., 2012). SFS curriculum should include activities designed to allow students to learn a variety of communication strategies (Menary, 2007; Reynolds et al., 2012; Prain and Hand, 2016). To obtain feedback and rework a communication product, as it happens in the professional world, these products can be integrated across multiple courses.

Curriculum activities for deepening knowledge through communication include written service-learning reflections that use tools such as DEAL, which stands for Describe, Examine, and Articulate Learning (See Glossary in **Appendix 5** for further information). Student-led presentations and discussions on critical readings and One-to-one Relational Meetings (Glossary) are other impactful communication activities. In addition to traditional improvement of multi-context communication practices such as poster presentations and deep-learning classroom activities, assignments for co-producing knowledge

(for example, participatory writing, see Glossary) are especially beneficial for SFS students to learn how to communicate effectively in multiple contexts. Finally, in an expanding age of online media, electronic media communication, and literacy training (Glossary) is essential.

LO 6 Collaborate and Demonstrate Leadership Skills and Professionalism as Inclusive Members of Diverse Teams

SFS students need to have the ability to collaborate and demonstrate leadership skills and professionalism as inclusive members of diverse teams given the collaborative nature of SFS work, combined with an increasingly team-based workplace across most sectors (Britton et al., 2017). Solutions to complex challenges in the food system necessitate a collective action approach that addresses a given problem from a variety of vantage points that include diverse perspectives drawing from different academic fields and sectors of society. Valley et al. (2018), define collective action as "a theme demonstrated when students are empowered and motivated to act together to achieve a common objective, address critical societal issues and contribute to the public good." In a recent study, the Association of American Colleges and Universities (AAC&U) reported that 71% of surveyed employers identified "teamwork skills and the ability to collaborate with others in diverse group settings" as a LO that needs more attention in higher education (Hart Research Associates, 2009).

Addressing food system problems often involves team collaboration across a variety of food system sectors. Team skills involve the capacity to determine with whom to collaborate to achieve specific goals (Hurlbert and Gupta, 2015). They also include many interrelated behaviors and attitudes related to leadership, facilitation, professionalism, work ethic, clear communication, agency, and engagement. The development of effective team skills is especially important for engaging in collective action, which inherently brings together diverse groups around a common goal [7].

Students of SFS programs have the opportunity to develop and hone team skills through many curricular avenues including campus farm experiences, off-campus internships, place-based research projects such as FARMS, community engagement opportunities, different kinds of experiential learning, interactive group techniques, public narratives, and capstone projects (See Glossary in **Appendix 5** for further information). While assessing individual teamwork skills is challenging, improvement in the assessment of this LO is important so that these skills can be refined and improved throughout the undergraduate curriculum. Impactful collective action requires SFS students to show solidarity both within their team and with the stakeholders they are serving. Teamwork (LO 6) is, therefore, a premise for achieving LO 7.

LO 7 Co-design, Implement, and Assess Food System Solutions Across Scales

The complexity and uncertainty inherent to work within food systems result in professional practice that requires skills in project management and collaboration, as well as experience in diverse processes of inquiry and the habit of critically reflecting on project outcomes. This LO relates to the collective action component of the implicit level of the SFSESP, where students are empowered and motivated to act together to achieve a common objective, address critical societal issues and contribute to the public good (Valley et al., 2018).

The LO draws upon elements of the previous six LOs but adds applied uses of these skills, namely solution (project) design, implementation, and assessment. At the outset, co-designing projects to address sustainability requires a systems approach to help identify scale and boundaries, specific components of the system under investigation and their interactions, as well as an understanding of the diverse stakeholders involved and the power dynamics that enhance or limit the achievement of equitable outcomes for all. Background in areas such as risk assessment, life-cycle assessment, benefit-cost analysis, ecosystem-services valuation, integrated assessment models, sustainable impact assessment, present and future scenario tools, food justice, and food legislation helps student deepen their food system assessment capacity. Students may apply these tools in a real-world case study. To implement a project in the food system, students will need to draw upon context-specific methodologies, communicate effectively within transdisciplinary, collaborative settings, and develop indicators to determine if their efforts reached their intended project goals. Efforts toward reaching LO 7 relates to Spiro (1988) cognitive flexibility theory, which promotes multiple representations of concepts and cases across ill-structured or complex knowledge domains while simultaneously fostering learners' ability to evaluate diverse knowledge sources. To develop cognitive flexibility to address complexity, students in SFS programs will need to practice working on projects at different scales, with different collaborators, and on different topics.

Collective action projects are inherently team-based to allow learners to practice their organizing, communication, and project development skills within the student group, between the student group and the organization or community partner, and between the student group and the broader class/teaching team. By the time a student completes their SFS program, they should be able to identify a wide range of actors and team members who they recommend should be involved in solution development. Common curricular activities that allow students to demonstrate growth and mastery in collective action are community-based participatory action research and other collaborative projects, service learning, as well as case studies and interdisciplinary capstone projects (See Glossary in **Appendix 5** for further information). In the classroom, diverse deep-learning classroom activities and practicing public narratives (Glossary) help train collective action skills.

LO 8 Advocate for Enhanced Environmental, Social, and Economic Sustainability in Food Systems

Advocacy refers here to voicing conceptions or understandings of necessary changes in food systems, based on a values-based perspective. For example, it might entail defense of interests of groups of excluded or disenfranchised people, or efforts to defend against a wide range of abuses of public power or social

exclusion beyond strictly legal problems (Fox, 2001). Advocacy encompasses a wide range of tools, tactics, and techniques to influence the setting and implementation of policies, guidelines, laws, regulations, and other decisions that affect people's lives (Brinsden and Lang, 2015). In our understanding, advocacy must be balanced with appreciation, which refers to interactions that aim to produce mutual understanding and affinity among potential allies in efforts to advance sustainability in food systems. These interactions entail intentional and skilled inquiry to build mutual understanding about the worldview (i.e., beliefs, values, behaviors) and capacities of potential partners in collective action (Cooperider and Whitney, 2005). Potential outcomes in students include the discovery of unexpected alignments of interests and underlying values, careful and sympathetic consideration of other's views and motivations, and recognition of opportunities to exert power through collective action.

This LO is aimed to prepare students to engage in values-based deliberation about sustainability in food systems, understood as a triple bottom-line conception considering social well-being, environmental protection, and economic viability (Rogers and Ryan, 2001). As noted in Valley et al. (2020), equity-related competencies such as food justice practice (Cadieux and Slocum, 2015; Meek and Tarlau, 2016) are essential, core elements in SFS required for learners to understand and enact change in food systems (Meek and Tarlau, 2016; Anderson et al., 2019a). Future food system professionals will need to address situations in which all three aspects of sustainability must be considered and advanced, e.g., transitioning from carbon-intensive agri-food systems (Marsden, 2013), working to address food system inequities (Galt, 2013; Cadieux and Slocum, 2015), and building food sovereignty (Meek et al., 2019) while dealing with power relations across relevant scales (Cadieux and Slocum, 2015).

Students will demonstrate their ability to achieve this outcome by creating objects that record and reflect advocacy and appreciation as these have operated in values-based dialogue about environmental, social, and economic sustainability in food systems. Such dialogue can occur through participation in collective action projects, in one-to-one relational meetings, civic deliberation arenas, civic arts such as community theater, community-engaged teaching and learning, or community-based research efforts in a capstone course (See Glossary in **Appendix 5** for further information). Objects that record and reflect these processes can take the form of reflective statements that both capture the essentials of a student's advocacy (i.e., what is advocated, and why and how?), and the essential viewpoints of others involved in the situation, as understood by the student. Non-verbal media could be used to express the dualistic "both/and" understanding that is inherent to this LO.

DISCUSSION AND CONCLUSION

The complex and interconnected challenges of food systems require professionals capable of thinking beyond disciplinary boundaries and acting collaboratively with diverse stakeholders in ways that are impactful in positively transforming society toward advancing sustainability. Within the last 15 years, an increasing amount of higher education institutions has developed sustainable food systems (SFS) undergraduate degree programs to create and train a professional workforce equipped with the skills and capacities to address food systems challenges. Here, SFS educators from three institutions in North America (Montana State University, the University of Minnesota, and the University of British Columbia) apply their experiences coupled with other SFS educators toward the co-design of adaptable program learning outcomes (LOs) aligned to the SFS Signature Pedagogy (Valley et al., 2018).

Our effort for co-designing adaptable LOs was driven by our joint desire to advance the field of SFS through contributing to a solid conceptual basis for SFS education toward the development of a professional food systems workforce. This effort was further driven by our concerns for the environmental, social, economic, and human health challenges of contemporary food systems and, the need to increase the societal impact of SFS education toward addressing these concerns. We contend that critical to enhancing the field of SFS is a solid conceptual basis of SFS education that overcomes the resource and institutional challenges including departmental and disciplinary silos that impede interdisciplinarity.

The eight LOs presented here comprise of the basic set of skills and attitudes that graduates of baccalaureate-level SFS degree programs are expected to have developed upon graduation. It is expected that our program LOs can be used to assess students' ability to meet these LOs. They will also serve as measurable parameters to evaluate the effectiveness of diverse programs in facilitating the students' achievement of these outcomes. Our adaptable LOs built on previous work led by the study team authors, including extensive interactions with food system stakeholders to understand the needs of a professional workforce as well as the conceptually underlying SFSESP framework (Valley et al., 2018). The framework promotes student skills including systems thinking, multi-, inter- and trans-disciplinarity, and critical reflection, and suggests pedagogical approaches to developing these skills such as experiential learning and open-ended case inquiries. The adaptable LOs represent a departure from positivist epistemology as the exclusive framework to develop curricula (still common in most institutions, including such which offer SFS programs) and offers a considerably different epistemology that values the social and cultural processes of knowing, teaching, and learning, fundamental to develop skills required from SFS professionals. All proposed LOs are skill- rather knowledge-based (**Table 1**). We understand broad SFS knowledge as a requirement for students to achieve our LOs. Thus, we did not detect the need to propose additional knowledge LOs about topics beyond what is necessary for meeting our LOs. Skill-based LOs are also stronger aligned with what is expected from SFS professionals.

The proposed LOs for SFS have resemblances to previously presented learning outcomes and objectives. For example, Ingram et al. (2020) presented a set of nine learning objectives of the Interdisciplinary Food Systems Teaching and Learning (IFSTAL) program in the United Kingdom for the development of a future workforce of food systems analysts. Common aspects of the learning objectives of the IFSTAL program with the SFS LOs presented here include a focus on systems thinking and analysis, pluralism, inter- and transdisciplinarity, and effective communication targeted at varied audiences. Likewise, especially

regarding interdisciplinarity, there is overlapping between our LOs and a Delphi survey that generated recommendations on what a Sustainable Agriculture and Food Systems major curriculum should include (Parr et al., 2007).

We believe the co-designed LOs presented here are adaptable to diverse socio-ecological contexts with diverse student communities, the various stakeholders that students will collaborate with, the range of fields of program instructors and their technical expertise, and the institutional background and geographic location in which SFS programs are implemented. Our eight LOs constitute a basic guideline to be adapted to the context-specificity of each institution rather than rigid standards. For example, while LO 4, focused on demonstrating practical skills, was found to be critical by survey respondents in some institutions, educators of other institutions may decide to not implement this LO because of its lower relevance to their program's context. Also, the LOs presented here can further be adapted in some educational contexts to be more progressive and radical to train a SFS workforce with the capacity to bring about substantive change to the food system (Holt-Giménez and Shattuck, 2011).

While our LOs refer to Baccalaureate degree-level SFS programs, they can be adapted for graduate-level SFS programs and courses. Also, while the LOs presented here were co-designed in a North American context with educators in Canada and the U.S., we believe they have applicability globally. International collaboration with educators and food system stakeholders will allow us to continue to refine the proposed LOs for diverse settings. These LOs represent a holistic ensemble of desirable student skills that interact, reinforce, and inform each other. Therefore, most of the pedagogical activities we suggest for deepening one LO simultaneously helps strengthen other LOs. For example, integrating open-ended case studies into our courses helps to strengthen systems thinking, critical reflection, diverse ways of knowing, and collective action skills within students.

We also emphasize the need to be realistic about what is to be expected from students during an undergraduate degree. Given the level of complexity required for achieving a LO such as systems thinking or collective action, the mastery or advanced proficiency of such a LO is to be seen within the context of what a student can accomplish during their time in an undergraduate degree. It is further important to recognize that the presented LOs need to remain dynamic and be revised in response to changing societal needs. We acknowledge that interactions with our students, food systems stakeholders, and other educators, along with our experiences teach us better than any conceptual paper with regards to student, workplace, and societal needs. Thus, we will continue engaging with our students, food systems stakeholders, and networks of educators to constantly improve our programs through an iterative process.

As societal challenges, opportunities, and needs change, it is anticipated these adaptable LOs be revisited for SFS education to develop graduates best equipped to respond to current and emerging societal needs of feeding humanity in just ways that support planetary health.

SFS is such a new and complex science that teaching it can easily become an inconsistent activity which may include interesting courses but without developing a clear and precise skillset among our students. To avoid this scenario, a continuous discussion about desirable student skills in SFS is necessary. This paper serves as a basis for a long-lasting, deep, and exciting discussion about LOs for SFS education.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/**Supplementary Material**.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Montana State University Institutional Review Board. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

SA, WV, NJ, JG, and RE led the study conception and design. RE led the acquisition of data and data analysis and developed the glossary. RE and SA led the drafting of the manuscript with contribution to writing and revising from all authors. All authors contributed to data interpretation.

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SUPPLEMENTARY MATERIAL

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Educator Practices and Perceptions of Integrating Sustainability and Food Systems Concepts Into Elementary Education: Comparative Case Study in Two Northwestern States in the United States

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Elementary education can equip future consumers and leaders with the systems thinking skills, real-world experiences, and knowledge to make decisions and lead progress toward sustainability transitions. The implementation of learning standards that focus on sustainability is one approach for integrating sustainability and food systems content into elementary education. The purpose of this study was to administer a survey with elementary-level educators to: (1) identify practices and perceptions of integrating sustainability and food systems concepts into the classroom; and (2) determine if practices and perceptions vary based on the presence of state learning standards focused on sustainability. A total of 171 educators completed the majority of the survey from two northwestern states in the United States: Washington (which has state learning standards focused on sustainability) and Montana (which does not have sustainability learning standards). Findings that 30% or less of the surveyed educators integrate sustainability and food systems content in their classroom highlights the urgent need for reforming elementary school curriculum to integrate sustainability as a central unifying framework to support societal and planetary health. Given the similarities in survey responses between educators in Washington and Montana, findings emphasize that state learning standards focused on sustainability are not adequate on their own to foster teacher adoption of sustainability content. There is thus a need for larger curriculum reformation to integrate sustainability as a framework, development of place-based teacher resources, and open access professional development to ensure that elementary-school students cultivate the systems thinking skills, real world experience, and knowledge that will allow them to develop the competencies to ultimately guide society toward meeting the Sustainable Development Goals of the United Nations.

Keywords: education for sustainable development (ESD), sustainability education, sustainable food systems education, learning standards, elementary education

INTRODUCTION

Human activities are having unprecedented impacts on Earth's systems (Steffen et al., 2015) with sustainability challenges in every sector of society, including food systems. The complex social, environmental, economic, and health interactions that comprise food systems have dramatic impacts on human and planetary health (Willett et al., 2019). For example, the food system accounts for ∼30% of total global greenhouse gasses emissions which contribute to climate change (Mason and Lang, 2017). In turn, climate change impacts agricultural productivity and food security (Mason and Lang, 2017). While food production and sales support farmer livelihoods and the economy, food access is an economic challenge for ∼26% of the global population who experience some level of food insecurity annually (Food Agriculture Organization, 2019). Food insecurity places the population at further risk of being malnourished with associated poor health outcomes (Food Agriculture Organization, 2019). Unhealthy diets are among the largest contributors to the global burden of disease (Gakidou et al., 2017), with an estimated two billion adults overweight and obese worldwide (World Health Organization, 2020). Given the challenges of food systems and other societal activities, advancing sustainability is critical for ourselves, future generations, and the planet.

In recognition of the need to enhanced sustainability, multiple national and global policy platforms have advanced strategies to promote sustainability. For example, the United Nations has developed and implemented Education for Sustainable Development and the Sustainable Development Goals (SDGs). Sustainable development describes a way of living in which humanity meets their economic and social needs in a culturally appropriate manner, without inhibiting the ability of future generations to meet their own needs (World Commission on Environment Development, 1987). Education for Sustainable Development is a pedagogical model that takes a learner-centered approach and integrates sustainability content across subject areas (UNESCO, 2014). The SDG's include 17 guideposts toward developing a more sustainable world by 2030 including ending hunger, creating affordable and clean energy, mitigating climate change, ensuring equitable and available education, supporting sustainable consumption and production patterns, and halting biodiversity loss among others (United Nations, 2015).

Education can serve a crucial role in sustainability transitions for society that balance environmental, economic, health, and social well-being goals (Sarabhai, 2015). The early stage of formal education, known as elementary or primary education (that generally encompasses kindergarten through fifth or sixth grade), plays a pivotal role in preparing future consumers and leaders with the systems thinking skills, real world experiences, knowledge, and motivation to lead sustainability transitions (Church and Skelton, 2010; Sarabhai, 2015). However, there remains a to need to understand how to effectively integrate sustainability into the elementary education classroom.

The implementation of learning standards is one approach for integrating sustainability and food systems content into elementary education. In addition, pedagogical models focused on sustainability are another approach for integrating sustainability into the elementary education classroom. Moreover, pedagogical models focused on sustainability can inform the development of learning standards as well as curriculum and assessments. In the United States, only two states, Washington and Wisconsin, have explicit state learning standards that focus on sustainability to guide curriculum (Wheeler et al., 2014; Wisconsin Department of Public Instruction, 2018). In most other states, sustainability topics are most commonly integrated into the elementary education curriculum by individual teachers and non-profit organizations (Church and Skelton, 2010). Two pedagogical models for informing learning standards and developing curricula that integrate sustainability are Education for Sustainable Development and the Sustainable Food Systems Education (SFSE) signature pedagogy (Valley et al., 2018). Both Education for Sustainable Development and the Sustainable Food Systems Education signature pedagogy outline methods for cultivating systems thinking skills, real world experience, and sustainability knowledge that will allow students to make changes that foster sustainability (Church and Skelton, 2010; Valley et al., 2018).

The purpose of this study is to identify elementary-school educators' practices and perceptions regarding integrating sustainability and food systems concepts in their classrooms. Research was carried out in the northwestern states of Washington and Montana in the United States (US) in order to assess whether teaching practices and perceptions vary based on the presence of formal state learning standards focused on sustainability (with Washington having state learning standards focused on sustainability and Montana not having state learning standards focused on sustainability). Through a semi-structured survey that included open-ended and close-ended questions, this study assesses educators' experiences using specific teaching methods, teaching about sustainability-related content areas, fostering necessary competencies in their students, and facing the challenges of integrating sustainability and food systems concepts into the curriculum. The survey was developed based on the pedagogical models of Education for Sustainable Development and the Sustainable Food Systems Education signature pedagogy. In addition, document analysis was carried out of Washington's Integrated Environmental and Sustainability Education Learning Standards in order to determine if they align with Education for Sustainable Development and can be used as an example of integrating sustainability. This study contributes to identifying educational strategies for integrating sustainability and sustainable food systems concepts into elementary school education in the United States in order to foster students who have the knowledge, skills, and motivation to make choices that support sustainability.

BACKGROUND

Socio-Ecological Systems Theory

Socio-ecological systems theory provides a relevant foundation for sustainability education. Specifically, socio-ecological systems theory provides a foundation for studying human development where individuals' environments are related to

each other and the larger social context (Bronfenbrenner, 1977). According to Bronfenbrenner's socio-ecological theory, the development of a person involves progressively more complex interactions between the person and their environments over time (Bronfenbrenner, 1986). Applying Bronfenbrenner's socio-ecological theory to sustainability education calls for progressively more complex interactions with sustainability content and projects throughout one's schooling (Bronfenbrenner, 1986). It is key that these interactions with sustainability concepts are present over time, throughout every year of schooling (Bronfenbrenner, 1986). Over the past five decades, socio-ecological systems theory has evolved to emphasize linked systems of social and biophysical factors that is applicable to examining sustainability (Berkes and Folke, 1998). Indeed, socio-ecological systems theory has extensively been applied as a framework for examining sustainability topics including sustainable food systems (Walker and Salt, 2012; Mason and Lang, 2017).

Sustainability-Focused Education Models

Spearheaded by the United Nations, Education for Sustainable Development (ESD) is a key strategy for progress toward sustainable development and meeting the SDGs (UNESCO, 2014, 2017). As an interdisciplinary and transdisciplinary educational model, ESD content and pedagogies work together to highlight the interconnectedness of the environment, the economy, and culture (UNESCO, 2012). ESD seeks to empower learners to make "informed decisions and [take] responsible actions for environmental integrity, economic viability, and a just society, for present and future generations, while respecting cultural diversity" (UNESCO, 2014). Key ESD content areas include local issues, climate change, biodiversity, sustainable consumption and production, poverty reduction, and disaster risk reduction (Leicht et al., 2018). In general, the content integrated into ESD is guided by the SDGs (United Nations, 2015).

With regards to pedagogy, ESD promotes participatory learning in a student-centered environment through issue-based, place-based, and action-oriented approaches (UNESCO, 2012). ESD pedagogies encourage students to ask questions, think critically, cooperate, collaborate, and make informed decisions through a range of teaching techniques such as storytelling, simulations, role-playing, class discussions, debates, case studies, outdoor learning, and modeling good practices (Cotton and Winter, 2010; Tilbury, 2011; UNESCO, 2012). The integration of ESD across all subject areas promotes systems-thinking and prepares students to make informed decisions in their futures.

The Sustainable Food Systems Education (SFSE) signature pedagogy (Valley et al., 2018) provides a complementary educational model to ESD in terms of providing sustainability content focused on food systems. The SFSE signature pedagogy is a conceptual model based on the following four common themes among SFSE higher-education programs: (1) collective action; (2) systems thinking; (3) experiential learning and; (4) interdisciplinarity (Valley et al., 2018). While the SFSE signature pedagogy was developed for undergraduate-level college students, it has the potential to inform elementary school education in complement with ESD. Both ESD and

the Sustainable Food Systems Education signature pedagogy place an emphasis on the interdisciplinarity and focus on cultivating systems thinking across disciplines through experiential pedagogies. In addition, both ESD and the SFSE signature pedagogy place an emphasis on integrating education into the larger community through collective action or real-world projects.

Sustainability-Focused Learning Standards

Learning standards are one approach to integrate sustainability content and pedagogies such as ESD and the SFSE signature pedagogy into the classroom. For example, ESD has been integrated into the learning standards of the national curricula of a range of countries, including Australia, Costa Rica, Cyprus, Ghana, Kenya, and others (Laurie et al., 2016; UNESCO, 2017; Witoszek, 2018). The United States does not have a national curriculum and each state has local control over the development of learning standards and curriculum. Only two of the 50 states in the United States, Washington and Wisconsin, have sustainability-related standards (Wheeler et al., 2014; Wisconsin Department of Public Instruction, 2018). Both Washington and Wisconsin integrated ESD content and pedagogies in the development of their sustainability-related standards (Wheeler et al., 2014; Wisconsin Department of Public Instruction, 2018). Specifically, Washington developed Environmental and Sustainability Education Learning Standards (ESE Learning Standards) for grades K-12 in 2009 in accordance with a law requiring environmental education throughout the state (Wheeler et al., 2014). The ESE Learning Standards are designed to be integrated across disciplines at all grade levels and focus on the following: (1) knowledge of the interconnections and interdependency of ecological, social, and economic systems; (2) opportunities to engage in inquiry and systems thinking that can be applied to natural and human-built environments and; (3) ability to make personal and collective decisions and take actions that promote sustainability (Wheeler et al., 2014).

METHODS

Study Sites

This study included two states in the northwestern United States: Washington and Montana. Washington was selected for its implementation of sustainability-focused learning standards while Montana was selected as a state close to Washington that does not have sustainability-focused state learning standards. Both states are characterized by large expanses of agricultural land (Montana Department of Agriculture, 2019; Washington Department of Agriculture, 2019). Washington has an area (71,362 square miles) that is roughly half the size of the state of Montana (47,164 square miles) while Washington has a population (6,724,540 people) that is over seven times that of Montana (989,415 residents) (United States Census Bureau, 2012). The Washington and Montana public-school system are managed by an office of public instruction, which develops and sets the learning standards for the states. Washington has a set of standards for K-12 Environmental and Sustainability Education, while Montana does not (Montana Office of Public

Instruction, 2020b; Washington Office of the Superintendent of Public Instruction, 2020b). Washington has 1,041 public elementary (K−5) schools, while Montana has 446 (Montana Office of Public Instruction, 2020a; Washington Office of the Superintendent of Public Instruction, 2020a).

Survey Instruments

Survey tools were developed and administered to elementary school teachers in Washington and Montana. Both surveys were designed based upon ESD and the SFSE signature pedagogy. The survey instruments administered in each location were the same except the Washington version had a section on their sustainability-focused learning standards (the ESE Standards). The survey instruments were reviewed for face validity by content experts in the fields of sustainable food systems, agriculture, and education. The survey tool was pilot tested for validity with five elementary school teachers in two Washington counties and was modified for clarity based on feedback.

The final survey instrument administered to teachers in Washington (**Supplementary Material**: Survey Instrument for Washington) contained 20 multiple-choice, Likert scale, and open-ended questions divided into three sections: (1) Background Questions; (2) Teaching Practices and; (3) ESE Learning Standards. Section one included demographic questions, including what grade the participant teaches, how many years they have been teaching, and what county they teach in. This section also asked teachers how much they knew about the state's ESE Standards, how they define sustainability, and what type of training they have received related to sustainability education. The second section included questions about the teaching methods participants use, what sustainability-related content participants teach, and what competencies participants strive to achieve in their students. The answer options for questions in this section were drawn from ESD documents and the SFSE signature pedagogy (UNESCO, 2012, 2014, 2017; Valley et al., 2018). The final section of the survey asked teachers how well they believe they met each of the three ESE Standards in their classrooms and to provide an example of how they met each ESE Standard in their classrooms.

The survey instrument administered to teachers in Montana (**Supplementary Material**: Survey Instrument for Washington) removed all mentions of the ESE Standards and thus included one less question compared to the Washington survey (19 total questions). Additionally, when teachers were asked how well they met each of Washington's ESE Standards, the standards were presented to participants as learning outcomes.

Exempt approval for human subjects to participate in this study was received from the Institutional Review Board at Montana State University prior to the distribution of the survey instruments. All participants provided informed consent prior to completing the survey and were offered a $15 incentive for completing a majority of the survey. The surveys were created online in Qualtrics XM (www.qualtrics.com) and distributed *via* email to elementary (grades K – 5) teachers at public schools in Washington and Montana. The sample group of teachers was selected using publicly available lists of all public elementary schools in the two states. For each state, a sample of 30 schools was selected using stratified random sampling. A random number generator was used to select 15 Title I schools and 15 non-Title I schools from a list of all public elementary schools in each state. The appropriate survey was emailed to every K-5 regular-classroom teacher at each of the 60 selected elementary schools using publicly available email addresses from the schools' websites. The survey was distributed to 610 teachers at 30 schools across Washington and to 362 teachers at 30 schools across Montana.

For the purpose of this research, the Title I designation included schools that are enrolled in a Title I school wide program, not a targeted assistance program. In order for a school to qualify for the Title I school wide program, >40% of students must be low income (US Department of Education, 2018). Therefore, this stratified sampling method ensured that lower-income and higher-income schools were equally represented in the sample, as economic status may impact the ability of a school to focus on teaching about sustainability. The random selection of schools within the strata ensured that a representative sample of schools and teachers across each state were included in the sample. Other demographic data, including school size and county, were collected in the survey so that their impact on sustainability education could be elucidated in the analysis.

In order to participate in the survey, an individual was required to be employed as a K-5 classroom teacher in a public school in either Washington or Montana that do not teach special classes such as gym classes, music classes, language classes, or special education classes.

Document Analysis of Learning Standards

An analysis of the ESE Standards was conducted in order to assess whether Washington's ESE Standards reflect the content and pedagogies associated with ESD and the SFSE signature pedagogy. The ESE Standards (Wheeler et al., 2014) are outlined in a publicly available document on the Office of the Superintendent of Public Instruction's website. This document was systematically analyzed, as described by Bowen (2009). A deductive framework (**Supplementary Material**: Document Analysis Framework) for analysis was developed that highlights key ESD content, pedagogies, and competencies, as described by the United Nations (UNESCO, 2014; Leicht et al., 2018) as well as key elements of the SFSE signature pedagogy (Stoy et al., 2018; Valley et al., 2018). The framework consists of a table that features each of these ESD and SFSE elements. The framework was applied to code the ESE Standards document to analyze the extent to which the ESD and SFSE elements are present in Washington's ESE Standards. For each ESD or SFSE element that was present, the appropriate quotation from the ESE Standards was copied into the table to demonstrate its inclusion.

Data Analysis

Participants that completed <75% of the survey or did not qualify to complete the survey (based on their answers to background questions) were removed from the sample. Then, quantitative data was analyzed using the JMP (JMP® SAS Institute Inc., Cary, NC, USA) statistical software program. *T*-tests were completed to compare differences among teachers in Washington and

Montana. Analysis of Variance (ANOVA) was completed to compare differences among teachers in different demographic groups, including state, grade-level taught, and school's Title I status. The Pearson p-value is reported for significant ($p < 0.05$) differences in survey responses among groups of teachers.

Responses to open-ended questions were coded by two researchers using an inductive coding approach (Saldaña, 2015). After the lead researcher developed a codebook, both the lead researcher and a second researcher coded all open-ended responses and resolved all discrepancies. The frequencies of themes were then tabulated.

RESULTS

Demographics

In Washington, 112 teachers completed or partially completed the survey, resulting in a final sample size of 87 participants from Washington (14.3% response rate; only participants that completed 75% or more of the survey were included in the sample). In Montana, 107 teachers completed or partially completed the survey, resulting in a final sample size of 84 participants from Montana (23.2% response rate). The demographic characteristics of participants from each state are detailed in **Table 1**. The associations between survey responses and educators' states, grades taught, and schools' Title I status are discussed throughout this section. The associations between survey responses and years teaching and rurality were not significant and are thus not discussed in this section.

Teaching Methods

The most common teaching methods associated with ESD used by the Washington survey participants ($n = 87$) include field trips (75%), small-group projects (68%), and demonstrating good practices for students (63%) (**Figure 1A**). Similarly, the Montana survey participants ($n = 84$) reported most commonly using field trips (79%), small-group projects (70%), and whole-class projects (65%) in their classrooms.

The teaching methods used by significantly different proportions of participants between Washington and Montana include outdoor learning ($p = 0.0182$), storytelling ($p = 0.0388$), and whole-class projects ($p = 0.0156$). Specifically, a greater proportion of participants in Montana used outdoor learning (52%), storytelling (58%), and whole-class projects (65%) in their classrooms, compared to teachers in Washington.

Additionally, four teaching methods were associated with grade level. Generally, participants that teach higher grade levels (4th and 5th) used collaborative real-world projects ($p = 0.0019$), debates ($p < 0.0001$), and small-group projects ($p = 0.0499$) more than participants that teach lower grade levels (K-2nd). However, participants that teach lower grade levels (K-2nd) tended to use storytelling ($p < 0.0001$) more often than those at higher grade levels (3rd-5th).

Six teaching methods differed by Title I status: case studies ($p = 0.0432$), collaborative real-world projects ($p = 0.0003$), community-based research projects ($p = 0.0007$), facilitated discussions ($p = 0.0309$), small-group projects ($p = 0.0453$), and whole-class projects ($p = 0.0272$; **Figure 1B**). In these six cases, these teaching methods were reported to be used significantly more often by teachers at non-Title I ($n = 64$) schools than those at Title I ($n = 98$) schools.

Content

Sustainability-Related Content

The most common content areas taught by Washington participants ($n = 86$) include local issues (50%), global issues (38%), and sustainable water use (37%; **Figure 2A**). In Washington, 22% of participants reported that the do not teach about any of the 11 content areas. Similarly, the sustainability content areas most commonly taught by Montana participants ($n = 84$) are local issues (44%); social, cultural, and environmental interconnectedness (36%); and sustainable water use (32%). In Montana, 21% of participants do not teach about any of the 11 sustainability-related content areas.

While there were no significant differences between the proportions of participants from Washington and Montana that reported teaching each sustainability-related content area, there were differences among participants that teach different grade levels for several content areas. A larger proportion of participants that teach higher grade levels tended to teach about several topics than did teachers in lower grade levels, including climate change ($p = 0.0004$); global issues ($p = 0.0004$); local issues ($p = 0.0366$); social, cultural, economic, and environmental interconnectedness ($p = 0.0045$); and sustainable energy use ($p < 0.0001$; **Figure 2B**). Additionally, a larger proportion of participants that teach lower grade levels reported teaching about none of the sustainability-related content areas in their classrooms than did participants that teach higher grade levels ($p = 0.0096$).

The proportion of participants that reported teaching about sustainability-related content varied by Title I status for two of the content areas, global issues ($p = 0.0177$) and sustainable consumption and production ($p = 0.0248$). Participants that teach at non-Title I ($n = 64$) schools reported higher levels of instruction in both these content areas.

Sustainable Food Systems Content

The most common content areas taught by Washington educators who participated in the survey ($n = 77$) include food preferences (44%), the cultural importance of foods (38%), and the role of pollinators in the food system (36%; **Figure 3**). Montana educators who participated in the survey ($n = 79$) most commonly reported teaching about the role of pollinators in the food system (62%), local foods (53%), and food preferences (37%).

Significantly more participants from Montana reported teaching about local foods ($p = 0.0146$) and the role of pollinators in the food system ($p = 0.0013$) in their classrooms than did participants from Washington. Additionally, a larger proportion of participants that teach higher grade levels generally reported teaching about cultural importance of foods ($p = 0.0131$) and greenhouse gas emissions in the food system ($p = 0.0089$) than teachers of lower grade levels. There were no significant differences in the proportions of teachers that teach about

TABLE 1 | Demographic characteristics of participants from Washington and Montana. Percentages listed indicate the percent of respondents that completed all or part of the survey.

		Washington		Montana	
		Count	Percent	Count	Percent
Grade Taught	Kindergarten	9	10.3%	8	9.5%
	First	16	18.4%	15	17.9%
	Second	14	16.1%	16	19.0%
	Third	14	16.1%	13	15.5%
	Fourth	13	14.9%	17	20.2%
	Fifth	15	17.2%	10	11.9%
	Multiage classroom	5	5.7%	5	5.9%
Years teaching	<5	18	20.7%	20	23.8%
	5–10	21	24.1%	13	15.5%
	11–20	29	33.3%	34	40.5%
	More than 20	19	21.9%	17	20.2%
Schools' title I status	Title I	43	53.1%	55	67.9%
	Not title I	38	46.9%	26	32.1%
Counties Represented		13		14	

sustainable food systems concepts based on their schools' Title I status.

Competencies

Of five competencies, participants from Washington ($n = 85$) and Montana ($n = 83$) most commonly reported trying to foster critical thinking (Washington 94.1%, Montana 89.2%), collaborative decision-making (Washington 91.7%, Montana 89.2%), and anticipatory thinking (Washington 67.1%, Montana 75.9%) skills in their students (**Figure 3B**).

The proportions of participants that attempt to foster these competencies in their students did not vary by state or Title I status but did vary by grade level for the anticipatory thinking competency ($p = 0.0025$), with kindergarten teachers least often striving to teach this competency (data not shown).

Challenges

The most common challenges participants from Washington ($n = 87$) faced when trying to teach about sustainability-related content in their classrooms were a lack of knowledge about Washington's ESE Standards (77%), a lack of resources (e.g., lesson plans, books, videos, outdoor space; 60%), and too many sets of learning standards and too little time (54%; **Figure 4**). The most common challenges participants from Montana ($n = 84$) faced when teaching about sustainability-related content in their classrooms were too many sets of standards and too little time (57%), a lack of professional development to effectively teach these concepts (48%), and a lack of resources (e.g., lesson plans, books, videos, outdoor space; 42%).

The only challenge which participants from Washington and Montana reported experiencing in significantly different proportions was a lack of resources (e.g., lesson plans, books, videos, outdoor space; $p = 0.0396$), which more Washington participants reported experiencing (60%). There were no

significant differences in the proportion of participants reporting each challenge based on grade level or Title I status.

Training

Relatively few participants from either state report having received training related to sustainability education (**Figure 5**). In Washington, 74.7% of participants ($n = 87$) and 71.4% of participants from Montana ($n = 84$) reported they have not received any training related to sustainability education. While a higher proportion of participants from Washington (4.6%) have received related professional development organized by a non-profit ($p = 0.0467$), a higher proportion of participants from Montana (16.7%) have received related professional development organized by their state or district ($p = 0.0101$). A small portion of participants (7.6%) mentioned other responses, most commonly personal research. Given the small sample sizes of teachers that have received training related to sustainability education, other demographic analyses were not performed.

Washington's ESE Standards
Document Analysis

The deductive framework for evaluating the presence of ESD and SFSE in Washington's ESE Standards (Wheeler et al., 2014) revealed that 50% of ESD and SFSE content areas are present in the ESE Standards. Content areas present in the Standards include: climate change, biodiversity, local and global issues, social/cultural/environmental/economic interconnectedness, and sustainable energy use. Content areas lacking in the Standards include: agriculture, sustainable diets, disaster risk reduction, sustainable consumption and production, and sustainable water use.

Eighty percent of ESD and SFSE pedagogies are present in the ESE Standards. Pedagogies which are present include: interactive and learner-centered, exploratory and action-oriented, inter and trans-disciplinary, and collaborative and participatory. The
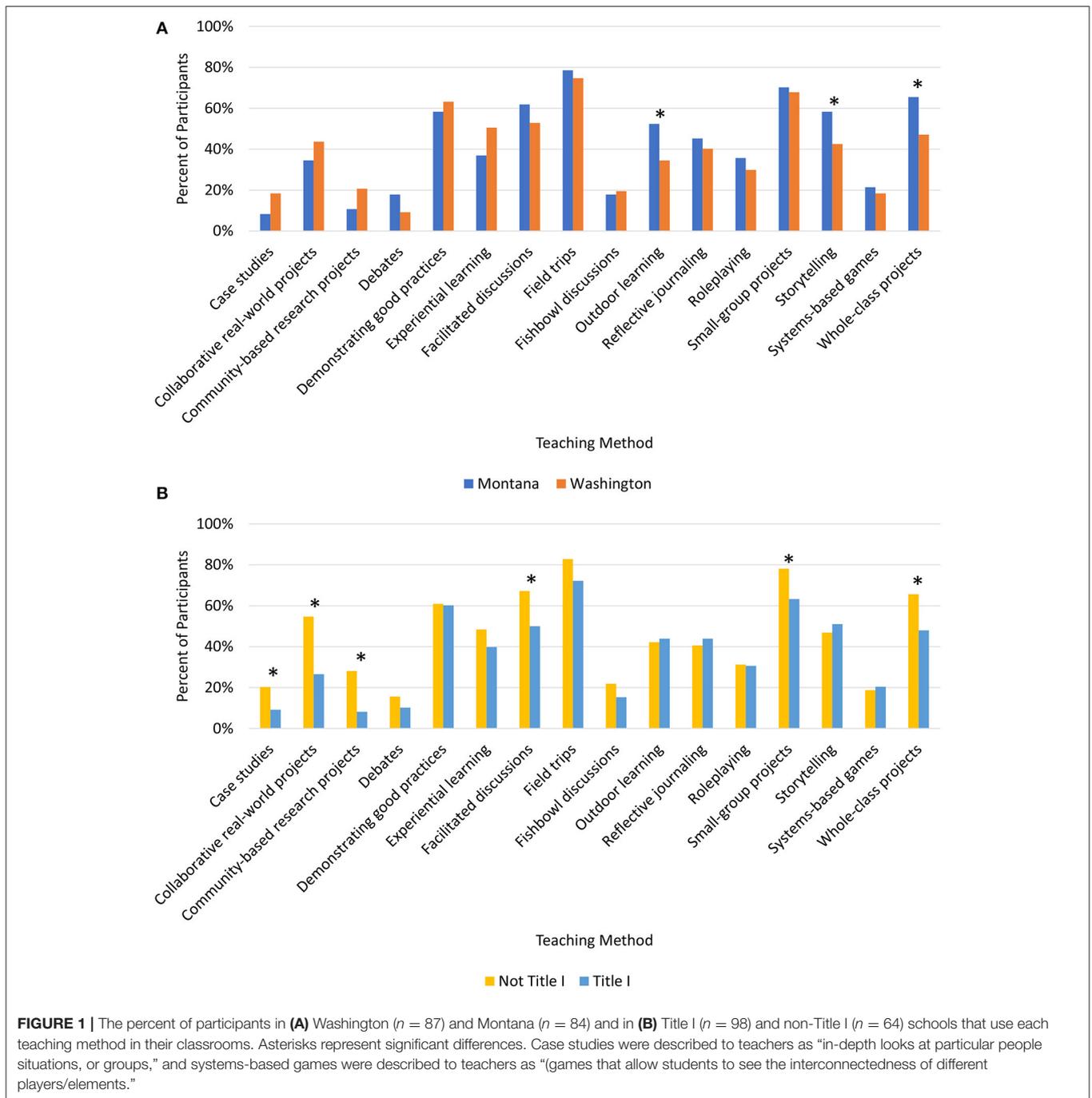
FIGURE 1 | The percent of participants in **(A)** Washington ($n = 87$) and Montana ($n = 84$) and in **(B)** Title I ($n = 98$) and non-Title I ($n = 64$) schools that use each teaching method in their classrooms. Asterisks represent significant differences. Case studies were described to teachers as "in-depth looks at particular people situations, or groups," and systems-based games were described to teachers as "(games that allow students to see the interconnectedness of different players/elements."

pedagogy lacking from the Standards is: self-directed and research based.

Finally, 100% of the competencies which are central to ESD and the SFSE signature pedagogy are present in the ESE Standards. These include: collaborative decision-making and problem-solving, systems thinking, critical thinking, anticipatory thinking (able to understand future impacts of their actions), and collective action (using agency to collaborate to solve community sustainability problems).

Sustainability Definition

Qualitative coding of respondents' definitions of "sustainability" revealed six themes (**Figure 6**). Four of these themes are also present in the definition of sustainability included in the ESE Standards (economics, environment, future generations' needs, and meeting current populations' needs), while two are not (able to be maintained over time and renewable/responsible resource use). The only theme included in sustainability definitions by different proportions of participants from Washington ($n = 85$)
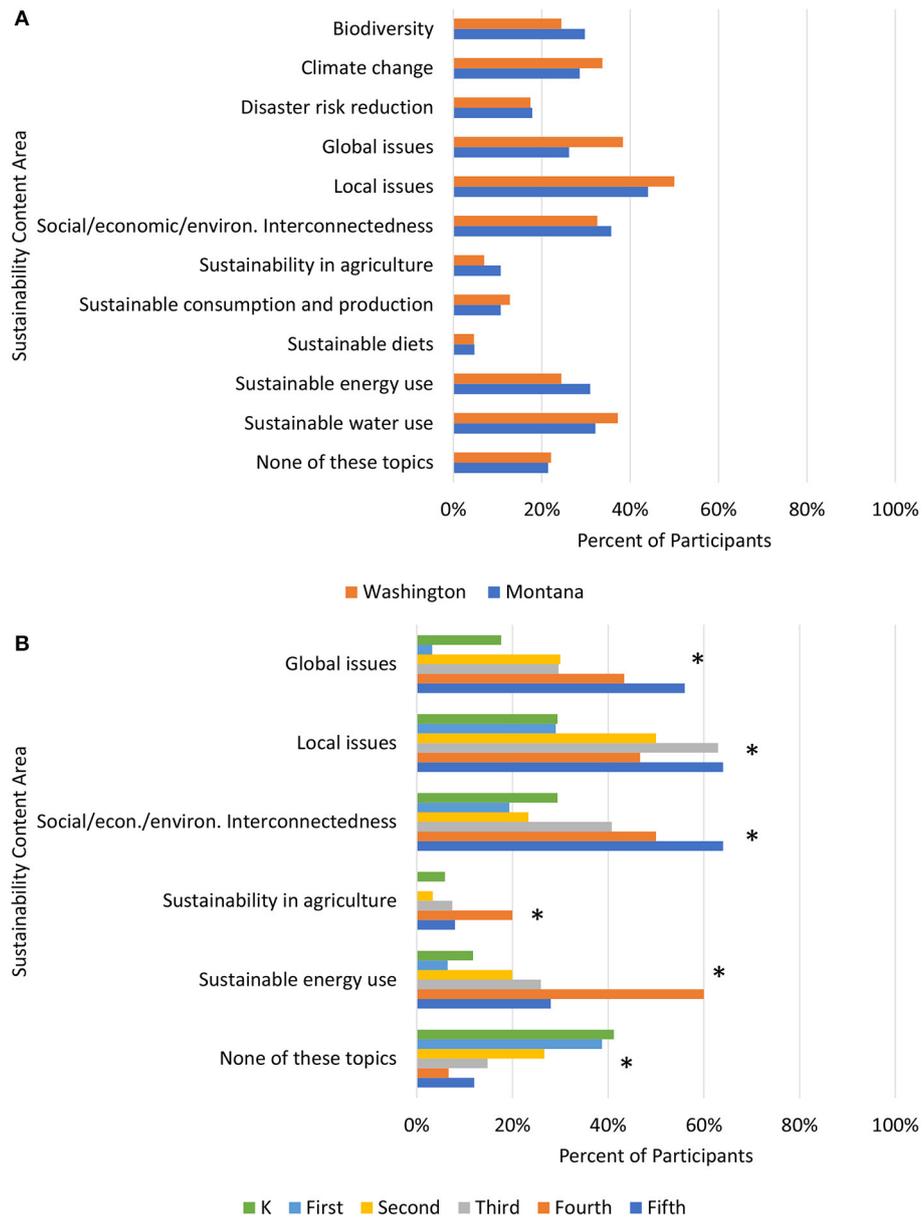
FIGURE 2 | Percent of participants **(A)** from Washington ($n = 86$) and Montana ($n = 84$) and **(B)** that teach each grade level that report teaching about each sustainability-related content area (K $n = 17$, 1st $n = 31$, 2nd $n = 30$, 3rd $n = 27$, 4th $n = 30$, 5th $n = 25$). Asterisks represent significant differences.

and Montana ($n = 83$) was economics ($p = 0.0417$), which Montana participants included more frequently. There were no significant differences between themes based on grade level or school's Title I status.

Knowledge and Implementation of Standards

When asked how much they knew about Washington's ESE Standards, 79% of participants from Washington ($n = 86$) reported knowing "nothing at all," 20% reported knowing "a little to moderate amount," and 1% reported knowing "a lot."

After being shown the three ESE Standards, Washington teachers ranked on a scale of one (not well at all) to five (extremely well) how well they think they meet each Standard in their classroom (**Figure 7A**). Participants from Washington ($n = 75$) ranked themselves, on average, at 1.97 for Standard 1, 2.13 for Standard 2, and 2.07 for Standard 3. The ESE Standards were also presented to participants from Montana, but were framed as three sustainability-related learning outcomes (**Figure 7A**). Participants from Montana ($n = 78$) ranked themselves (on a scale of 1–5), on average, at 2.44 for Standard 1, 2.55 for Standard 2, and 2.29 for Standard 3.
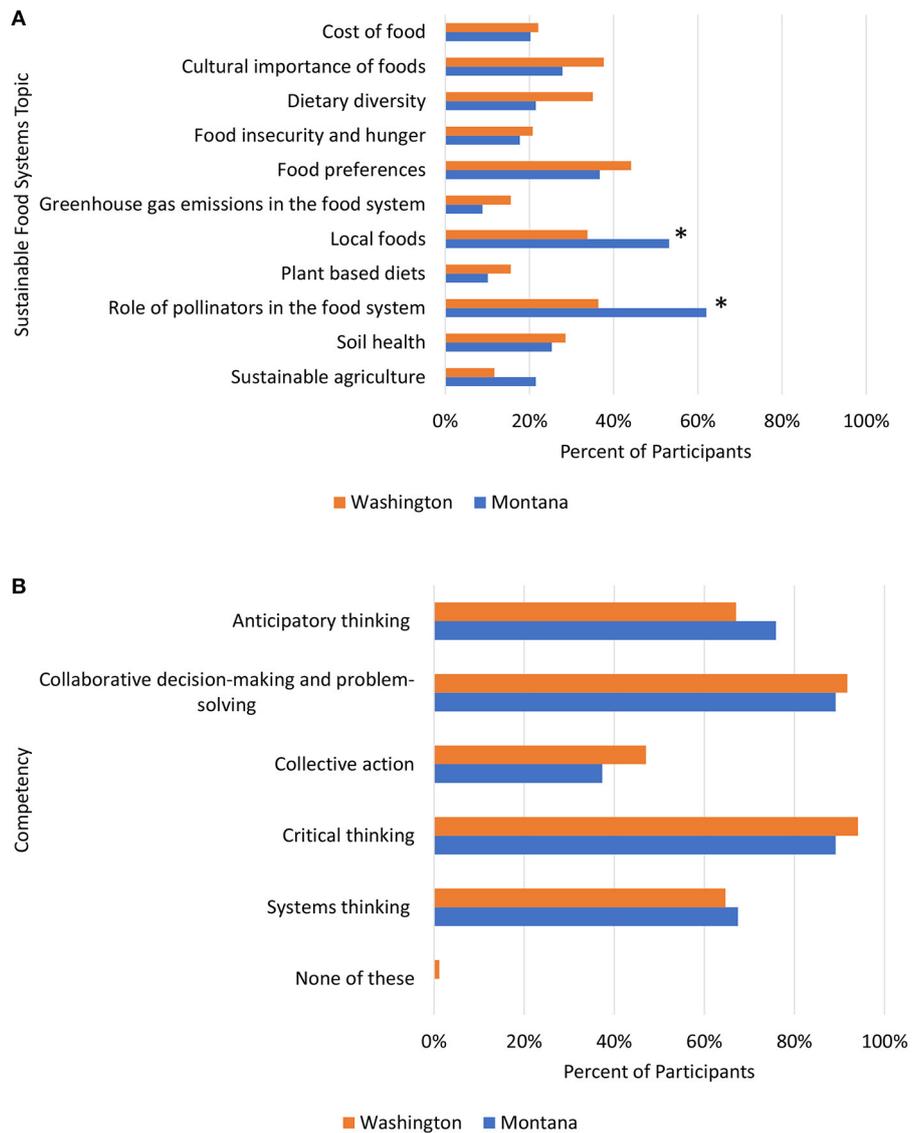
FIGURE 3 | (A) The percent of participants from Washington ($n = 77$) and Montana ($n = 79$) that report teaching about each food systems content area. **(B)** The percent of participants from Washington ($n = 85$) and Montana ($n = 83$) that report striving to foster each competency in their students. Note: Anticipatory thinking was described to teachers as the "ability to understand future impacts of their actions." Collective action was described to teachers as "using agency to collaborate to solve community problems." Systems thinking was described to teachers as the "ability to understand that everything is interconnected." Asterisks represent significant differences.

There are significant differences between how well participants from Washington and Montana believe that they meet Standard 1 ($p = 0.0080$) and Standard 2 ($p = 0.0230$). In both cases, participants from Montana believe they meet the Standards better than participants from Washington believe they do. Grade level is also significantly correlated with how well participants believe they meet Standard 1 ($p = 0.0112$) and Standard 2 ($p = 0.0074$) in their classrooms (**Figure 7B**). There were no significant differences in how well participants believe they meet the ESE Standards based on their schools' Title I status.

About 54% of participants ($n = 77$) were able to describe a lesson or activity they use to meet Standard 1 in their classrooms (**Figure 8A**). The most common content area was ecology (51.9%), and the most common teaching method was discussion (26.0%). "Other" content areas include soil, climate change, renewable resources, natural disasters, and others. "Other teaching" methods include collective action projects, drawing, games, STEM building, and others. Agriculture was the only theme which varied significantly between states ($p = 0.0301$), with more participants from Montana than Washington teaching about it. Additionally, the only theme which varied significantly

FIGURE 4 | The percent of participants from Washington ($n = 87$) and Montana ($n = 84$) that report facing each challenge when trying to teach about sustainability in their classrooms. Asterisks represent significant differences.
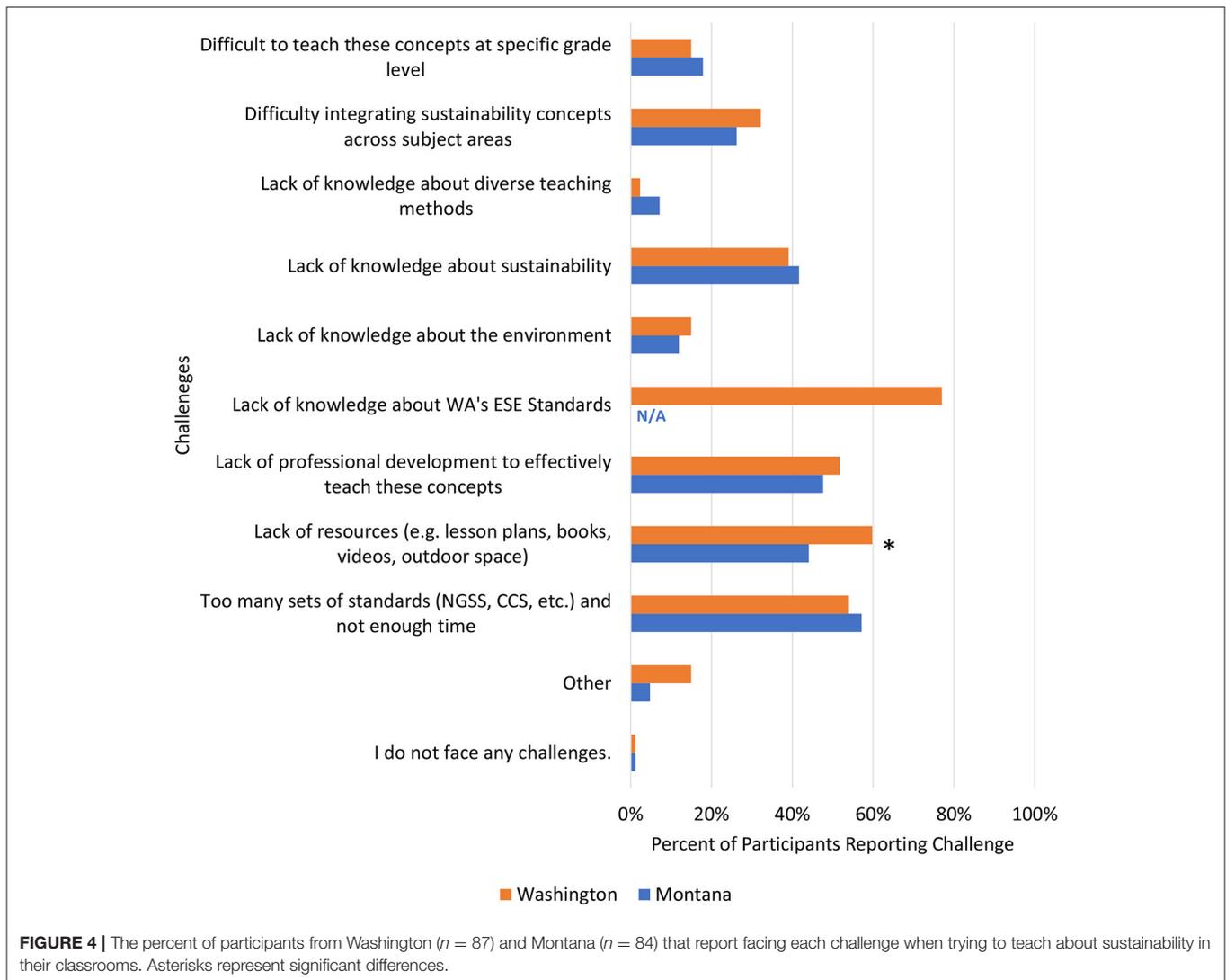
based on Title I status was economics ($p = 0.0177$), which more non-Title I school participants described teaching about than did participants that teach at Title I schools (data not shown). There were no significant differences based on grade level taught.

About 56% of participants ($n = 79$) were able to describe a lesson or activity used to meet Standard 2 in their classrooms (**Figure 8B**). The most common content area was ecology (45.6%), and the most common teaching method was STEM building (15.2%). "Other" content areas include natural resources, pollution, recycling, Native American topics, and others. "Other" teaching methods include roleplaying, art projects, guest speakers, games, writing exercises, and others. Both ecology topics ($p = 0.0028$) and natural vs. manmade topics ($p = 0.0164$) were mentioned significantly more often by participants from Montana, while participants from Washington mentioned more "other" content areas ($p = 0.0022$). There were no significant differences based on grade taught or Title I status.

About 42% of participants ($n = 59$) were able to describe a lesson or activity used to meet Standard 3 in

their classrooms (**Figure 9**). The most common content area was waste reduction (44.1%), and the most common teaching method was collective action (33.9%). "Other" content areas include soil, water, gardening, climate change, and others. "Other" teaching methods include art projects, outdoor learning, field trips, watching videos, and others. Both waste reduction topics ($p = 0.0441$) and collective action activities ($p = 0.0058$) were described significantly more often by participants from Montana than by participants from Washington. There were no significant differences based on grade taught or Title I status.

DISCUSSION

Findings that 30% or less of the surveyed elementary school teachers in Washington and Montana integrate sustainability and food systems content in their classroom highlights the urgent need for reforming elementary school curriculum to

integrate sustainability and food systems content. Given findings of the limitations of integrating sustainability due to limited time and resources, it is essential not to include sustainability as another curriculum topic. Rather, it is essential to view sustainability as a framework with which to approach other disciplines and content areas as well as to explore the linkages of these content areas. If utilized as a unifying and guiding framework, sustainability would be a central part of all of elementary school education rather than approached as an add-on. Resources would more likely be appropriately allocated to sustainability education including teacher training, curriculum materials, and funds. Additionally, implementation

of a sustainability framework to guide elementary school education could elucidate synergies between other content areas while fostering systems thinking of both educators and students. Multiple organizations around the world are beginning to utilize sustainability frameworks to guide their missions; similarly, educational institutions can use sustainability to guide learning outcomes. In 2019, the 40th UNESCO General Conference adopted the new global framework on Education for Sustainable Development for the period of 2020-2030 to focus on integrating ESD into policies, learning environments, training educators, and empowering youth (UNESCO, 2019). Integration of such a sustainability framework to unify elementary school curriculum could overcome many of the limitations identified in this study with regards to integration of sustainability and foods systems content in the classroom.

This study further highlights that state learning standards focused on sustainability are not adequate for teacher adoption of sustainability content and require additional resources and approaches. The use of Education for Sustainable Development (ESD) related teaching methods, the focus on sustainability and food systems topics, and the effort to foster these competencies in their students did not generally vary based on the presence or absence of sustainability-related state learning standards. Findings that the proportion of respondents that teach about sustainability-related concepts did not vary based on state emphasize that factors in addition to the presence of sustainability-related state learning standards need to be taken into account including grade level, local culture, and access to the outdoors. In fact, despite Montana's lack of sustainability-related state learning standards, the surveyed Montana teachers implemented ESD and Sustainable Food Systems Education (SFSE) signature pedagogy teaching methods and content in their classrooms more often than those in Washington. In addition, differences in content taught were found between grade levels,
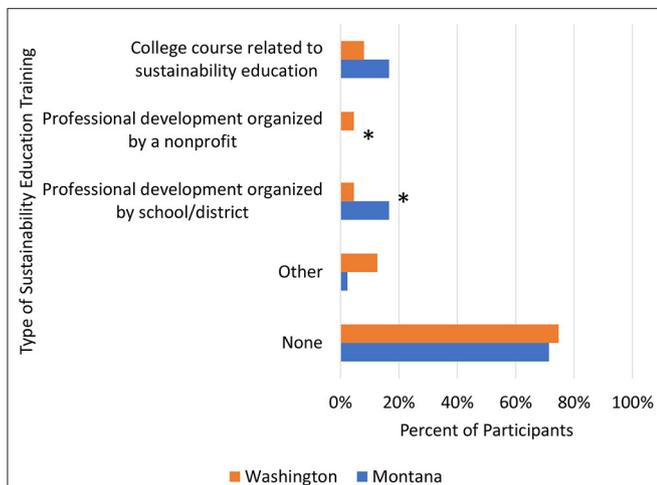

**FIGURE 5 |** The percent of participants from Washington ($n = 87$) and Montana ($n = 84$) that report having received each type of training focused on teaching about sustainability. Asterisks represent significant differences.
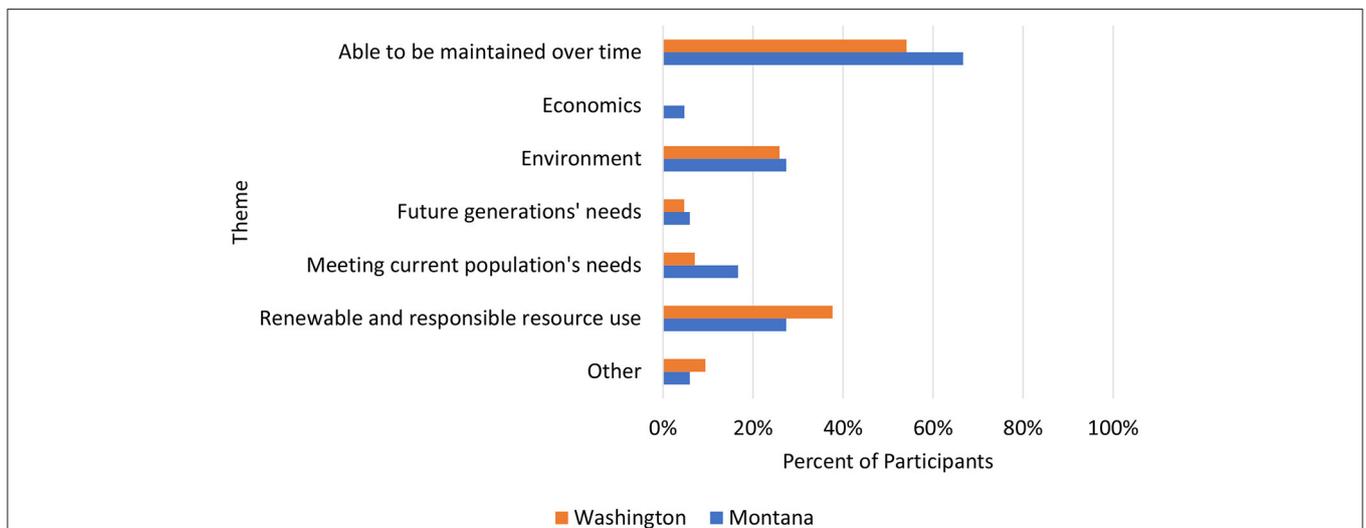
FIGURE 6 | The percent of participants from Washington ($n = 85$) and Montana ($n = 83$) whose definitions of sustainability contained each of the six identified themes.

FIGURE 7 | The average level of belief that participants **(A)** from Washington (n = 75) and Montana (n = 78) and **(B)** that teach each grade level are meeting the three ESE Standards (K n = 17, 1st n = 29, 2nd n = 27, 3rd n = 24, 4th n = 29, 5th n = 20). Asterisks represent significant differences, and grade levels not connected by the same letter are significantly different.

FIGURE 8 | The percent of participants that mentioned each theme in their descriptions of an activity or lesson that they use to meet **(A)** Standard 1 (n = 77) and **(B)** Standard 2 (n = 79) in their classrooms.

which align with grade-appropriate content areas where higher grade levels cover more complex topics, such as global issues. There were not any differences in the delivery of sustainability and food systems content based on Title I Status, highlighting that sustainability and food systems content is accessible for all, despite the differences in available funding between Title I and non-Title I schools. While there is not a difference in delivery of content based on Title I status, comparisons cannot be made across other studies as there are few to no studies contrasting differences between Title I and non-Title I teaching methods.

While political affiliation and political ideology are recognized as key determinants of perceptions and behaviors associated with sustainability (Casper et al., 2021), they did not appear to have an impact on the responses of surveyed educators. For example, Casper et al. (2021) found that Democrats in the United States reported significantly higher values and norms associated with supporting environmental sustainability. Over the past decade, there has been a strong divide between "red" (conservative or Republican) states and "blue" (liberal or Democrat) states in the United States with regards to support over sustainability policies such as climate change
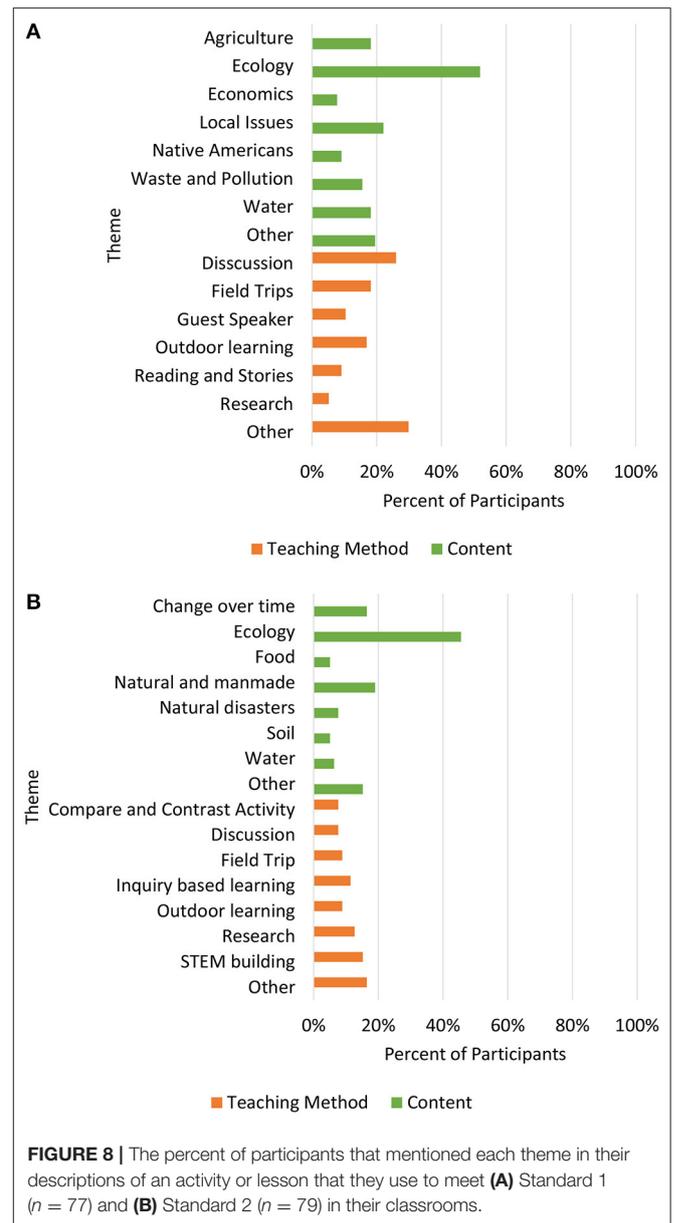
and energy, rooting from ideological disagreements over the role of government intervention in the economy (Hess et al., 2016). A greater number of blue states (with majority of Democrat voters) have policies supporting environmental protectionism compared to red states (with majority of Republican voters). With Washington being a "blue" state and Montana being a "red" state, we expected variable perceptions and behavior with regards to sustainability education. The lack of differences found between the surveyed educators in Washington and Montana support previous research that while Democrats reported higher sustainability values, sustainability program engagement, awareness of sustainability initiatives, and influence of sustainability initiatives on behavior were politically neutral.

FIGURE 9 | The percent of participants (*n* = 59) that mentioned each theme in their descriptions of an activity or lesson that they use to meet Standard 3 in their classrooms.
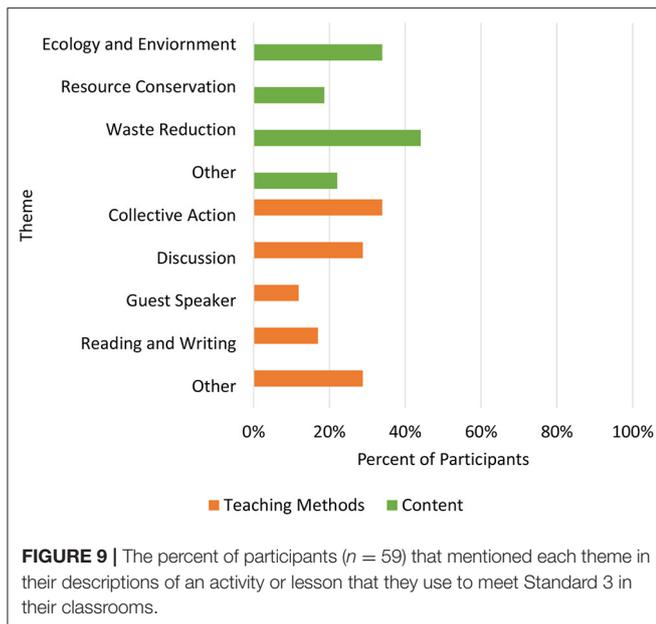
In addition, while differences were not found across states with and without sustainability-focused learning standards, we support that such standards provide a viable way to adapt ESD to local contexts. Despite the low rate of implementation of the ESE Standards by Washington elementary school teachers, examination of the ESE Standards highlight they provide an example of how to adapt ESD to a local context of US public education. Findings indicate that Washington's ESE Standards contain 50% of ESD and SFSE content areas, 80% percent of ESD and SFSE teaching methods, and 100% of the competencies which are central to ESD and the SFSE Signature Pedagogy. Sustainability-focused standards along with supplementary teacher training and resources are required to facilitate the integration of sustainability in the classroom.

On the basis of findings, sustainability and foods systems content that seem most accessible to integrate into the elementary school classroom includes pollinators, local foods, local issues, and sustainable water use. Although the proportion of respondents that are teaching about sustainability concepts in both Washington and Montana are fairly low, there was a greater use of student-centered teaching methods that are recommended for the integration of ESD into a curriculum by the surveyed educators from both states. Based on the prevalent teaching methods, field trips, small-group projects, and demonstrating good practices for students may be effective and accessible ways to integrate sustainability content in the classroom in order to foster critical and systems thinking, collaborative decision-making, problem-solving, and anticipatory thinking.

Only three of the 15 teaching methods aligned to ESF varied in this study based on the presence of sustainability-related state learning standards including outdoor learning, storytelling, and whole-class projects. These three methods were used more often by participants from Montana, indicating that factors other than the presence of sustainability-related state learning standards impact the use of ESD-aligned teaching methods including local cultural norms and environmental ethics. For example, Montana has seven tribal reservations where storytelling is associated as an Indigenous pedagogy (McKeough et al., 2008). Additionally, findings of variation of the implementation of teaching methods based on grade level are aligned with grade-appropriateness of different teaching methods. Further, findings that indicate that teaching methods used more often by participants that teach at non-Title I schools than by those at Title I schools indicate training and resource requirements to implement specific student-centered and interactive teaching methods that align with ESD. It is unknown if these finding are unique to this study as comparisons among other studies are difficult to make since there are few to no studies that contrast differences between Title I and non-Title I teaching and delivery methods. While educators are using a wide range of interactive teaching methods in their classrooms, additional training and support integrating interactive teaching methods could facilitate teachers to meet the goals of ESD.

The multiple limitations that were identified in this study with regards to integrating sustainability in the classroom (including a lack of resources (e.g., lesson plans, outdoor space, books), too many education standards, lack of professional development to teach about sustainability, multiple definitions of sustainability, and not enough time to teach about sustainability) can inform evidence-based actions to support education aligned with ESD including the implementation of sustainability as a unifying framework for elementary school education. For example, findings that ~80% of participants from Washington report that they know "nothing at all" about Washington's ESE Standards indicates the need for widespread professional development for educators on sustainability as well as clear communication on sustainability.

Widespread teacher training would ensure that all teachers have the foundational knowledge needed to teach about sustainability topics and engage their students through a wide range of interactive pedagogies. It would also ensure that teachers know where to find the appropriate resources to integrate sustainability education into their current curriculum in a transdisciplinary way. Existing research provides insight into how successful ESD-related professional development programs and ESD-focused teacher training programs can be structured and implemented (Mckeown, 2012; Nolet, 2013; The Bamber et al., 2016; Redman et al., 2018; Brandt et al., 2019). There are ESD-related professional development programs and ESD-focused teacher training programs around the country which provide a useful baseline for states that are interested in adopting larger-scale training programs.

While economic constraints may hinder professional development, access to resources has fewer economic constraints. We thus recommend the development of teacher resources be made widely available that describe how teachers at each grade

level can meet each sustainability-related standard within other lessons that already meet other existing learning standards. Particularly, resources are needed for teachers at lower grade levels (K-2), who reported teaching about sustainability content less frequently than did teachers at higher grade levels (3–5). In addition, if sustainability is implemented as a unifying framework for elementary school education, it will be a priority for funding and professional development. Likewise, implementing sustainability as a unifying framework for elementary school education would overcome the challenge that the surveyed educators variably define sustainability. Educators will not be able to effectively implement ESD, the SFSE signature pedagogy, or sustainability-related state learning standards if their definitions of sustainability do not align with globally prevalent definitions such as that of the United Nations. We recommend that professional development programs aligning future teachers' definitions of sustainability with the UN's definition.

The challenge of overcoming too many required learning standards and not enough time to cover all content aligns with what others in the field of sustainability education have found (Church and Skelton, 2010). Among the most commonly cited reason why sustainability education has not been adopted throughout the United States is the lack of time for teachers to teach about sustainability, given an already full curriculum with other content (Church and Skelton, 2010). However, ESD and the ESE standards are intended to be implemented in a trans- and inter-disciplinary way (UNESCO, 2012; Wheeler et al., 2014). The integration of sustainability as a framework aligned with existing standards at each grade level would overcome the need for extra time for sustainability content.

Overall, on the basis of findings, we recommend the following evidence-based actions at the elementary school level to equip future consumers and leaders with the systems thinking skills, real-world experiences, and knowledge to make decisions and lead progress toward sustainability transitions:

1. **Reform elementary school education with sustainability as a central framework**. We call for urgent reformation of elementary school education where sustainability is a central unifying framework to approach all disciplinary areas as well as to explore connections between these areas. Sustainability is central for the well-being of society and the planet and should be approached as such across the curriculum at all grade levels and in terms of prioritization of resources. In particular, we urge for sustainability not to be approached as an add-on to curriculum. Integration of a sustainability framework to unify elementary school curriculum could overcome many of the limitations identified in this study with regards to integration of sustainability in the classroom.
2. **Develop a diversity of professional development resources and lesson plans on sustainability that are widely accessible to all educators**. There is a need to develop sustainability resources for educators that teach at various grade levels and subject areas including science, social studies, math, art, music etc. There is a further need to develop sustainability lesson plans for different disciplinary areas that are appropriately

scaffolded in complexity across grade levels that align to the learning standards and outcomes of those levels and areas so that sustainability remains a central tenant of all curricula at all levels. Sustainability is a complex topic and appropriate scaffolding will be essential across grade levels. In addition, sustainability resources should be adaptable to be place-based and context-specific to different locations to highlight local sustainability challenges and solutions. Such resources should be made centrally available and sharable between educators through an online platform.
3. **Provide open access continuous professional development on sustainability for all educators.** Given economic constraints of professional development, we encourage open access and continuous professional development on sustainability for all educators. Trainings can begin by educating teachers about sustainability and food systems concepts as a foundation and then they can transition to educating teachers on how to engage students on these topics. We encourage school districts and state education agencies to collaborate with non-profit organizations to ease the burden of developing resources and supporting teachers.

CONCLUSION

This study highlights the urgent need for reforming elementary school curriculum to integrate sustainability as a central unifying framework to support societal and planetary health. Findings emphasize that state learning standards focused on sustainability are not adequate on their own to foster teacher adoption of sustainability content; rather, there is need for larger curriculum reformation to integrate sustainability as a framework, development of place-based teacher resources on sustainability, and open access professional development alongside learning standards. Such approaches would help overcome the multiple challenges which need to be addressed in tandem with the creation of learning standards in order to ensure that all students cultivate the systems thinking skills, real world experience, and sustainability knowledge that will allow them to develop the competencies to ultimately guide society toward meeting the SDGs. Through coordinated efforts between educators, state education officials, academics, and non-profit organizations there is potential to provide the widespread training and resources that educators need in order to successfully adapt ESD and the SFSE signature pedagogy into elementary education.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by IRB at Montana State University. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AS, SAh, CB, and SAr contributed to the study design and development of the survey tool. AS led data collection and data analysis with contributions from TW and led the preparation of the manuscript with contributions from all authors. All authors contributed to the article and approved the submitted version.

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Centering Equity in Sustainable Food Systems Education

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Sustainable food systems education (SFSE) is rapidly advancing to meet the need for developing future professionals who are capable of effective decision-making regarding agriculture, food, nutrition, consumption, and waste in a complex world. Equity, particularly racial equity and its intersectional links with other inequities, should play a central role in efforts to advance SFSE given the harmful social and environmental externalities of food systems and ongoing oppression and systemic inequities such as lack of food access faced by racialized and/or marginalized populations. However, few institutional and intra-disciplinary resources exist on how to engage students in discussion about equity and related topics in SFSE. We present perspectives based on our multi-institutional collaborations to develop and apply pedagogical materials that center equity while building students' skills in systems thinking, critical reflection, and affective engagement. Examples are provided of how to develop undergraduate and graduate sustainable food systems curricula that embrace complexity and recognize the affective layers, or underlying experiences of feelings and emotions, when engaging with topics of equity, justice, oppression, and privilege.

Keywords: food systems pedagogy, systems thinking, equity, critical reflection, sustainable food systems education, affect

INTRODUCTION

Food systems[1] are foundational drivers of change and power relationships on local to global scales, cutting across social, political, economic, health, and environmental systems. Poor quality diets are among the top contributors to the global burden of disease (Murray et al., 2020), and producing the food that comprises these diets puts pressure on the earth's systems through major contributions to greenhouse gas emissions, fresh water use, and biodiversity loss (Willett et al., 2019). Our current industrial food systems are not effectively contributing to the health of people or the planet, with notable disparities for the most vulnerable populations and regions (Global Nutrition Report, 2020). However, discussions about "fixing a broken food system" in order to "feed the world" assume that food systems of the past functioned to produce equitable outcomes. This framing overlooks the violences of racial inequities, colonial histories, and disparities in power between privileged groups and marginalized groups that continue to be subject to harmful social and environmental externalities of food systems and ongoing oppression and systemic inequities due to exploitative globalization (Cadieux and Slocum, 2015; Holt-Giménez and Harper, 2016; Holt-Giménez, 2017)[2].

The way in which food is produced and moves through food supply chains impacts laborers and other stakeholders as well as consumer food environments, including the availability, affordability, acceptability, and sustainability of foods (Downs et al., 2020). Systems thinking identifies innovative ways to reorient food systems toward the production and consumption of just, equitable, healthy, and sustainable diets and toward prioritizing access to affordable and culturally relevant food for all (Cadieux and Slocum, 2015; Valley et al., 2018; Iowa State University Extension and Outreach, 2021). Food systems thinking is an approach that goes beyond the conventional focus on linear and distinct food system elements and that moves toward accounting for more complex, interconnected, and dynamic linkages (Ingram et al., 2020).

Given the complexity of the problems within our current food systems, there is a need for people from diverse disciplines trained in food systems thinking (cf. Ingram et al., 2020), regardless of the sector or discipline. Often described as multi-, inter-, and trans-disciplinary, sustainable food systems education

(SFSE) is rapidly advancing, with a signature pedagogy that serves as a framework in which future practitioners in this field are educated and equipped to both compete in a dynamic and heterogenous job market and foster new vocational opportunities for food system transformation (Valley et al., 2018). However, we argue that this training must center equity,[3] particularly racial equity and its intersectional links with other inequities (Ebel et al., 2020; Valley et al., 2020). Concepts of sustainability often focus on environmental aspects with an "equity deficit" that fails to acknowledge connections with social needs, welfare, and economic opportunity for *all* (Agyeman et al., 2003). Several U.S.-based organizations, from the Sustainable Agriculture Education Association[4] to the Inter-Institutional Network for Food, Agriculture, and Sustainability[5] to the Agriculture, Food, and Human Values Society[6], are starting to compile resources for their membership on how to teach about food systems in ways that center equity given the urgent need to address adverse effects of food production and distribution faced by marginalized populations.

An advancement toward centering equity in SFSE requires a fundamental shift from siloed, disciplinary ways of "seeing" the world to systemic approaches that embrace and work through complexity, uncertainty, and relationships (e.g., de Sousa Santos, 2014). Systemic ways of knowing necessitate adopting a pluralistic approach to acknowledging the importance of diverse stakeholder perspectives in conceptualizing issues and recognizing outcomes and impacts of interventions. An equity-centered approach draws from an emergent understanding of relational systems thinking and cross-epistemological research and teaching (Goodchild, 2021). Sustainable food systems education's engagement with pluralism and equity requires an awareness of historical and current power relations among stakeholders and their communities in order to interrupt the reproduction of systems of oppression within food systems. Developing systems thinking capacities within SFSE programs must center equity in ways that interrupt and interrogate colonialism, white supremacy, patriarchy, heteronormativity, ableism, and the "monoculture of the capitalist logic of productivity" (de Sousa Santos, 2014, p. 174). Not doing so is likely to reproduce the harms and violences of our current food systems (Giordano, 2017; Stein et al., 2017; Bansal, 2018), such as attempts to improve food system outcomes that fail to give explicit attention to race and racializing processes, thereby reproducing racial inequities (Slocum, 2007; Sullivan, 2014; Valley et al., 2020).

Rather than providing an extended analysis of the "why" of centering equity, here we write about the "how" in our own context. This paper describes efforts at several institutions, including multi-institutional collaborations, to develop and

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[1]Many people, particularly those from Indigenous and local communities, conceptualize food systems as encompassing the dynamic and reciprocal relationships between people and the places and spaces where we acquire food, prepare food, talk about food, exchange food, or generally gather meaning from food. Others focus more on elements of the food supply chain: "the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation, and consumption of food, and the output of these activities, including socio-economic and environmental outcomes" (HLPE, 2017, p. 23). Regardless, food systems are deeply embedded elements of our daily lives and generate impacts across scales.

[2]For expanded debates between philosophies of oppression that go beyond our brief applied perspective, see Nussbaum (1993), Charusheela (2009), and de Sousa Santos (2014). We base our perspective on the work of the Gesturing Towards Decolonial Futures collective (e.g., Stein, 2019) and Mignolo's (2011) colonial matrix of power which addresses the interrelated facets of racism, colonialism, capitalism, enlightenment humanism, the nation-state, etc.

[3]Forms of equity include racial, age/generational, ability, class/economic, culture/ethnicity, gender, health (physical and mental), livelihood/employment, political, religion, sexual orientation, and urban/rural, among other categories of social differentiation.

[4]Sustainable Agriculture Education Association: https://sustainableaged.org/.

[5]Inter-institutional Network for Food, Agriculture, and Sustainability: https://asi.ucdavis.edu/programs/infas.

[6]Agriculture, Food, and Human Values Society: https://afhvs.wildapricot.org/.

apply pedagogical materials that center equity while building students' skills in systems thinking, critical reflection, and affective engagement.

CENTERING EQUITY IN TEACHING AND FRAMING FOOD SYSTEMS

The cornerstone of our vision for SFSE pedagogy is equity and its full integration into curricula at the undergraduate and graduate level, instead of being discussed in one-off or certain class sessions. What will it take to bring about this vision? Here, we describe two multi-institutional collaborations and efforts by faculty at three different institutions to develop curricula that frame food systems in ways that center equity while fostering essential process skills.

Multi-Institutional Collaboration for Developing Curriculum to Center Equity
Teaching Food Systems Community of Practice

Fully integrating equity into sustainable food systems curriculum necessitates collective work across institutions. We support that a collaborative mechanism such as a Consortium or a Community of Practice (CoP) is critical for the adoption and full integration of equity into curricula. Here, we provide an example of our Teaching Sustainable Food Systems CoP that has been a collaborative mechanism for educators in North America to identify, develop, review, and share curriculum materials for SFSE.

Specifically, the "Teaching Food Systems CoP"[7] was launched in 2016 by faculty members at Columbia University, in collaboration with the Center for Biodiversity and Conservation at the American Museum of Natural History, in parallel with the redesign of an undergraduate food systems course (described below). The goals of the CoP are to convene academics and practitioners focused on SFSE, to: (1) support and grow a CoP for developing and implementing curricula in food systems courses; (2) share materials using systems thinking frameworks to teach about food systems; and (3) foster assessment tools on student learning in systems thinking.

Several CoP members collaborated on a study to determine the extent to which SFSE programs in the U.S. and Canada address equity and proposed an equity competency model to support the development of future professionals capable of dismantling inequity in the food system (Valley et al., 2020). The authors argue that the limited number of SFSE programs explicitly stating equity terms (17%) indicates a significant gap between the knowledge, skills, and attitudes being called for by food justice scholars and activists and the educational outcomes associated with institutions responsible for preparing future professionals. Given the findings, the CoP Subcommittee on Equity, Inclusion, Diversity, and Justice and Indigenous Peoples and Local Communities (EIDJ and IPLCs) developed training materials that explore how teachers and students in undergraduate and graduate STEM classrooms can engage

with EIDJ content in ways that recognize affect—feelings and emotions (Isen et al., 1987). Since affect controls cognitive behavior (Isen et al., 1987; Carver and Scheier, 2001), we support that affect and affective states including emotion, mood, interpersonal stance, attitudes, and personality traits (Scherer, 2005) are recognized within SFSE learning contexts and are critical to centering equity in this context. It is important for sustainable food systems educators to consider the words of Zembylas (2013): "classrooms are not homogeneous environments with a common understanding [or experience] of oppression, but deeply divided places where contested narratives are steeped in the politics of emotions to create complex emotional and intellectual challenges for teachers" (p. 181).

During training sessions with fellow CoP members, the EIDJ and IPLCs Subcommittee asked educators to consider the role of emotion and affective state in key relationships in teaching and learning [between students and teachers, subject matter, fellow students, and developing self, as per Quinlan (2016), as well as between teacher and teacher]. This approach draws from the work of Fawaz (2016) in that explicit attention to the variation and shifting intensity of affective responses can result in productive aspects of encounters with pain and trauma, working to expand students' feelings in order to encourage investment in redressing issues of structural oppression, such as racism, sexism, homophobia, and colonialism. In sustainable food systems, these issues are central and foundational. Ultimately, critical pedagogical strategies must function within the larger context of how structural inequality is operationalized in departments and across campuses. It is imperative to move in the direction of democratic pedagogy, informed by transformational connections coupling the classroom and society. This approach connects education with social and political change, making the classroom a lens in which change and action is understood (de los Reyes et al., 2001), especially when local framing can aid qualitative inquiry[8] (Stanley and Haynes, 2019).

At the same time, such pedagogies pose risks to traumatized students and they demand comprehensive preparation, considerations of safety, and accountability for student well-being (also see Clegg et al., 2021, this issue). Requiring systemically traumatized students to engage affectively can reinscribe marginalization and exclusion from educational environments (Dalton et al., 2017; Cordova-Cobo and Cobo, 2020; Wahl, 2021). Institutional support and resources for this critical trauma-informed preparation may not be as readily available as it should be. Nevertheless, the dual moral imperatives of addressing injustice on the one hand, and not traumatizing already marginalized students on the other, remain in tension. Much of this critical trauma-informed education is both readily available and of basic professional and moral importance. Through recognizing the necessity of considering affect in SFSE curricula, Subcommittee members have identified strategies

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[7]Teaching Food Systems Community of Practice: https://tinyurl.com/44mkzfca.

[8]As quoted in an interview of scholar Yvonna Lincoln: "There are plenty racial and social injustice issues close to our own institutions, in places where we can explore, with critical qualitative research, scenarios of oppression, inequity, discrimination, and make compelling cases for serious policy revisions" (Stanley and Haynes, 2019, p. 1921).

for developing capacities to be safe, self-aware, accountable, and intellectually generative when engaging with EIDJ content (**Table 1**; also see Appendix 1 in **Supplementary Material** for supplementary resources for educators).

Inclusive Food Systems Curriculum USDA Higher Education Challenge Project

Faculty from Montana State University, University of British Columbia, and University of Minnesota launched the Sustainable Food Systems Consortium in 2013 and have been collaborating on a project titled "Advancing an Inclusive Food Systems Curriculum based on a Signature Pedagogy" supported by a USDA Higher Education Challenge (HEC) grant focused on creating inclusive and replicable 4-year core curricula models for Baccalaureate degree-level SFSE programs, guided by a signature pedagogy model of cognitive maturation in young adults (Valley et al., 2018) as well as methods for enhancing inclusion of under-represented students. These curricula models include a range of materials such as curriculum maps, lesson plans, hands-on course activities, and evaluation tools that are aligned to the sustainable food systems signature pedagogy including holistic and pluralistic ways of understanding sustainability challenges, experiential learning, and participation in collective action projects. The learning approaches of the sustainable food systems signature pedagogy are recognized to be inclusive of diversity of perspective and supportive of underrepresented students (Valley et al., 2018) as well as catering to multiple learning styles essential for designing inclusive curricula that account for students' educational, cultural, and social background and experience (Smith, 2002). Additional inclusion approaches being implemented by participants of this project for centering equity in the curriculum include: (1) focus on complex issues of public welfare; (2) development of civic identity; (3) appreciation of different forms of knowledge and understanding; (4) peer support and; (5) skill development for addressing food system issues in multi-sector and multi-cultural settings (Whittaker and Montgomery, 2012).

Participants of this project further developed adaptable learning outcomes for SFSE where each learning outcome is framed with consideration of justice, equity, diversity, and inclusion (Ebel et al., 2020). As an example of a product of this effort, members of the collaboration at the University of British Columbia published the Just Food Educational Resource[9], a teaching and learning open education resource for post-secondary instructors and other educators interested in teaching food justice and equity.

Additionally, participants of this project collaborated with the Teaching Food Systems CoP to offer the "Teaching Sustainable Food Systems in Our Times Sandbox Webinar Series[10]," to provide professional development opportunities for educators to enhance and share knowledge and skills regarding justice, equity, diversity, and inclusion. Multiple webinars in this series provide examples of how to integrate

equity-minded curriculum into teaching and learning including through self-reflection, storytelling, cultural protocol, positionality, Indigenous methodologies, multicultural texts, and community partnerships.

Most recently, HEC grant collaborators partnered with Gesturing Towards Decolonial Futures[11], an arts/research collective based at the University of British Columbia aiming to identify and deactivate colonial habits of being and to gesture toward the possibility of decolonial futures. Collaborators facilitated a 6-week professional development program for sustainable food systems educators in the U.S and Canada to explore contributions of decolonial perspectives and embodied practices in relation to SFSE.

Program and Course-Level Efforts
Montana State University

Faculty of the Master of Science in Sustainable Food Systems and Bachelor of Science in Sustainable Food and Bioenergy Systems at Montana State University (MSU) have been centering equity in the curriculum through evaluation and modification of course content. Specifically, the faculty have been developing content that emphasizes systems thinking, critical and deep reflection, interdisciplinarity, collaboration and communication with diverse stakeholders, future visioning and design, practical skills, experiential learning, and participation in collective action projects (Jordan et al., 2014; Valley et al., 2018). Most recently, MSU faculty have been revising existing curriculum of core courses in the sustainable food systems programs to better align with consideration for equity-minded approaches and content. For example, the "Food Environments and Sustainable Diets" graduate course expanded its focus of examining linkages between food environments, food security, diets, sustainability, and health within the frameworks of socio-ecological theory and policy to also include linkages with equity. Each of the five course units aligned to different dimensions of food environments and sustainable diets were modified to include content and assignments focused on health equity, food access, affordability, cultural relevance, food sovereignty, and Indigenous peoples' food systems. In addition, students of this course participated in the 21-day Racial Equity Habit Building Challenge developed by Food Solutions New England[12] as an experiential assignment. Following participation in the Challenge, students engaged in reflection regarding their experience through pod discussions and written reflections, including their perspectives of applying learnings and awareness to their work in the food system. The course syllabus for "Food Environments and Sustainable Diets" can be found in **Supplementary Material**.

Rutgers University

Rutgers School of Public Health's Public Health Nutrition Concentration within its Master of Public Health program has also been centering equity within its curriculum. Two

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[9]Just Food Educational Resource: https://justfood.landfood.ubc.ca/.
[10]Teaching Sustainable Food Systems in Our Times Sandbox Webinar Series https://waferx.montana.edu/sandbox_webinar_series.html.

[11]Gesturing Towards Decolonial Futures: https://decolonialfutures.net/.
[12]21-day Racial Equity Habit Building Challenge developed by Food Solutions New England: https://foodsolutionsne.org/21-day-racial-equity-habit-building-challenge/.

TABLE 1 | Strategies for educators to consider the role of emotion and affective state when centering equity in sustainable food systems education.

Strategies	Examples and tactics	Key resources
Learn about and practice trauma-informed teaching, including the need to realize, recognize, and respond in the classroom setting[a].	Consider how course content is likely to activate and unsettle students. To engage in care: 1. Do assume many students are traumatized. 2. Do focus on empowering ways of relating (consent, giving control). 3. Be prepared to do the work (e.g., address lack of knowledge, unawareness of unconscious biases, and assumptions in yourself and others, through learning about trauma-informed teaching and building support within institutions for this work). 4. Do prepare students for difficult material or processes. 5. Do give power to students to care for themselves by turning off cameras, declining to participate in activities, and being observers rather than participants. 6. Do plan for the extra time it takes to hold space for processing and reacting. Specific harms to avoid: 1. Do not address content related to systems of historical and on-going forms of oppression without first seeking resources to support completing self-awareness work and basic education (see example resources in next column). 2. Do not make assumptions about identity, migration, citizenship, or race based on appearance or language skills. 3. Do not tokenize marginalized/racialized students or focus on them as representatives when issues arise. 4. Do not provoke/require students to relive or re-tell individual stories of trauma in class or assignments.	Zembylas, 2013; Fawaz, 2016; Thomas et al., 2019; Cordova-Cobo and Cobo, 2020; Valley et al., 2020; Clegg et al., 2021, this issue; resources in Appendix 1 in **Supplementary Material**
Articulate course goals that center affective capacities to engage with topics of privilege, oppression, equity, and justice, while recognizing that marginalized students have often already been forced to develop affective skills for surviving daily experiences of systemic oppression, and that evaluations based on retraumatizing activities are unjust.	Avoid role playing where students of one background have to assume the role of an individual from a traumatized group, especially if there might be members of that traumatized group in the classroom.	de los Reyes et al., 2001; Stanley and Haynes, 2019
Recognize and consider the difference between individual and collective affective states in a classroom.	Incorporate activities throughout a course that draw attention to individual affect that can both facilitate and distract from academic participation, as well as recognize collective affect circulating at the group level. 1. One example of such an activity is inspired by the body-based practices in Menakem (2017) and can be conducted together with students before engaging with material that can impact affective load and circulation. 2. Breathe: Ask students to take a deep breath, inhaling slowly through the nose, letting chest, and belly expand, then exhaling through the mouth. 3. Scan and Connect: Invite students to settle in, feet flat on the floor, engage their core, straighten back and shoulders, tuck chin in, and breathe in deeply again and hold the breath while connecting with sensations in their body, noticing areas of construction, tightness, pain, emptiness, mood, energy. Ask students to try to identify the sensations within their body. 4. Release: Ask students to breathe in, hold their breath, raise their shoulders to their ears, clench jaw, tighten all the muscles in their body and hold for three counts, then release (loudly if preferable). Repeat two more times. 5. Reflect: Ask students to think about the sensations they felt during the exercise, and ask them to pay attention to when they feel these sensations throughout their day and what causes these feelings to occur, to raise awareness of how affect is manifest within their body.	Nahl, 2004; Dalton et al., 2017; Menakem, 2017; Kubala, 2020
Address potential lack of knowledge or awareness by educators, school administrators, and students about unconscious biases and assumptions.	By understanding, and promoting the understanding by others of, the harms that can occur in teaching and learning about SFSE and by focusing on empowering ways of relating to the various identities and life experiences of students, educators can be more prepared for uncertainty and to facilitate confrontation.	Dee and Gershenson, 2017; Tate and Page, 2018 (note, neither directly engages SFSE); Valley et al., 2020

(Continued)

Strategies	Examples and tactics	Key resources
Be accountable for the process of engaging in these topics with students, and open to feedback from students and fellow educators. Work to recognize the potential for critical pedagogy—driven by education centered on both social change in the classroom and throughout society—"driven by diverse ideas, options, backgrounds, groups, and theories." (McArthur, 2010, p. 494).	Ultimate accountability goes beyond objectives and goals on the front end (course design) and evaluations on the back end. Educators should consider who is and is not in the classroom, and should build meaningful relationships with community partners through collaborations and pluralized design, where course content is co-planned and co-produced with invited community partners.	Mountz et al., 2008; McArthur, 2010; Stein et al., 2020, 2021
Challenge students to consider the complexity of how ecological sustainability and social equity and justice intersect and interplay in real world situations.	By exploring dilemmas presented in the real world, students build an understanding, appreciation, and desire to have the broad scope of considering sustainability and equity in food system challenges and solutions. One example of this is to explore avocado production in Mexico. Avocados are often a favorite food of many students who have not considered how they are causing forest destruction and encroaching on monarch butterfly sanctuary land, or how the people producing avocados for export are experiencing human rights abuses. Using a popular food, avocados, to explore interconnections of sustainability and equity enables students to expand their resolve to think broadly when encountering all food system issues.	Leonard, 2019; Mondragón and López-Portillo, 2020

[a] *"Realize the widespread impact of all forms of trauma—including racial and historical trauma—on children's development and school functioning as well as the diversity of student responses to trauma...recognize the signs and symptoms of all forms of trauma in students and families...respond by fully integrating knowledge about all forms of trauma into policies, procedures, and practices, and seek to actively resist re-traumatizing students and families"* (Cordova-Cobo and Cobo, 2020, para. 6).

of the required courses, "Global Food Systems and Policy" and "Global Food and Culture" were designed to provide students with a deeper understanding of the elements of the food system and how they influence nutrition, health, environmental, social, economic, and equity outcomes. Equity is addressed throughout these courses in lecture content, assigned readings, videos and podcasts, in-class discussions, and assignments.

Assignments include reflections that require students to critically think about topics such as cultural appropriation of food, how food production systems influence our diets, how to intervene within the food system to improve health and equity outcomes, among others. By encouraging students to critically examine the root causes of inequity throughout our food systems they will be better positioned to identify solutions aimed at addressing it in their future work. Course syllabi and descriptions of the assignments can be found in **Supplementary Material**.

Columbia University

First developed and offered by Columbia University's Department of Ecology, Evolution, and Environmental Biology in 2011, "Food, Ecology, and Globalization" was a broad survey course for science and non-science majors with a focus on the factors that influence food choice and the implications of those choices at many scales. In 2018 and 2020, a core team of instructors redesigned the course to more intentionally center racial equity and food justice, working with students through each class session to explore the context for how racism and equity operate within food systems with a key learning outcome that students be able to understand and describe why equity is at the heart of food system transformation. For example, in 2020, the core team collaborated with Spiller (UNH)

to develop a new course session "Introduction to Systems Thinking as a Tool For Understanding Food Systems and the Role of Racism in Food Systems." During this virtual session, students were introduced to a framework for understanding levels of racism developed by Race Forward: The Center for Racial Justice Innovation (2014), and applied this framework to food systems, then worked in breakout groups to use the systems thinking tool "rich pictures" to visualize the topic and analyze the role of racism within food systems. This session, and several others throughout the course, focused on the use of innovative tools to bridge different levels of content knowledge and surface systemic drivers of social-ecological systems (several of the materials used in the course were published by the Network of Conservation Educators and Practitioners[13], see Betley et al., 2021a,b, and Paxton et al., 2021). The course syllabus and descriptions of the assignments can be found in **Supplementary Material**.

DISCUSSION

Given the harmful social and environmental externalities of food systems and ongoing oppression and systemic inequities, it is critical for equity, and particularly racial equity, to be a central focus in efforts to advance SFSE. However, few resources exist regarding how to engage students in equity and related topics in SFSE. Here, we provide examples of multi-institutional collaborations and program efforts to develop and apply pedagogical materials that center equity while building students' skills in systems thinking, critical reflection, and affective engagement. Importantly, we support collaborative mechanisms for identifying and sharing pedagogy such as

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[13] Network of Conservation Educators and Practitioners: https://ncep.amnh.org/.

the Teaching Food Systems CoP and the Inclusive Food Systems Curriculum USDA HEC project. These are examples of multi-institutional collaboratives to facilitate co-development of pedagogical approaches to teaching and framing food systems that center equity.

All of the efforts we describe have reinforced to us, as educators, the need to engage both colleagues and students in these equity-centered discussions, and the need for continual professional development to improve the ways in which we engage. For example, simply adding content about racial equity to a course syllabus is insufficient and can perpetuate harms against racialized students who may be systemically traumatized. We encourage sustainable food systems educators to carefully study and consider how they incorporate affect in their pedagogical approaches, with strategies presented in **Table 1** as a possible starting point including specific tactics that have been successfully employed in our classrooms. We also encourage the development, expansion, and strengthening of new and existing multi-institutional collaborations that broaden our understanding of how best to develop future professionals capable of effective decision-making in a complex world, and allow educators to share resources and lessons learned from varied and iterative approaches across diverse student populations.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

SAh, SAk, EB, ES, LT, and WV led the conception and design of the perspective. DC, BI, LT, and WV developed content on affective considerations for educators when engaging with EIDJ content. EB and ES led the drafting of the manuscript and all authors contributed to writing and revision. All authors gave final approval of the version to be published.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs. 2021.737434/full#supplementary-material

Supplementary Data Sheet 1 | Appendix 1: Selected training and resources for educators to **Supplement Table 1**.

Supplementary Data Sheet 2 | Syllabus for Food Environments and Sustainable Diets (Montana State University).

Supplementary Data Sheet 3 | Syllabi for Global Food Systems and Policy and Global Food and Culture (Rutgers University).

Supplementary Data Sheet 4 | Syllabus for Food, Ecology, and Globalization (Columbia University).

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frontiers
in Sustainable Food Systems

Centering Justice in a Sustainable Food Systems Master's Program

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The new Master of Science in Sustainable Food Systems (MSFS) program at Prescott College was re-envisioned as part of the preferred teach out partnership with Green Mountain College that closed in 2019. In collaboration with faculty from both colleges, the new MSFS program was developed to intentionally center social justice and offer students a *Food Justice* concentration. Food justice is a growing movement that seeks to shift global, industrial food systems toward more equitable, just, and sustainable foodways. Using this definition, students in the *Food Justice* core course uncovered how forms of institutional oppression prevent certain communities from accessing healthy and culturally appropriate food. This course was designed and taught from an anti-racist, anti-colonial, and culturally sustaining pedagogical framework. The *Food Justice* course frames students' investigation of the current food system and how issues of privilege, access, and identity relate to food justice throughout the MSFS program. Through experiential learning, students were asked to develop and implement a project that aligns with social justice values. In this perspective paper, we describe our experiences as sustainable food systems educators in making structural changes to the master's program. We share the values and assumptions that led to the development of the *Food Justice* concentration and course; detail our pedagogical frameworks; and highlight students' projects as a manifestation of the student experience.

Keywords: culturally sustaining pedagogy, sustainable food systems education, food justice, experiential learning, graduate programs, justice, pedagogy

INTRODUCTION

This profile of the Master of Science in Sustainable Food Systems (MSFS) program at Prescott College (PC) provides an example of how an existing food systems curriculum was re-envisioned to intentionally center social justice and research-engaged teaching (Neary et al., 2014; Harfitt and Chow, 2020). PC's MSFS program is an intentionally online, asynchronous program that was accredited and launched in the Fall of 2019 as part of a preferred teach-out agreement with Green Mountain College (GMC), Vermont, which, unfortunately, closed July 2019. In this paper, we share some of the values and assumptions that led to the development of the *Food Justice* concentration and course and detail our pedagogical frameworks. Highlighting student projects, we provide concrete examples of active learning that illustrate students' understanding of racism and other injustices in the food system. The goals of this paper were to (1) Provide context and strategies for graduate level SFS program development, and (2) Offer our pedagogical perspectives and praxis to provide tangible insight for SFS educators.

AUTHOR AND COLLABORATIVE POSITIONALITY

We are educators operating from diverse and intersecting identities. We acknowledge the power and privilege we hold as educated, middle-class, cisgender female scholars working in higher education, particularly in relation to teaching justice at a predominantly white institution (PWI). As white and biracial settler educators working and living on Yavapai-Prescott and Kānaka Maoli lands, we approach place-based learning from a relational and ethical standpoint.

With the 2019 closure of GMC, PC welcomed students and faculty. The MSFS Program Director (Currey) and five faculty members transitioned to PC where Greeson was already teaching a PC course entitled *Food Justice*. The interdisciplinary faculty specialize in agroecology; ethnoecology; nutrition; public health and policy; social ecology; soil ecology; and sustainability education. Both Greeson and Currey shared insider positionality as they embarked upon, with the other members of the transitional faculty (now PC faculty), revising and seeking accreditation for the PC MSFS program (Hinkelman, 2018). We both also shared outsider positionality as Greeson came to know the existing GMC MSFS curriculum, faculty and students, and Currey came to know the PC faculty, college-wide course offerings and ethos. With clear support from PC leadership, the urgent need to have a newly accredited program in place for transferring students and shared power to bring about change, our collaboration team redesigned and re-positioned the program in 6 months.

BACKGROUND: MSFS OVERVIEW

GMC's MSFS program, launched in 2011, was the nation's first online, asynchronous master's level sustainable food system program. The 39 credit-hour program consisted of 13, three-credit courses, including a capstone project requirement [**Supplementary Table 1**; *for learning objectives and course descriptions see* Green Mountain College (GMC). 2018, p. 14]. All courses were required and taken sequentially in the order noted in **Supplementary Table 1**. There were 139 graduates over 8 years.

The transition to PC created opportunities to modify the MSFS curriculum at the program level, but also to systematically revise course content. Modifications sought to improve students' awareness of the structural inequities in the food system, their positionality and the skill sets needed to bring about more sustainable and just communities (Valley et al., 2020; Kelly et al., 2021). We highlight the development of the *Food Justice* concentration with the *Food Justice* course at its core, below. The main strategies and tactics for centering justice in the MSFS program included:

1. Embracing PC's low-barrier, holistic admission process (no-fee; no testing; see Glazer et al. 2014, p. 3) that recognizes prospective students for online, graduate programs are more likely to have recent, substantive volunteer (see Stapleton, 2021) and/or work experience rather than recent academic experience. Independent college students, as Reichlin Cruse et al. (2018) note, are more likely to work at least part-time, be women, be People of Color, and be parenting children under the age of 18.

2. Reducing the credit hour count by nearly 10% to improve affordability of, and thus access to, the program for students seeking to influence food systems in their communities;

3. Reducing the number of required courses so that students have more agency over their education by choosing electives;

4. Creating courses and concentrations, such as *Food Justice,* to help students build awareness about structural biases and their positionality in the food system (Prescott College, 2021);

5. Moving the *Food Justice* course into the first semester (**Supplementary Table 1**) as a triggering event for cognitive presence in the program so that students encounter the entirety of the MSFS curriculum with social and environmental justice competencies (Akyol and Garrison, 2011; Almasi and Zhu, 2020; Valley et al., 2020), and

6. Investing in professional development such that all courses are developed and revised centering justice and supporting students' application of what they are learning in their communities (e.g., XITO, 2015; Fernández, 2019).

As a result, PC's MSFS program, accredited and launched in August 2019, is an online, asynchronous program 36 credits in length consisting of 12, three-credit courses, including a student-led capstone project (**Supplementary Table 1**; for learning objectives and course descriptions see Prescott College 2021, p. 210). Eight courses are required with students having agency over four courses, which include their capstone and three electives. Electives can lead to nine-credit concentrations in: *Food Justice*; *Sustainable Diets and Biodiversity*; and/or *Food Entrepreneurship*. Students may also choose a Dual MBA in Sustainability Leadership and MSFS (45 credits) degree path. Currently, 59 students are enrolled with 20 graduates.

FOOD JUSTICE CORE COURSE AND CONCENTRATION

As educators committed to examining and teaching sustainable food systems, we approached not only course content but the program curriculum from the standpoint that food systems are intersectional and must include social and environmental justice. Intersectionality refers to the ways forms of oppressions intersect and overlap (Crenshaw, 1991; Collins, 2001). This lens aligns with PC's focus on social justice and helped to support a *Food Justice* concentration which consists of the following courses: *Food Justice*; *Food Systems;* and *Mobilizing Change*.

Course Design
The *Food Justice* course is a core course taken in the first semester of the students' master's degree program. Students who complete this course should be able to:

1. Understand historical, conceptual, and theoretical frameworks of food justice, and interpret the ways the

underlying institutionalized oppression have created such injustices.

2. Analyze foundational and emerging literature on industrialized and global food systems, food (in)justice, food sovereignty, food access.

3. Identify and critique elements of food production including human and animal labor and environmental injustices.

4. Examine contemporary socio-political movements through sustainable food system case studies from an anti-oppressive lens.

5. Develop a community-based project focused on a local (to the student) food justice issue.

To scaffold student learning and engagement for these five learning outcomes, this 8-week course is divided into four, 2-week sessions: (1) Foundational Concepts, (2) (In)justices of Food Production, (3) Decolonizing Food Justice and Indigenous Diets, and (4) Sustainable Food Systems: Exploration and Critique. Course learning outcomes and corresponding activities are assessed through authentic and formative assessment (Wiggins, 1990; Fook and Sidhu, 2010). Course assignments attempt to bridge asynchronous, online learning with Hyflex inspired teaching (Kyei-Blankson and Godwyll, 2010).

Course activities strive to foster critical thinking and develop higher order understanding of power and oppression that underpin complex problems within contemporary food systems. Greeson facilitates a learning community by creating spaces for students to engage with course content through peer-to-peer dialogue. Course activities include: asynchronous online dialogue; semi-synchronous small group virtual meetings; blog posts; and an experiential learning project.

Experiential learning projects grounded in social justice and place-based praxis can be difficult to implement during an 8-week block and in an online program, especially when students encounter the course during their first semester. To accommodate project timelines, students meet with the instructor and develop project proposals during the first 2 weeks of the course. Students with reciprocal relationships are encouraged to collaborate with their community on a project, while students with minimal to no relationships are counseled to use the assignment to examine their positionality and as an opportunity to build relationships. Every other week students reflect on their projects in the blog post assignment and with their small groups.

The *Food Justice* course was not only designed to introduce students to food justice movements but the course intentionally centered pedagogical frameworks cognizant of intersectional approaches to food justice and food justice education. The next section describes our pedagogical approaches and offers tangible ways these frameworks can be implemented in a graduate level course.

Pedagogical Frameworks

Pedagogical frameworks focused on a culturally sustaining pedagogy were central to the course design, learning outcomes, and content development. An anti-racist, anti-colonial culturally sustaining approach leads students to unpack their positionalities in relation to (in)justices within food systems and ensures multiple voices and perspectives are heard and represented in the syllabus (Paris and Alim, 2017; Alim et al., 2020). Informed by Tuck and Yang (2012), we use the word anti-colonial to shift the onus as settlers attempting to dismantle colonial structures in education (Tuck et al., 2014). In doing so, these pedagogical approaches seek to address the Eurocentric epistemological dominance and colonial structures of the academy including the erasure of Queer and BIPOC voices in sustainable food system projects and scholarship (Ramírez, 2014; Leslie, 2017, 2019).

Food systems educators can critically examine whose voices are prioritized in academia and consequently in course syllabi (Smith and Garrett-Scott, 2021; Smith et al., 2021). Some things for educators to consider in syllabi development: Whose voices are being included and excluded in the scholarly conversation? Are educators including scholars with marginalized identities and food justice activists? What perspectives are needed to deepen the conversation? This is particularly important in food justice education, where folks who are marginalized within the food system "beyond institutionalized racism and white privilege" including gender, ethnic, class, ability, and sexual differences (Sbicca 2012, p. 36) are leading activism work.

These pedagogical approaches invite students to share their thoughts and think critically about the material and topics by including multiple perspectives, learning styles, and ways of knowing. To reconfigure the politics of knowledge and center food justice activism, there was a concerted effort to largely include BIPOC authorship and decolonizing or Queer standpoints, and students were offered scholarly and non-scholarly sources including multiple resource formats (e.g., peer review journals, podcasts, art). In the course design, students were encouraged to view activists from marginalized identities as experts whose knowledge ought to be valued in the academy.

Posthumanism challenges human-centered narratives and colonial curricula (Barad, 2007; Braidotti, 2013, 2019; Bayley, 2018). The food justice movement and literature largely focus on human access to healthy, culturally appropriate foods; and human cost associated with inhumane working conditions in the food production industry (Gottlieb and Joshi, 2010; Food Chain Workers Alliance, 2012; Bauer and Stewart, 2013). This is appropriate, considering only 13.5% of all food workers surveyed reported earning a livable wage (Food Chain Workers Alliance, 2012). Despite the US's reliance on immigrant workers, H-2A program exploits and abuses non-citizens working within US food systems (Bauer and Stewart, 2013). Yet, liberation movements are increasingly called to understand the ways in which movements are not isolated from one another and that white supremacy and colonization underpin all forms of oppression. Ko argued Black liberation is inexplicably tied to animal rights, in that "our understanding of the world, our understanding of social categories, our understanding of ourselves have been birthed from a toxic, oppressive, colonized cultural womb" (Ko 2019, p. 17) and justice movements are underscored by white supremacy. Offering these counter-hegemonic narratives to dominant sustainable food system discourse allowed students to examine potentially harmful siloed thinking.

A post-humanist framework provides students with the opportunity to critically think about the anthropocentricity of justice work and the whiteness of alternative food movements (Breese, 2011). Specifically, incorporating literature on the more-than-human cost to contemporary food production (Stanescu, 2013) introduces students to the role more-than-humans play in traditional foodways such as traditional hunting and gathering (Kimmerer, 2013; Coté, 2016; Kagawa-Viviani et al., 2018). One of the four course sections (see section Course Design, above) centers Indigenous food sovereignty and decolonizing diets (Montgomery and Vaughan, 2018; Mihesuah, 2020). Students explored the ways Indigenous communities restore cultural knowledge and rights to determine their food systems. To consider the more-than-human interconnectedness in contemporary food systems is inherently tied to the decolonial project (see Salmón, 2000; TallBear, 2017), Indigenous food sovereignty, and perceptions of place as it relates to food and experiential learning projects.

Place-Based Experiential Learning Projects

The place-based experiential learning assignment asked students to develop and implement a project within students' communities (Harfitt and Chow, 2020). These projects are opportunities to anchor theory and content to real-world applications while integrating student-centered, interest driven learning, with critical place-based engagement (Gruenewald, 2003). Experiential learning reinforces critical thinking and provides students with depth and connection that otherwise might be challenging in online courses.

In this section, we reflect on student projects implemented both prior to and during the COVID19 pandemic. Teaching during a global pandemic—albeit in an online graduate program—shifted how we defined community engagement (Ramsey et al., 2020). We also recognize that these projects took place in communities all over the globe and will look different in different contexts. As such, instructors can support students by being emergent and reflexive. For example, in 2020, students developed projects that were mindful of social distancing restrictions to explore online communities or develop curriculum for communities of inquiry (**Supplementary Table 2**).

While experiential learning can be a powerful learning strategy in any course, it can be especially relevant for food justice-focused courses. These projects allow students to connect justice and activism with course content; however, often these projects might focus on communities marginalized by social and environmental injustices. Student-developed and implemented projects not only encourage students to engage and learn about their communities but also offer students opportunities to work toward being culturally responsive. It is through the project process that students begin to develop their academic identity, social justice eye, and community relationships.

Educators must guide students using social justice and culturally responsive teaching, to encourage students to work *with* communities (Freire, 2000; Rose and Paisley, 2012; Gallant et al., 2017). In one-on-one discussion with the instructor,

students were guided in project development, and reminded to be conscientious of white savior narratives and to listen with humility. Rather than approaching a community or organization with their project ideas but as a collaboration—educators might ask students to think about ways scholars/learners can center folks that are marginalized by asking how these projects could benefit them. What is particularly important for educators and students is to be thoughtful that we may be causing unintentional harm to already oppressed groups and to be mindful of extractive practices (e.g., learning outcomes; Stoecker, 2016). Students practiced critical reflexivity (Evans et al., 2013) in relation to course content through bi-weekly blog assignments. As a result, some students focused on building relationships with communities as a first step for future collaboration.

Supplementary Table 2 lists select project titles implemented by students prior to and during the COVID-19 pandemic. As summarized in their titles, project topics were wide in scope and entirely place-based and learner-interest driven. Often these projects were developed within the students' professional arena, such as the workshop developed for the *Agricultural Training Exchange Supporting Alaska Native Communitie*s and the undergraduate food justice curriculum written for *Food Justice: Education, Sustainability & Youth Engagement in Valencia College*. Projects conducted before the pandemic generally had more face-to-face community involvement while projects during the pandemic required more creativity and flexibility. Students utilized a variety of media to disseminate their projects including but not limited to creative videos, social media infographics, formal presentations, podcasts, websites, and scholarly papers.

DISCUSSION AND CONCLUSION

More SFS programs are being developed in higher education to address complex problems within our food systems, yet many of these programs do not directly espouse equity in their curricula (Valley et al., 2020). Explicitly centering justice and equity dismantles the inherent whiteness of the SFS movement (Alkon and Guthman, 2017) and "power asymmetries present in organizations and within communities" (Ramírez 2014, p. 748). From our perspective, this extends into educative practices in the academy as it relates to SFS. By employing an anti-racist, anti-colonial culturally sustaining framework, equity grounds both course content and design whereby power and privilege are thoughtfully considered and enacted. While we cannot in this paper present an in-depth analysis unpacking our pedagogical and theoretical approaches, we hope that offering an overview stirs SFS educators to approach their program structure and classes from a culturally sustaining lens because dismantling oppression starts in our classrooms (Gannon, 2020).

In the process of re-envisioning the MSFS program at PC, the program team intentionally integrated justice and community-oriented praxis into the curriculum at multiple levels. Through our experiences and recommendations, we

hope that other food systems educators might find tangible ways to center justice, and in turn help shape critical and accountable SFS professionals who will work toward dismantling systemic oppression. Finally, we recognize justice work is ongoing and requires active listening, humility, and self-reflection.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Prescott College IRB. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

KG: co-conceptualization, writing concentration and course level—original draft preparation and revisions. RC: co-conceptualization, IRB exemption application, and writing program level—original draft preparation and revisions. Both authors contributed to the article and approved the submitted version.

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Author Disclaimer: The paper describes the development of an academic program that RC directs and KG teaches within.

frontiers
in Sustainable Food Systems

Cultivating Pedagogy for Transformative Learning: A Decade of Undergraduate Agroecology Education

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Existing scholarship on agroecology and food systems education within U.S. colleges and universities has focused primarily on preparing students to be professionals working in agrifood systems. Developing students' skills and competencies, though vitally important, may not suffice for supporting transformative learning. Transformative learning shifts students' perceptions and awareness and informs future actions, constituting a potential avenue for leveraging education to support transformations toward more socially just and ecologically viable agrifood systems. It is unclear, however, what pedagogies and educational practices enable transformative learning. This paper explores the integration of multiple pedagogical innovations within an advanced agroecology course taught at the University of Vermont. Over a decade, the teaching team has made iterative adjustments to course content and pedagogies with the goal of catalyzing action toward transforming agrifood systems. In this paper, we evaluate our pedagogical approach, asking: (1) How well do course content and pedagogy align with our definition of transformative agroecology as transdisciplinary, participatory, action-oriented, and political? (2) How well does our approach enable transformative agroecological learning, and how is that identified? We present our course evaluation as a case study comprising qualitative analyses of course syllabi, student comments on University-administered course evaluations, and most significant change (MSC) reflections. MSC reflections proved to be a valuable method for identifying and assessing transformative learning. Through a curricular review, we found that substantial changes to course content and evaluative assignments between 2010 and 2020 align with a transformative approach to agroecology. This is validated in students' MSC reflections, which provide evidence of transformative learning. In sharing evaluative results, processes, and insights, we aim to contribute to a broader movement of

scholar educators committed to iteratively and collaboratively developing transformative pedagogies within agroecology and sustainable food system education. We contend that reflexive practice among educators is necessary to leverage education for transforming agrifood systems.

INTRODUCTION

Courses and degree programs related to sustainable agriculture and food systems are becoming increasingly common throughout North America (Parr et al., 2007; Galt et al., 2012; Jordan et al., 2014; David and Bell, 2018). The rising popularity of sustainable agriculture and food systems education (SFSE) is in part a response to the complex and interwoven social-ecological problems created by industrial agrifood systems (Meek and Tarlau, 2016). Agroecology programs are a popular subset within the diverse courses and degree programs that comprise SFSE (Fernandez et al., 2013; Runck et al., 2015; David and Bell, 2018).

Agroecology is commonly understood to have three dimensions: scientific inquiry, on-farm practices, and social movements (Wezel et al., 2009). Many scholars, practitioners, and activists now emphasize explicitly transformative agroecology that attends to issues of power, agency, equity, and ecological renewal (Anderson and Anderson, 2020). We define transformative agroecology as a transdisciplinary, participatory, action-oriented, and political approach to working toward socially just and ecologically sound agrifood systems. This integrates previous work by Méndez et al. (2013) and González De Molina (2013) on the systems and structures that shape relationships, knowledge, and power within agrifood systems. As in participatory action research processes (Méndez et al., 2017), reflexive practice is necessary to grapple both individually and collectively with the complexity of a transformative approach to agroecology. Reflexive practice allows producers, consumers, researchers, activists, students, and educators to continually and critically assess the impacts of positionality on transformative endeavors.

Transformative agroecology requires distinct approaches to teaching and learning (Anderson and Anderson, 2020). Pedagogical approaches within agroecology education have important implications for which types of knowledge are valued. This, in turn, has important implications for transformation and transition processes (Anderson et al., 2019b). Anderson and Anderson (2020) highlight recent work exploring pedagogy to support transformative agroecology learning, but none of the cited work explores higher education in the U.S. To date, existing scholarship on agroecology pedagogy within U.S. colleges and universities has focused primarily on cultivating students to be future professionals working in agrifood systems (e.g., Runck et al., 2015). Developing students' skills and competencies, though vitally important, may not suffice for supporting transformative learning.

The concept and theory of transformative learning was originally introduced by Mezirow (1978) and Mezirow (1991). Transformative learning entails a shift in a student's frame of reference. Drawing on social constructivist theory, Mezirow's theory of transformative learning suggests that meaning is constructed through experience and reflection (Probst et al., 2019). As a result, transformative learning aligns with experiential approaches to education (Cranton, 1994). Designing learning opportunities that support students in reflecting on their own positionality within food systems, and then facilitating engagement with selected components of their own local food system serve as mechanisms for leveraging higher education to transform agrifood systems. Although scholar-educators exploring agroecology and SFS education cite Mezirow's theory of transformative education (e.g., Galt et al., 2013b; Migliorini and Lieblein, 2016), to date there has been limited explicit consideration of specific pedagogies for transformative learning as defined above. Questions remain regarding how to both identify and assess transformative learning within agroecology and SFS education. What pedagogies facilitate transformative learning? More broadly, how can agroecology education support broader processes of agroecological transformations in the U.S.?

These questions inspired our evaluation of an advanced undergraduate agroecology course offered at the University of Vermont. Over the past decade, course instructors (incl. Méndez, Izzo, Faulkner, Caswell, Horner, and Kinnebrew) have made iterative adjustments to the course in response to emerging research on effective pedagogy for sustainability and critical food systems education. This includes integrating critical reflection, student leadership, and teamwork with several high-impact educational practices (Kuh, 2008) such as experiential- and service-learning and student participation in a long-term participatory action research (PAR) project. Changes to course pedagogy and content have been intentionally cultivated to catalyze action toward transforming agrifood systems.

In this article, we employ case study methods to critically assess this iterative approach to transformative agroecology education within a U.S. institution of higher education. To gain a holistic understanding of how evolving course pedagogy contributes to the broader goals of transformative agroecology, we used the following questions to guide our evaluation: How well do course content and pedagogy align with our definition of transformative agroecology as transdisciplinary, participatory, action-oriented, and political?; and, to what extent does our approach enable transformative agroecological learning, and how is that identified? We also explore an innovative evaluative method to identify and assess transformative learning. Our

analysis indicates that experiential learning on farms, peer-to-peer learning, teamwork, and reflection all contributed to transformative learning experiences for students.

Reflexive practice amongst scholar-educators, as well as critical and iterative course evaluation, are necessary to align pedagogy with transformative agroecology. This article aims to contribute to the ongoing work of exploring the complex connections among pedagogy, transformative student learning, and collective struggles to realize viable and equitable agrifood systems.

OVERVIEW OF AGROECOLOGY AND SUSTAINABLE FOOD SYSTEMS EDUCATION

There are few scholarly articles exploring formal agroecology education and effective pedagogy in the U.S. context. By contrast, there is a robust body of scholarship on SFSE and attendant pedagogies, which provides valuable commentary on extant efforts to design effective courses and degree programs. We briefly review this scholarship with an eye toward identifying the goals of SFSE, the pedagogical approaches employed to achieve those goals, and the methods for evaluating pedagogical efficacy. We then compare the goals, pedagogies, and evaluative methods of SFSE with the smaller body of work on formal U.S. agroecology education. Finally, we identify knowledge gaps related to pedagogy for transformative agroecology learning; this provides the context within which we situate our course evaluation.

Recent SFSE scholarship has focused primarily on identifying key pedagogies for cultivating students' professional capacity to address "wicked problems" within food systems (e.g., Jordan et al., 2005; Galt et al., 2012; Ebel et al., 2020; Francis et al., 2020). Trends within this scholarship are synthesized by Valley et al. (2018), who propose a signature pedagogy for SFSE (SFSESP). They identify four major pedagogical themes comprising a SFSESP: systems thinking; multi-, inter-, and trans-disciplinarity; experiential learning; and participation in collective action projects. Valley et al. (2018) propose that a signature pedagogy framework can be used to identify approaches for educating future professionals working within agrifood systems.

The professional framing of Valley et al.'s (2018) SFSESP builds on earlier work emphasizing competency development within SFSE. Galt et al. (2013a) proposed a focal shift from content to student skill development, arguing this will support a future generation of professionals capable of tackling "wicked problems." Within this competency framework, values-based pedagogy (Galt et al., 2012) and critical pedagogy are presented as building blocks in the development of a skilled workforce. The concept of educating for professional skills and competencies remains central in recent SFSE scholarship (Ebel et al., 2020; Valley et al., 2020) as well as broader calls for a sustainable food systems workforce (Carlisle et al., 2019).

While the signature pedagogy and competency frameworks highlighted above focus on cultivating students' professional capacity, Meek and Tarlau's (2016) framework for critical food systems education (CFSE) offers a more political approach focused on developing students' transgressive subjectivities. They argue that rather than focusing exclusively on students' understanding of food systems complexity, education and innovative pedagogies should be leveraged to support agrifood systems transformation. In proposing their CFSE framework, Meek and Tarlau (2016) contend that there is a tension between these two educational paradigms. Rather than being mutually exclusive, however, Meek and Tarlau advocate for complementarity between professional and transformational approaches to food systems education. They propose integrating innovative pedagogies from SFSE with critical insights and pedagogies rooted in grassroots movements and popular education. Despite the potential of this integrated approach to food systems education, the CFSE framework remains underutilized within scholarship proposing and analyzing food systems pedagogy in the U.S. (Classens et al., 2021 are a notable exception). More frequent use of signature pedagogy and competency frameworks within this body of work is further indication of an educational approach oriented toward professionalization rather than transformation.

The limited scholarship on agroecology education also focuses on skills and competencies. In an early review of an undergraduate agroecology course, Jordan et al. (2005) identify service-learning as a valuable pedagogical tool for applying systems thinking. The service component of the course was framed as an attempt to cultivate a sense of civic professionalism, defined by the authors as "professionals who orient work to projects of civic innovation and renewal." Similarly, Runck et al. (2015) propose an extended classroom framework integrating systems action education with adventure learning to develop students' capacity to tackle "wicked problems." Within agroecology education, capacity building is defined as "the process used in education to improve students' abilities to work effectively with challenges they will face in agriculture and food systems development and research programs" (Francis et al., 2012). Capacity building aligns with the competency frameworks guiding SFSE and suggests a focus on agroecology education as an avenue for professionalization.

Of the articles we reviewed that examine formal agroecology education in the U.S., only one aligned with a more transformative approach to agroecology education. Code (2017) explores research methods and experiences driving the design, development, and delivery of innovative agroecology pedagogy. In their analysis, they argue that epistemological innovations must be included as a component of pedagogical innovations within agroecology education. The author defines epistemological innovations as ways of knowing beyond Western scientific inquiry, disciplinary education, and systems thinking. Instead, Code (2017) advocates for pedagogical approaches that emphasize the relational, contextual, and experiential foundations of knowledge. They contend that attending to epistemological innovations within agroecology education is necessary for transformation toward more holistic ways of knowing that encompass the full complexity of agroecosystems. Expanding the types of knowledge included enables agroecology education to contribute to what the author terms "paradigmatic change," in addition to cultivating skillful future professionals.

This aligns with Meek and Tarlau's (2016) proposal for complementarity between professional and transformational approaches to food systems education. Code (2017) does not explicitly espouse transformative agroecology or transformative learning, though their insights on the interconnections between epistemology and pedagogy imply a holistic and equity-oriented approach to agroecology education that aligns with transformative agroecology.

In exploring the development of pedagogical innovations within agroecology education, Code (2017) reviews a subset of the scholarship focused on agroecology pedagogy within the U.S. and Europe. Their review demonstrates the dominance of the Norwegian graduate program within the agroecology pedagogy literature. Although scholar-educators involved in the Norwegian Master's program have developed and shared formative insights on agroecology education, their work emerges from a unique context. As a result, it may not translate fully to undergraduate courses in North America. This suggests the need for further research on pedagogical innovations and their efficacy in U.S. institutions of higher education.

Classens et al. (2021) note that scholarship has largely overlooked how the pedagogical approaches and efficacy of SFSE are mediated by the institutional conditions within which teaching and learning occur. Specifically, Classens et al. (2021) review how the neoliberalization of higher education has contributed to a focus on "education as a tool for the reproduction of a globally competitive workforce." The authors argue that CFSE must attend to the diverse institutional conditions of colleges and universities in order to contribute to agrifood systems transformation.

Based on our review, it is evident that there are many shared goals and pedagogical approaches across SFSE and agroecology education. With some notable exceptions (e.g, Galt et al., 2013b; Code, 2017; Classens et al., 2021), much of the scholarship exploring food systems and agroecology education emphasizes education as a tool for professionalization. This common goal translates into common pedagogical practices. Experiential education, action education, inter- or trans-disciplinarity, and systems thinking are emphasized across the literatures. In addition to pedagogical overlap, there is a commonly identified need for more dynamic evaluative methods and long-term research on student learning experiences to assess the efficacy of innovative pedagogies within agroecology and SFS education (Galt et al., 2012; Code, 2017; Valley et al., 2018).

The need for evaluations of pedagogical efficacy must be considered alongside the specific and possibly competing goals of agroecology and SFS education (Meek and Tarlau, 2016). Courses and programs designed to train future professionals may have distinct pedagogies when compared to courses or programs focused on transformative learning. Where goals and pedagogical approach differ, so too will methods for evaluating pedagogical efficacy. There is a need for scholarship exploring how professional and transformative approaches to agroecology and SFS education can be integrated, and how to evaluate the efficacy of this integrated approach. To date, however, there has been relatively little attention paid to transformative learning in agroecology or SFSE scholarship. Assessments of effective pedagogies for transformative learning constitutes a vital next step for agroecology and SFS education.

We situate our course evaluation within these gaps in the scholarship on SFS and agroecology education. In evaluating the evolution of our course pedagogy over time, we explore how to align pedagogy with transformative agroecology and introduce a novel evaluative methodology for identifying and assessing transformative learning.

METHODS

Interactions between course design and student learning constitute complex social processes. To attempt to make sense of this complexity, we integrated multiple analytical methods and data sources within our process of course evaluation. Our methods follow a non-experimental, interpretive, and retroactive case study approach. Case studies have previously been useful in course evaluations that seek to explore relationships between student learning and course pedagogy in the context of food systems education (Galt et al., 2013b). The case study method also aligns with the concept of "agroecological lighthouses" (Altieri, 1999), which have been described as examples "from which agroecological principles radiate out" (Nicholls and Altieri, 2018).

We begin with a description of the course, which provides important context for the ensuing analysis and discussion. We then provide an overview of the data sources and analytical methods employed to evaluate various aspects of course design. Our analysis includes two components. First, we conduct a curricular review based on syllabi from the past 10 years. Second, we share results of thematic analysis of student evaluations over the same 10-year period as well as student reflections from the most recent iteration of the course, which took place from September through December 2020.

Case Study Context

The University of Vermont is a Land Grant university located in Burlington, Vermont. The Advanced Agroecology course has been taught in the Plant & Soil Science Department since 2008.

The course is required for undergraduate students studying Agroecology. It is also popular with students in the Food Systems and Environmental Studies programs, who consistently constitute about 50% of the class. The course is usually composed of third- and fourth-year undergraduate students and a few graduate students.

Advanced Agroecology holds twice weekly lectures and a weekly 3-hour lab. There are typically five lab sections, and each section is paired with a local farm. In 2020, however, we worked with three partner farms after one farmer partner retired and another farm was unable to host students during the Covid-19 pandemic. The three farms we partnered with in 2020 include: an urban collective farm focused on annual vegetable production, a peri-urban diversified livestock-vegetable operation, and a working educational farm affiliated with the University.

We use the term "farm teams" in this course to foster the sense that each lab section constitutes its own micro learning community. Over the course of the semester, the farm teams

spend most labs at their partner farm. As of 2018 the Advanced Agroecology course also includes undergraduate agroecology research fellows (UARFs) who function as farm team captains, providing peer leadership. This role requires liaising with farmer partners, coordinating use of shared lab equipment, and organizing peers for on-farm lab activities.

Curricular Review

To explore the extent to which course design aligns with the tenets of transformative agroecology, we conducted a curricular review of the course over a ten-year period. Curricular reviews can identify key pedagogical themes across multiple curricula (Valley et al., 2018). We began by qualitatively identifying course learning objectives, teaching methods, assigned content, and evaluative assignments as presented in course syllabi from 2010 to 2020. This process enabled comparative analysis of how course design and pedagogy have evolved over time. We then employed content analysis to identify focal topics and prominent voices within assigned materials and compared content analyses from 2010 and 2020 to identify changes over time.

The curricular review was guided by the tenets of transformative agroecology. We considered whose voices were represented in assigned materials, where those voices were located, and whether course materials, focal topics, teaching methods, and evaluative assignments aligned with a transdisciplinary, participatory, action-oriented, and political approach to agrifood systems transformation.

Thematic Analysis

To evaluate the efficacy of course pedagogy for transformative learning, we conducted thematic analyses of open-ended student comments in end-of-semester course evaluations as well as student reflective essays submitted at the end of the 2020 course. Prior research indicates that conventional course evaluations are not well suited for assessing student-centered instruction, problem-based learning, and complex learning (Frick et al., 2010). Open-ended evaluative comments do, however, provide insight into students' experience of the course over time. To address the limitations of student evaluations, we integrated a most significant change (MSC) reflection. In the MSC reflections, students responded to a prompt asking them to identify the most significant change in their thinking about agrifood systems during the course. MSC methodology was developed by Dart and Davies (2003) as a holistic, participatory tool for evaluating development projects. Moving beyond evaluation of pre-defined outcome metrics or indicators, MSC techniques allow individuals most impacted by an intervention to share their experiences in a holistic manner. In an educational setting, MSC techniques require critical reflection on the outcomes or changes experienced through participation in a project or course (Choy and Lidstone, 2013). Acton (2019) notes that inclusion of MSC techniques facilitates student self-reflection on their own educational experiences.

All student evaluations and MSC essays were uploaded to *NVivo* 1.4.1 and coded. We used sensitizing concepts related to our research questions to guide the initial analysis (Bowen, 2006). Charmaz (2003) posits that "sensitizing concepts offer ways of seeing, organizing, and understanding experience." Within grounded theory research, sensitizing concepts are used as a foundation for analysis. Initial sensitizing concepts of transformative agroecology and transformative learning guided the first phase of coding for both the student evaluations and the MSC essays.

In developing initial codes, we used a constant-comparative method. This analytical approach entails constantly comparing data during the process(es) of coding (Leech and Onwuegbuzie, 2007). This process also enabled us to identify linkages between data sources. We grouped initial codes of student evaluations and MSC essays to identify major themes relevant to our course evaluation (Creswell, 2013). We identified a unique set of themes for the two data sets, but we compare these themes, along with results from the curricular review, within our discussion. Themes provided a frame for making sense of students' learning and transformation in relationship to course pedagogy.

The final step of our thematic analyses entailed "member checking" our results (Creswell, 2013) with individuals who were students in the course. Sharing findings with individuals who have intimate knowledge of the case being studied is an important method for validating interpretative case study analysis (Yin, 2013). These prior students all served as farm team captains in their role as UARFs. As a result, they carried unique insight into the experiences of their peers. We asked the students if thematic analyses of student evaluations and MSC reflections resonated with both their own experiences and with the informal feedback they received from their farm teams. They validated our analyses and provided critical feedback that helped us better represent the full complexity of student experiences. Confirming our analyses with prior students, integrating multiple data sources, and applying multiple analytical methods enabled a more holistic evaluation of course pedagogy and student learning.

RESULTS

First, we present findings on the curricular review, focusing specifically on the aspects of course pedagogy that have evolved substantially in the past 10 years. After analyzing the evolving curricular context, we present thematic analysis of institutional student evaluations over the same 10-year period. Finally, we turn to the MSC essays to identify themes across students' transformative learning experiences. This section focuses disproportionately on students' 2020 MSC essays. Due to the nature of the prompt, these essays yielded an extremely rich source of data on how course content and design supported transformative learning. Additionally, as the most recent students to have taken the course, this content presents the most relevant means of assessing the efficacy of current pedagogy for supporting transformative learning.

Curricular Review

In our review of syllabi from 2010 to 2020, we identified six aspects of course pedagogy that we deem central to course design and intended student learning. These include course learning objectives, the evolution of a collaborative and transdisciplinary

TABLE 1 | Learning and teaching outcomes (LTOs) as listed in course syllabi.

	2010	2020
LTO 1	Students become familiar with current research and applied concepts and applications within the field of agroecology.	Students become familiar with current research and applied concepts and applications within the field of agroecology.
LTO 2	Through hands-on field and *laboratory* exercises in local farming systems, students learn ecological and social research and analytical skills, which are commonly used in agroecology and agrifood systems research.	Through hands-on field exercises in local farming systems, students learn *practical*, ecological and social research and analytical skills, which are commonly used in agroecology and agrifood systems research.
LTO 3	Students practice working in groups.	Students practice working in groups.
LTO 4	Students practice their critical thinking and communication skills throughout the course by participating in discussions and preparing written and visual material.	Students practice their critical thinking, *reflection* and communication skills throughout the course by participating in discussions and preparing written and visual material.

Changes are italicized. Despite substantial changes to course content and pedagogy, there is little substantive change in the learning outcomes guiding the course.

teaching team, the integration of the course with a long-term PAR project, the integration of undergraduate agroecology research fellows (UARFs), assigned content, and student-led discussions (SLDs).

The learning objectives of the course essentially remained unchanged despite the multiple changes implemented in response to both student feedback and emerging research. Between 2010 and 2020, "practical skills" and "reflection skills" were added to course learning objectives (**Table 1**).

The earliest pedagogical shift is the introduction of teaching team members. Initially the course was taught by Professor Méndez. Over time, Méndez incorporated multiple faculty collaborators whose work aligned with the expanding course content and focal topics. The creation of a teaching team co-evolved with the formalization of farmer partners' role in the course *via* integration of a long-term PAR project started in 2017. The PAR process was formalized to integrate on-farm research in a way that was beneficial to both student learners and farmer partners. As a pedagogical tool, PAR leverages student learning to support farmers' management processes. The PAR project also created greater coherence between the service-learning and soil science research components of the course, insofar as initial weeks of service-learning enabled relationship- and trust-building foundations for engagement between farmers and students within the PAR project. Shifting to a PAR approach also required greater reflexive practice among the teaching team as we collectively navigated iterative cycles of service-learning and research. This complemented a growing emphasis on reflexive practice in the curriculum as evidenced by reflective essay

assignments and in-class reflective exercises (**Figure 1**). Through this work instructors sought to engage students in thinking about their previous and current experiences and their connections to food, the food system, and the agroecological content of the course.

The integration of a long-term PAR project with the course necessitated additional support for managing the considerable logistical challenges of coordinating not only five lab sections, but also five partner farms. To address this challenge, instructors incorporated UARFs to liaise with farmer partners and provide peer leadership within farm teams. The integration of UARFs was also designed to align with course learning objectives and key pedagogies that emphasize peer-to-peer learning.

We conducted content analysis on all assigned materials and evaluative assignments. We found a marked shift in both the agroecological topics and sources highlighted within course materials from 2010 to 2020 (**Figure 2**). This finding aligned with qualitative coding of the syllabus, which revealed a transition from a predominant emphasis on agroecological science and practices toward greater inclusion of food sovereignty, social movements, and PAR.

We also identified substantial changes in the evaluative assignments required of students over the past decade. Although SLDs occupied one out of two weekly lectures in 2010, this decreased to five SLDs over the course of the semester in 2020. SLDs provided a chance for students to assume the role of teacher and to learn from peers, disrupting the traditional student-teacher hierarchy and top-down model of knowledge transfer (Anderson and McLachlan, 2016). The semester-long research paper was substituted for a shorter assignment with greater creative license granted to students, who were able to choose between a blog post and a research brief. Providing choice within both course materials and evaluative assignments pushed students to reflect on what types of learning suit their learning goals and preferences. Student choice regarding assignments also evidences a more participatory pedagogy designed to facilitate students' sense of agency within their education. The introduction of reflective essays also demonstrates a transdisciplinary pedagogy that seeks to integrate multiple types of knowledge as well as students' past experiences, beliefs, and values within course learning.

Student Evaluations

Across 10 years of formal student evaluations administered through the University, we identified three major themes: experiential learning, peer-to-peer learning, and critiques of course design.

Since 2010, student evaluations have clearly demonstrated widespread appreciation for on-farm learning. Students' on-farm experiences evolved over the years from a service-learning and soil sampling lab hybrid to a combination of service learning and PAR. Student evaluations consistently emphasize the power of hands-on learning from farmers, with a distinct emphasis on the service-learning portion of the course. Despite the integration of a long-term PAR project, students do not explicitly mention participating in the PAR project as a valuable component of experiential learning.
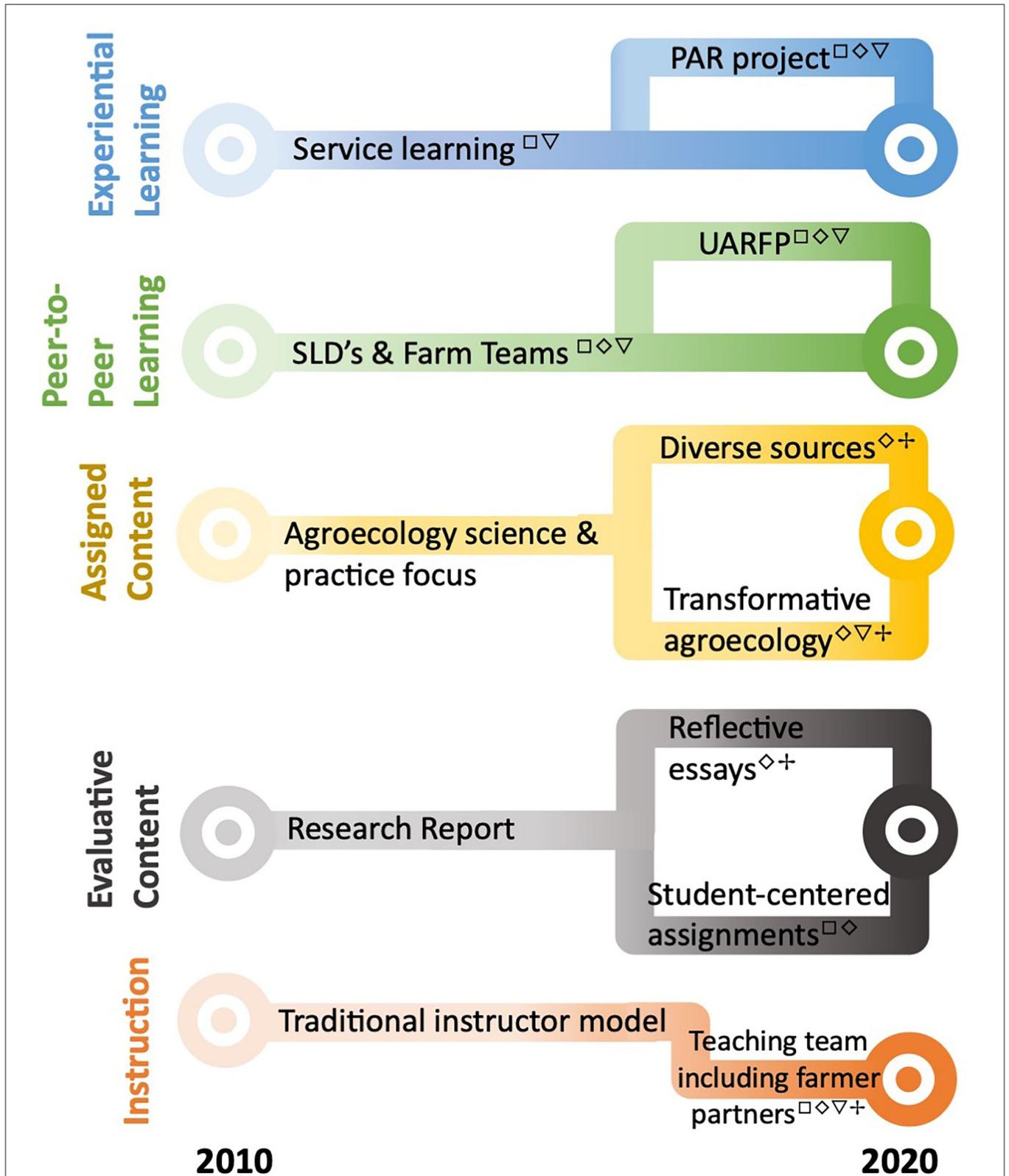
FIGURE 1 | This highlights the evolution of course pedagogy from 2010 to 2020. Major course components are grouped into pedagogical elements to provide a sense for how all elements of course pedagogy have co-evolved. The color saturation gradient represents the intentional shift over time toward pedagogies more aligned with a transformative approach to agroecology. Superscripts indicate the tenets of transformative agroecology supported by each pedagogical innovation: □—Participatory, ◇—Transdisciplinary, ▽—Action-oriented, +—Political.

FIGURE 2 | Comparative content analysis of assigned course materials in 2010 and 2020. The size of sub-rectangles represents the quantity of sources of that type in the respective year's syllabus. Gray Literature includes policy briefs, research briefs, and content from popular books and news print sources. "Other sources" includes movement manifestos and encyclopedia entries. *New in the 2020 syllabus.

In addition to hands-on learning on farms, students emphasized the value of peer-to-peer learning. Student evaluations indicate widespread appreciation for student-led discussions. Students reported high levels of course engagement when preparing SLDs with their farm teams and learning from their peers when other groups led discussions. Although course

redesigns decreased the number of student-led discussions over the years, reported appreciation of SLDs increased. The year in which students most commonly and forcefully emphasized the value of SLDs was the first year of the UARF program. As part of their fellowship, UARFs took a lead role in coordinating SLDs, which may explain the particularly forceful emphasis on SLDs as an important site of peer-to-peer learning.

Despite appreciation of experiential and horizontal learning, student evaluations presented substantial critiques of course design. Many student critiques were constructive, such as a 2020 student's suggestion to further highlight and honor indigenous knowledge and spiritual ways of knowing. More frequently, students identified frustrations and deficits with course content. Three consistent critiques appeared across all 10 years. First, students expressed a desire for more emphasis on local examples of agroecology and were frustrated by the emphasis on Latin American case studies in lectures. Second, students cited frustration with the theoretical or abstract content presented in lectures. Specifically, students expressed a desire for less emphasis on PAR, social movements, and the political aspects of agroecology. This ties into students' desire for more practical "how-to" content, which constitutes the third major critique that appeared across the years. Students' interest in hands-on learning over distant case studies lends credence to a central argument of transformative agroecology: that theory and practice mutually complement one other when theory is built out of practical dilemmas. It is not necessarily a less political agroecology that students seek, but rather one built out of their experiences and the cognitive-emotive complex. The fact that, as students in lab, there is no reason to "struggle" for access to seeds, water, or land can make the more overtly political aspects of the course less tangible. These critiques also imply a disconnect between lectures and lab; students struggle to understand their on-farm experiences as exposure to local agroecological practices constrained and shaped by social, political, and environmental forces.

Despite offering feedback on student satisfaction with key components of course design, survey comments did not provide indications of transformative learning. Responses focused on what students enjoyed, and more often on what was lacking or frustrating regarding course design. Survey responses can inform instructors' iterative redesign of course materials and pedagogies but offer little insight into how these changes influence student learning outcomes.

MSC Reflections

Our analysis of student MSC essays revealed five categories of transformative learning during the most recent 2020 semester. The transformative learning categories include student empowerment, relationship-building, learning related to social justice, systems thinking, and transdisciplinary learning. These categories capture forceful themes within the students' reflective essays on their most significant learning during the semester. These categories also include references from all 25 of the essays considered.

Due to the nature of the writing prompt, nearly all students identified one or more areas of transformative learning during their engagement with the Advanced Agroecology

course. Although in certain instances students self-identified their learning as transformative, it was more common that interpretation was required. We interpreted instances in which students expressed shifts in perspective and consciousness or awareness as indicative of transformative learning.

Empowerment

Students' perceptions of their roles and responsibilities within agrifood systems changed in multiples ways as a result of taking this course. We identified three sub-themes that capture students' sense of empowerment in contributing to agroecological transformations: shifting consumer identities, increased self-efficacy, and future visioning.

Multiple students viewed their learning through the lens of consumer identity. These students reported developing a deeper awareness of their responsibilities as consumers alongside increased capacity to make ethical consumer choices. For example, one student wrote, "I have gained confidence as a consumer because I feel I am more aware of the food system I am a part of, which can help me make more informed decisions." Other students echoed this sentiment, confirming that their learning in the course enabled them to become more "sustainable" consumers. These statements indicate a degree of personal transformation as students become aware of their embeddedness within agrifood systems.

Other students, however, demonstrated what Anderson et al. (2019b) term "more-than-consumer" consciousness, which implies awareness of the political implications of consumers' decisions and role(s) within agrifood systems. For some students, this shift in consciousness was deeply personal, as with one student who wrote, "I know that what I have learned in this class will be the beginning of my process of reconnecting with the food that I eat." For others, their more-than-consumer consciousness extended outward:

> By being able to critically address the issues of food sovereignty within our food systems, as well as being able to recognize the role of agroecology in politics and as a social movement, I truly became aware of my duty as a student to speak up and fight against the social, environmental, and political injustices of our time.

This student experienced a shift in their understanding of the "duty" they have to engage with agrifood systems beyond the role of consumer.

The perception of personal responsibility and capacity to participate in agrifood systems as more than a consumer aligns with an increased sense of self-efficacy evident in many student essays. One student reported that through learning about the political dimensions and implications of agroecology, they perceived that they could have an impact in agroecological movements. This student went on to share a new commitment to participating in local politics. Others similarly communicated intentions to mobilize their learning from the course to participate in social movements related to agriculture, food, and racial justice more broadly.

For other students, increased self-efficacy was framed in a more internal way. One student reflected,

"As the semester draws to a close, I realize that the experiences and lessons I learned through [Advanced Agroecology] have allowed me to recognize my strengths as a student and the possibilities for expanding this role well beyond just an academic setting." This reflected a transformation in the student's perception of themselves and their capacities. Another student similarly reflected on the leadership role they assumed in their group, noting "I really have not identified myself as a leader in much of my life. However, working on the farm made me question why I don't see myself fitting in those shoes." Through their experience working with peers on their partner farm, this student began to perceive their leadership capacity and question why they had not previously identified as a leader.

Finally, multiple students communicated an intention to utilize the skills and knowledge gained through the course in their future endeavors. For some students, the experience of service learning on partner farms affirmed or strengthened a preexisting desire to work in agriculture. For example, one student reflected, "I feel grounded in the fact that what I've learned from this class, combined with everything I've learned outside of it, will help me do the work I always knew I was meant to do, the work of fighting for a just world through... food." Other students, however, directly connected their learning in the course to changes in their perceived capacity to integrate agroecology into their professional futures. One student noted that "Advanced Agroecology has enlightened me with future career pathways and skills that I didn't realize that I was capable of." This demonstrates how course content can transform students' plans and perceptions of the possible.

Social Justice Learning

Nearly all (20 out of 25) student essays connected their learning in the course to an enhanced awareness of social justice issues. Within this category, we identified three subthemes that captured the range of students' transformative learning related to social justice: systemic racism within food systems, collective action, and critical consciousness. Considered together, student reflections indicated that when course pedagogy pushes students to consider issues of justice and equity, it enables students to connect the ecological and social-political dimensions of agroecology.

Several students explicitly named systemic racism as one of the social justice issues entangled with agrifood systems. Many students related their learning in the course to a heightened awareness of racial inequities, exploitation, and oppression. As one student explained,

> Racial justice goes right along with food justice and agroecology, because our food system is racialized. To practice agroecology should also mean to fight for racial and social justice of all kinds, because they all intersect–we cannot solve one of these issues without solving the other.

In communicating their learning, awareness, and engagement with issues related to racial justice, students demonstrate the application of Freirean praxis, which Meek and Tarlau (2016) define as a dialectic between learning and taking

action "to change the inequitable social, economic, political, and agricultural systems that shape our lives". Indeed, several students shared the ways in which their learning in the course motivated them to engage directly with social justice projects and movements. One student connected their participation in Black Lives Matter protests and political engagement with their new capacity to "critically [apply] what [they] learned in this course to recognize the importance of valuing the ecological knowledge and practices of various cultures, knowledge systems, and disciplines."

In learning about the social-political dimensions of agroecology, many students reported a transformed understanding of the role of social movements, grassroots organizing, and collective action in realizing sustainable agrifood systems. For instance, one student reflected that "after gaining a better understanding of agroecology as a movement, I would suggest the movement is at least equally as important as practices and principles, if not more important." Another student reflected on their "newfound recognition that farmers can be active agents of transformative change in a food system, rather than solely responsive to and restricted by market forces and policies." These statements demonstrate enhanced awareness of the power of collective action and grassroots organizing for change within agrifood systems.

Some students framed their perception of social movements in more deeply personal terms, such as one student who stated that their new understanding "of how social movements function and why they are necessary in agroecology... changed the way I think about the world and my role in it." Another student went a step further in reflecting on how their learning transformed their perception of the role of collective action in creating viable agrifood systems:

> I've realized that maybe focusing on my own situation and my family's farm is not going to achieve much, and that I would probably fail by myself. The interconnectedness and prevalence of agriculture across our societies forces any transition in food systems to be undertaken by whole communities that can support themselves and not by individuals fighting their own "good fight."

These quotes demonstrate the powerful linkages across social justice learning, self-efficacy, and systems thinking as students' awareness of the social-political dimensions of agrifood systems transforms their perceptions of their roles and responsibilities in working toward sustainability.

Finally, many students demonstrated development of a critical consciousness. General statements regarding the impacts of globalization and neoliberal trade agreements on peasant and rural livelihoods indicated critical consciousness of the intersection of agrifood systems and international political economy. Many students also explicitly reflected on their increased awareness of the inequities stemming from capitalism and industrial agriculture.

> If anything has changed this semester, it has been my thinking around capitalism. It has never been so apparent to me the ways in which it hurts so many members of our society. While

agroecology can be a solution within this system, I don't think it can reach its full extent with farming corporations ruling our food system.

This example demonstrates that not only did students develop critical consciousness through course pedagogy, but they were also then able to apply that critical consciousness to their understanding of agroecological transformations.

As with earlier sub-themes, some students developed their critical consciousness in more personal terms. For example, one student reflected that how gender operates within agrifood systems had become a topic of increasing interest and importance. It is interesting to note, however, that despite a vast majority of female students, the intersection of gender and equity within agrifood systems was not a prominent theme. More students focused on critical analysis of economic and racial inequities. In reflecting on their social justice learning, students integrated multiple aspects of course pedagogy, from their discussions with farmer partners, to lectures, student-led discussions, and assigned content related to food sovereignty and food justice.

Systems Thinking

Critical consciousness often develops alongside systems thinking capacity. As students become more aware of the systems and structures that (re)produce inequities and injustices, they are better able to consider the full social-ecological complexity of agrifood systems. Systems thinking is evidenced by students grappling with complexity, identifying the interdependence of social and ecological dimensions of sustainability, and perceiving their embeddedness within agrifood systems.

For many students, increased awareness of and engagement with social justice and food sovereignty movements led to shifting perception of what constitutes sustainable agriculture. One student reflected,

> What a grower does day-to-day, I thought, was the backbone of agroecology. But after discussing the Declaration of Nyéléni, I realized that to study agroecology as a whole is not just to study agriculture. It is a whole philosophy on global food systems made to support growers' livelihoods, food sovereignty, and living in harmony with nature.

While some students came to perceive the social-ecological interweaving of agroecology through assigned material and discussions, other students did so through their on-farm experiences. For example, one student reflected, "I had never considered that a farm could have much of an impact beyond the soil they grow on and the surrounding ecosystem." After spending time on their partner farm during labs, this student came to see that farms play a vital role in supporting communities and preserving culture. Other students noted that both readings and farmer conversations around livelihoods and PAR expanded their awareness of the social components of sustainable agrifood systems.

The process of grappling with the full complexity of agrifood systems was not always a comfortable one for students. Many

students reflected on ways in which they perceived their prior education to be lacking. For example, one student noted that their previous courses "oversimplified the life of a farmer" in ways that promoted an incomplete understanding of agrifood systems. In reflecting on their learning in the course, another student wondered, "How can agroecology work within the system to create change? How can two sets of conflicting values, agroecological principles and agricultural production that exists within a capitalist society, manage to create some change within the system?" Asking complex questions can lead to frustration when no simple answers are possible, but the process of considering such questions is indicative of complex systems thinking and is vital for agroecological transformation.

Relationship Building

While systems thinking often arose in conjunction with learning about social movements and justice, systems thinking also developed alongside student perceptions of the importance of relationships in agroecology. Interactions with peers, the teaching team, farmers, and the farms fostered new relational awareness. As one student put it, "It was the people and the conversations that have helped me to grow throughout the course of the semester." In exploring student learning tied to relationship building, we identified three sub-themes: appreciation for cooperative agriculture, appreciation for community, and relational processes of horizontal learning.

Multiple students reported a change in their perception of farming as a communal or community-building endeavor. One student reflected, "I always perceived farmers as being more profit oriented and worrying about the market prices and whatnot. However, [our partner farmers] revealed that their priorities lie in their community's needs." This is representative of students' shifting awareness of the ways in which farms play important roles in supporting and building communities.

Students also reflected on the ways in which cooperative approaches to agriculture benefited farmers. On one farm a student noted, "in the same way my lab group aided me this semester, it is [the farm's] collaboration of perspectives, thoughts, and ideas that helps them continuously improve." On another farm, a student reflected that over the course of the semester she became aware that farming "is something that I truly believe one cannot do on their own… farming is also an experience that I believe should be shared between people and allows for unique and strong connections." Despite differing partner farm business models, students from all farm teams reflected on the community-wide relevance of agroecology.

Students also shifted how they personally related to the concept of community within the context of agroecology. One student reflected "I really loved working with people who were just as passionate about learning and growing as I was, and it helped us not only grow food well, but also foster community well, something that felt especially important during this time of Coronavirus." Interacting with peers and farmers during lab periods enabled students to engage in learning about agroecology in the context of building relationships. This experience fed back into transformative learning, as students were able to

identify the power of relationships for realizing agroecological transformations. For example, a student reflected that,

> Through my involvement in our class, my farm team, and Catamount Farms I have found belonging and community in a way that lacked in my previous experiences. Fundamentally, finding a sense of belonging through active involvement is a principle that I will use going forward as I look to influence change and build relationships in my future.

Service learning on farms enabled students to build relationships with both peers and farmers. These relationships, rooted in place, enhanced student learning regarding the relational nature of agroecology and transformative processes.

One way that relationship-building enhanced student learning was by enabling peer-to-peer or horizontal learning. Multiple students noted the power of learning with and from their peers. In reflecting on their learning experience within their lab group, one student shared appreciation for the diverse backgrounds of their peers and the "excellent perspectives, thoughts, and ideas" they added to the on-farm learning portion of the class. For some, these experiences led them to shift their understanding of who can be an educator and how learning happens. One student noted, "So much valuable knowledge is shared and considered when done through horizontal learning that my past classes failed to teach me." Experiences cultivating and learning in community settings, in which peers and farmers became important sources of knowledge, expanded students' notions of the purpose and processes of education and transformative learning.

Transdisciplinary Learning

This was the most forceful category we identified in the students' reflective essays. We identified transdisciplinary learning through both explicit and implicit language related to critical learning that transgressed traditional boundaries that define higher education courses. Through this process, we identified three sub-themes of transdisciplinary learning: expanding perceptions of education, epistemological plurality, and critical reflection. Across these sub-themes, students emphasized the power of experiential learning and the ways in which course pedagogy enabled learning beyond academic disciplines.

The experiential education students received on their partner farms during weekly lab periods provided the primary pathway to transformative transdisciplinary learning. For many, this experience contributed to an expanded sense of the purpose and sites of agroecological learning. After a semester of on-farm learning, one student reflected, "I changed my attitude toward education. No longer was I there to check off a box so I could get somewhere I actually wanted to be. I was there to be present and observe what was happening around me." While for this student, the process of expanding their conceptualization of education entailed intimate connection with place, for others the process was more fraught. One student recalled,

> Heading into this agroecology class, I was so excited to learn more interesting facts—what plants are best intercropped with one another? How do growers control pests ecologically? Instead,

I was met with nebulous theory, philosophy, and paradigm, which actively worked to undo my thorough grasp of the world.

Transdisciplinary learning may require students to unlearn in order to learn, and this can be a disorienting and uncomfortable process.

Transdisciplinary learning requires students to reflectively make sense of complex experiences and diverse knowledges, and to integrate this learning with past experiences and personal values or beliefs. Students demonstrated critical reflection in both explicit and implicit ways. For example, one student continually related course content back to where they grew up, noting that prior to the course, "[their] own reflections have always been focused in looking at alternatives to corn and soybean that can be just as profitable or just as pragmatic to implement." In reflecting on course content, however, they shifted their perception of agrifood systems in their home country. Another student similarly shared, "several of the things we studied I connected with my previous experiences, creating both nuance and a deeper knowledge."

Reflecting on their experiences and learning expanded students' perception of valid knowledge beyond the Western, academic delimitation. Course pedagogy was designed to support epistemological plurality, with students learning from farmers and being exposed to diverse perspectives and knowledge sources in assigned materials. Student reflections demonstrated how the diversity of course content and pedagogies interacted to align the course with agroecological principles of epistemic plurality: "I was intrigued by this term [*diálogo de saberes*] when I first heard it in

Ernesto's lecture, but it was not fully illustrated for me until I witnessed [our partner farm] carrying it out." In this example, a student understands the concept of *diálogo de saberes* ("dialogue of knowledges") by contextualizing it within their on-farm experiences. At a different farm, a student similarly reflected,

> The class was an illuminating example of how different ways of knowing can interact and collaborate. For example, while we conducted soil tests with standardized instruments, [our partner farmer] explained that [they] wear sandals in order to feel the textures, humidity, the slope and other physical factors of the soil.

Through the integration of lectures, discussions, reflections, soil sampling, PAR, and experiential learning on farms, students are exposed to multiple ways of doing, learning, and knowing agroecology.

DISCUSSION

Our evaluation reveals that the Advanced Agroecology course has evolved toward a more inclusive pedagogical approach that aligns with our definition of transformative agroecology and effectively facilitates transformational learning (**Figure 1**).

Lessons Learned From Ongoing Curricular Review

Our analysis of course content demonstrated the importance of ongoing review and a willingness to update pedagogical techniques over time. In our course, changes to course content, and assignments promoted greater student agency. This aligns with broader efforts to cultivate more inclusive and transdisciplinary pedagogies that do not maintain a dominant emphasis on scholarly research and Western, scientific knowledge (Quaye and Harper, 2007; Posselt et al., 2019). Highlighting diverse knowledge sources and supporting varied learning styles also enable dialogue across multiple ways of knowing (Anderson and Anderson, 2020) and reflect the turn toward more transdisciplinary and holistic framings of agroecology (Mason et al., 2020).

Expanded opportunities for student agency complemented the increasingly diverse set of course materials. Encouraging student agency in course design contributes to a more participatory approach to agroecology education. This aligns with both a core tenet of transformative agroecology and with calls to expand student roles in developing agroecology education (Lieblein et al., 2012; Francis et al., 2016; Code, 2017). We see evidence of the efficacy of this participatory approach to agroecology education in the MSC reflections, in which student empowerment emerged as a forceful theme. For students accustomed to traditional Western higher education, however, the shift to a more student-centered learning process may be inherently uncomfortable (Lieblein et al., 2012; Hooks, 2014; Jordan et al., 2014; Francis et al., 2020). The potential for student frustration and discomfort when presented with greater agency in their own learning process indicates a need to build more resources and time into curricula to navigate these challenges.

PAR projects require more extensive and deeper use of reflexive practice within the course, encouraging students to reflect both in the classroom and as part of the PAR process. In their farm teams, students must navigate the inevitable unexpected bumps of participatory, applied research on working farms. Integrating reflection, research, and on-farm actions, PAR may be a way of simultaneously enabling transformative student learning and leveraging university education as a site of AE transformation toward equitable agrifood systems. This could be explored as a reinterpretation of the dual ladder approach (Francis et al., 2016) in which individual student learning occurs concurrently alongside broader, collective learning that transgresses traditional educational boundaries. Despite the challenges of integrating long-term research and undergraduate education, our course evaluation indicates that PAR holds unique promise as a pedagogical approach for transformative agroecology education.

Introducing multiple changes in course content and pedagogy would not be possible without the simultaneous shift to a teaching team model. The teaching team model diffuses the increased workload required to implement context-based and student-centered pedagogies while also bringing multiple perspectives and skillsets to cultivate a participatory and transdisciplinary learning environment. The teaching team model also provides instructors with the community support needed to navigate the many institutional roadblocks to implementing innovative pedagogies within the confines of a neoliberal university context (Anderson and McLachlan, 2016; Classens et al., 2021).

Participatory Pedagogy Is Powerful

Students appreciation of experiential learning on farms coheres with scholarship advocating for contextual, place-based learning within agroecology education (Porter et al., 2015; Code, 2017; David and Bell, 2018; Fernández González et al., 2021). Students' reports of integrating experiential and abstract learning are particularly important in addressing the ontological reversal that defines much of the theory-centric pedagogy within institutions of higher education. Francis et al. (2016) argue that a phenomenological approach to agroecology education is necessary to resituate lifeworld phenomena as the foundation for theoretical, model-based, or conceptual understanding. Considered in this context, experiential learning may support transformative learning by shifting students' perceptions of both learning processes and the validity of lived experience as a foundational source of knowledge (Francis et al., 2016). Experiential learning is intrinsically tied to transdisciplinarity (Francis et al., 2013), which further suggests transformative agroecology learning.

In the classroom, SLDs and collaboration within farm teams facilitated participatory learning, which is a core component of transformative agroecology education. Participatory pedagogies engage students as both learners *and* teachers, contributing to an educational space that works to dismantle hierarchies between knowers and learners (Lieblein et al., 2012; Code, 2017). In this sense, participatory pedagogies that integrate instructor-led and student-led lessons seem vital for transformative agroecology education.

As we suspected, course evaluations did not enable us to definitively answer our guiding question regarding the efficacy of course pedagogy for transformative learning. Nevertheless, student evaluations did provide insight into how students experienced course pedagogy. This enabled us to infer which pedagogies and student experiences may support specific aspects of transformative agroecology learning. Course evaluations also identified aspects of course pedagogy that are particularly frustrating, overwhelming, or unclear for students. This highlights opportunities for providing additional support for students to enable transformative learning from within a zone of discomfort (Galt et al., 2013b). In this way, despite deficiencies, course evaluations can be a meaningful component of both iterative course design and instructor praxis.

MSC Reflections Capture Transformative Learning

Integrated in the course for the first time in 2020, MSC reflections proved to be a valuable method for identifying and assessing transformative learning. Thematic analysis identified 5 dimensions of transformative learning: student empowerment, relationship-building, social justice learning, systems thinking, and transdisciplinary learning. Below we explore the connections

between course pedagogy and these dimensions of transformative learning. We also situate these connections in the broader context of agroecology and SFS education.

Empowerment theory (Gutierrez, 1995) suggests that by changing students' attitudes and beliefs, transformative learning may facilitate or encourage students to participate in collective action for social change (Allen, 2008). In analyzing students' MSC reflections, many linked an increased sense of empowerment and self-efficacy to a new commitment to engaging in social movements. In other instances, students connected a sense of empowerment to their future careers, expressing expanded potential to engage in professional endeavors thanks to course learning. Comparing these learning outcomes suggest there may be different layers of transformative learning. Valley et al. (2018) discuss three levels of impact in proposing their SFSESP. Our course evaluation suggests that further research is needed to explore when and how deeper transformative learning occurs that facilitates student empowerment to engage in collective action and social movements committed to agrifood systems transformation.

Engagement with issues related to social justice constituted a distinct dimension of transformative learning. Many students reflected that course learning prompted them to engage with social movements and grassroots organizing. While some students were drawn to agrifood systems issues and movements specifically, others translated their course learning and experiences into broader engagement with justice and equity, such as the movement for Black lives. A smaller handful of students discussed how course content on food sovereignty invoked a sense of responsibility to engage in equity-oriented work within future professional endeavors in food systems. This demonstrates that students in agroecology and SFS courses may apply learning in both professional and non-professional capacities, such as engagement with social movements. The potential for students to apply social justice learning beyond professional contexts is underexplored in recent scholarship on the intersection of SFSE and equity. Like SFSE in general, an equity competency model recently proposed by Valley et al. (2020) is designed to "support the development of future professionals capable of dismantling inequity in the food system." Although Valley et al. (2020) identify profoundly important educational goals and pedagogies related to equity and justice within agroecology and SFS education, our analysis suggests that the professional framing of their equity competency model may limit or obscure important non-professional learning outcomes.

Moving beyond a primarily professional framing to consider the broader impacts of agroecology and food systems education aligns with a whole systems approach. Systems thinking is frequently cited as vital for learning about agrifood systems (Code, 2017; Valley et al., 2018; Francis, 2020).

Thematic analysis of students' MSC reflections validates these assertions, identifying systems thinking as a key dimension of transformative learning. In attempting to further understand the role of systems thinking for transformative agroecology education, we consider Code's (2017) contention that systems thinking is an insufficient paradigm for developing students' ability to engage with the full complexity of agroecosystems.

Code (2017) cites Bortoft (1996) critique of systems science, which highlights the paradox of breaking down living systems into artificially distinct elements in order to identify linkages. In lieu of this approach, Code (2017) draws on Schumacher (1995) proposal for a scientific paradigm of "life in its wholeness." Yet, our identification of systems thinking within students' MSC reflections aligns with this concept of a science of wholeness, suggesting that systems thinking may carry multiple meanings within agroecology and SFS education. Clarifying what is meant by "systems thinking" is imperative for developing pedagogies conducive to transformative learning.

The critique of systems thinking aligns with our findings that relationship-building is an important dimension of transformative agroecology learning. Based on thematic analysis of MSC reflections, we propose that relationship-building is a vital complement for systems thinking in agroecology education. Many students reflected on the impact that relationships had on their learning about agroecosystems. Students emphasized that the relationships they cultivated with peers and farmers during the course demonstrated the power of horizontal learning and co-production of knowledge. Based on our course evaluation, the role of relationship-building and horizontal learning as transformative pedagogies within higher education institutions warrants further exploration.

Relationship-building also enabled and reinforced transdisciplinary learning, the final dimension of transformative learning that we identified. Student reflections explored how cultivating relationships with peers and farmers transformed their perception of when, where, how, and with whom teaching and learning occur. Experiential learning on farms transgressed traditional disciplinary boundaries and provided a context for students to experience the value and necessity of integrating multiple ways of knowing within agroecosystems. Opportunities for critical reflection enabled students to integrate transdisciplinary learning within the course with their previous experiences, values, and beliefs.

Critical reflection is consistently identified as a key pedagogical tool for agroecology education (e.g., Runck et al., 2015; Francis et al., 2016; Code, 2017). In the most recent iteration of our advanced agroecology course, we expanded the role of reflection *via* the partial application of MSC methodology. The MSC reflection proved to be a valuable tool for both transformative learning and holistic course evaluation. Reflections provided rich data on student learning outcomes and enabled critical assessment of how well course materials and pedagogies supported transformative learning. Our experience adapting the MSC methodology echoes prior research in proposing MSC techniques as valuable evaluative tools in educational contexts (Choy and Lidstone (2013)). A more complete application of the method would engage students in participatory evaluation of the MSC reflections to collectively identify the MSC experienced by the class as a whole. This evaluative strategy would align with recent calls to redefine the role of students within agroecology and SFS education (Code, 2017). MSC methods also align with a more participatory agroecology pedagogy promoted by scholar-educators in Norway (Lieblein et al., 2012). As a

reflective, relational, and participatory method of evaluation, MSC techniques are particularly well-suited to identifying and supporting transformative learning (Choy and Lidstone, 2013; Acton, 2019).

We concur with Meek and Tarlau (2016) that Agroecology sustainable food system education can and should be leveraged to transform agrifood systems toward justice and ecological viability. Beyond training a workforce capable of engaging with agrifood systems as they currently exist, education provides a venue for forming individuals capable of supporting such transformations. This is evident in the concept of *formación* that guides popular education initiatives led by social movements in Latin America. *Formación* corresponds to training or educating toward a transformative purpose (McCune et al., 2017). Formal agroecology and sustainable food system education in the U.S. can serve a similar role, providing liminal spaces that expose students to alternatives to the oppressive and extractive systems in which they are embedded. In this way, agroecology courses may constitute a "domain of transformation" (Anderson et al., 2019a) where agroecology overlaps and interfaces with the dominant regime— in this case, neoliberal institutions and traditional "knowledge transfer" approaches to agricultural education. In domains of transformation, there are simultaneously factors that enable *and* disable transformative processes; the reality of the latter does not inherently negate the potential of the former (*ibid*). The tension of teaching transformative agroecology from within the academy may also be clarified through the lens of non-reformist reforms, which prefigure transformation *via* smaller shifts that cumulatively enable broader change (Gorz, 1967). Viewed in this way, courses that facilitate transformative learning may cultivate young adults who, at best, are prepared to stand in solidarity with collective struggles for transforming agrifood systems toward justice and equity, and who, at a minimum, are more aware of -and thus more open to- alternatives to the dominant, industrial agrifood system. By contributing to a shift in whose knowledge and expertise are valued, transformative agroecology education also contributes to thick legitimacy for agroecology more broadly (Montenegro de Wit et al., 2016).

Additional Considerations

This paper evaluates an agroecology course taught in the Northeastern U.S. and is intended to assess and improve student learning. The goal of sharing evaluative results, processes, and insights is to contribute to a broader movement of scholar-educators committed to iteratively and collaboratively developing transformative pedagogies within Agroecology sustainable food system education (Galt et al., 2013b). To that end, we find it necessary to identify unique factors that call for further consideration and evaluation, both within our own course and in the design and evaluation of other courses.

First, the integration of the course with a long-term PAR project conducted in collaboration with multiple farmer partners results in a diversity of students' on-farm learning experiences. Over the years, course instructors intentionally engaged a diversity of farmers and farm types to expose students to the multiple manifestations of agroecological practice. This also provided an opportunity for peer-to-peer learning as students were able to share their experiences with students assigned to other farms. In the context of evaluating transformative learning, however, the range of students' on-farm experiences may impact student learning. In future iterations of course evaluation, assessing student learning grouped by farm teams may provide insight into whether some farm experiences are more conducive to certain types of learning.

Second, a substantial portion of our evaluation was based on MSC reflections submitted by the most recent cohort of students who took the course in fall semester 2020. The course took place as the world was weathering a deadly pandemic and the U.S. was experiencing widespread protests of racial injustice. Amidst this extraordinary backdrop, it is possible that students were more open to certain kinds of learning. For example, multiple students protested police violence and participated in the movement for Black lives. These experiences likely influenced student learning, contextualizing course materials and pedagogies designed to encourage collective action for social justice. The influence of current events on students' lives and learning highlights the importance of reflexive practice for situating learning and learners within the world beyond the classroom.

Finally, the questions guiding our course evaluation focused explicitly on identifying and assessing transformative learning. This enabled us to deeply explore the alignment of both course pedagogy and student learning with a transformative approach to agroecology. At the same time, however, we did not dive deeply into the full spectrum of student experiences. Future work could integrate assessments of transformative learning within a broader exploration of student experience and outcomes.

CONCLUSION

In evaluating transformative learning, we observed and reflected on the ways that agroecology education transcends professional preparation to shift students' perceptions of agrifood systems and their place within them. Yet U.S.-based agroecology and food systems scholarship tends to focus on cultivating students as food systems professionals. The reasons for this are multifaceted and complex, and hence difficult to resolve. They include western scientific epistemologies that reject transformation as part of their mission, tension with the neoliberal bent of many universities, and the reluctance of instructors to engage with what could be perceived as political or activist content. Our course, which applies many of the same pedagogical innovations currently leveraged for professionalization, suggests that transformative learning is occurring. This is particularly important in the context of undergraduate education. Many undergraduate students may not go on to work as professionals within food systems, and those who do may need different skills and competencies in the future than those currently emphasized in agroecology and sustainable food system courses and programs. Expanding educational goals and evaluative methods will enable scholar-educators to identify and unpack the

deeper impacts of innovative food systems education currently practiced in multiple pockets throughout the U.S.

Cycles of critical, collective reflection have informed our conceptualization of the purpose of agroecology education which, in turn, informs our pedagogical approach. We perceive education as a critical component of transformative agroecology more broadly. We therefore seek to align course pedagogy and student learning with the tenets of transformative agroecology as we understand it: transdisciplinary, participatory, action-oriented, and political. A teaching team model serves as the foundation supporting our pedagogical approach, which is built around a framework of experiential learning on farms. As a foundation for the rest of the course, the identities and structure of the teaching team matter greatly. Including farmers and graduate students models a more inclusive and transdisciplinary approach that contributes to dismantling traditional hierarchies of knowledge and expertise. Future work should explore how teaching teams form, interact, and mediate pedagogy and student learning.

Innovations in pedagogy require synergistic innovations in evaluative methods. Traditional course evaluations administered by colleges and universities do not provide opportunities for in-depth, critical reflection on individuals' learning outcomes Choy and Lidstone (2013). To address the deficiency of standard course evaluations, we complemented 10 years of student comments on university evaluations with most significant change (MSC) reflections. MSC methods are uniquely capable of identifying unintended, complex, and diverse outcomes of a program or intervention and provide a means of qualifying and dignifying anecdotal evidence of transformative impacts (Dart and Davies, 2003). MSC holds potential as an evaluative method aligned with transformative agroecological goals to democratize knowledge and dismantle top-down educational approaches that impose predetermined evaluative metrics.

Our analysis of student MSC reflections indicates that agroecology education can contribute to developing students' political subjectivities as actors embedded within agrifood systems. This suggests the need to critically explore the purpose(s) of agroecology and SFS education beyond professionalization. We propose that a key goal of agroecology education is one of ontologically reembedding students within agroecosystems and cultivating their identities as more-than-consumers (Anderson et al., 2019b). Emphasizing an ontology of interconnectedness (Vargas Roncancio et al., 2019) will further enable agroecology education to explore power and responsibility beyond the false binary of producers and consumers and will encourage students to examine the roles of relationships, solidarity, and sovereignty movements within food systems.

We contend that agroecology education can be an important site for movement building. As noted above, students may develop expanded political consciousness and a sense of self-efficacy that spur engagement with struggles to realize socially and ecologically sustainable food systems. We also support and expand on Galt et al.'s (2013b) proposal for a movement of sustainable food systems educators. Our case study demonstrates the importance of the teaching team model as a foundation for implementing pedagogies for transformative learning. Collaboration and solidarity amongst instructors implementing innovative pedagogies may function as a compass in navigating the many challenges to designing and implementing courses and programs capable of contributing to broader processes of agroecological transformation.

DATA AVAILABILITY STATEMENT

The data analyzed in this study is subject to the following licenses/restrictions: We analyzed student essays and student evaluations as part of a course evaluation to improve course design and student learning. Student work is not publicly available. Course syllabi are available upon request. Requests to access these datasets should be directed to Catherine E. Horner, chorner@uvm.edu.

AUTHOR CONTRIBUTIONS

CH led the acquisition of data, data anlaysis, and drafting of the manuscript. NC and CM contributed to writing and revising the manuscript and provided critical feedback on multiple drafts. NC, CH, and KN created all figures. KN, TM, MC, EK, JF, VI, VM, SL, and NM provided substantial contributions to the conception and design of the work and provided substantive critical feedback on multiple drafts, improving the intellectual quality of the work. All authors contributed to data interpretation and revisions.

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Developing a Functional Food Systems Literacy for Interdisciplinary Dynamic Learning Networks

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The impact of human activity on the planet cannot be overstated. Food systems are at the centre of a tangled web of interactions affecting all life. They are a complex nexus that directly and indirectly affects, and is affected by, a diverse set of social, environmental and technological phenomena. The complexity and often intractability of these interactions have created a variety of food-related problems that people seek to address in a collaborative and interdisciplinary manner through the adoption of a holistic food systems perspective. However, operationalising a systemic approach to address food system challenges is not a guarantee of success or positive outcomes. This is largely due to the partiality inherent in taking a systems perspective, and the difficulty in communicating these different perspectives among stakeholders. A functional food systems literacy is therefore required to aid people in communicating and collaborating on food system problems within dynamic learning networks. The Interdisciplinary Food Systems Teaching and Learning (IFSTAL) programme has been operating since 2015 as a social learning system to develop a food systems pedagogy with a range of multi-sectoral partners. The findings in this paper arise out of iterative reflexive practice into our teaching approach and delivery methods by former and current staff. In order to foster integrative engagement on food system challenges, we propose and define a functional food systems literacy—a theoretical minimum that can aid diverse stakeholders to explore and intervene in food systems through more effective communication and collaboration. Derived from a reflective analysis of instruments and methods in delivering the IFSTAL programme, we provide a framework that disaggregates functional food systems literacy according to four knowledge types, and includes examples of skills and activities utilised in the IFSTAL programme to support learning in these different domains. We argue that claims to comprehensive food systems

knowledge are unrealistic and therefore propose that a functional food systems literacy should focus on providing a means of navigating partial claims to knowledge and uncertainty as well as fostering effective collaboration. We believe that this will enhance the capabilities of stakeholders to work effectively within dynamic learning networks.

INTRODUCTION

As a basic human need, food is at the centre of many complex webs of interaction and activity, which affect all life on the planet (Rockström et al., 2020). These webs of food-focused activity can be described as "food systems," which the Food and Agricultural Organisation (FAO) considers to "encompass the entire range of actors and their interlinked value-adding activities involved in the production, aggregation, processing, distribution, consumption and disposal of food products that originate from agriculture, forestry or fisheries, and parts of the broader economic, societal and natural environments in which they are embedded" (FAO, 2018). These activities are often distilled down to four basic steps of (i) producing, (ii) processing, (iii) packaging and distributing; and (iv) retailing and consuming food; waste and disposal may also be considered (Ingram, 2011). These activities lead to a set of outcomes that include food and nutritional security, environmental sustainability, and socio-economic well-being. What is crucial is that these activities have variable and undesirable outcomes, an activity that may be "good" for food security, may also benefit other socioeconomic and/or environmental outcomes, or conversely it may be detrimental to them.

There are numerous representations of food systems depending on the observer and their individual framings that may change over time [e.g., GECAFS, 2005; Ingram, 2011, 2020; Stuckler and Nestle, 2012; Gustafson et al., 2014; Tendall et al., 2015; Parsons and Hawkes, 2018; Global Panel, 2020; SAM (Scientific Advice Mechanism), 2020; Kennedy et al., 2021]. The number of components, processes, and range of interactions between parts of a food system and other subsystems give rise to complex behaviours (Ingram, 2011; Tendall et al., 2015), but also make it difficult to analyse synergies and trade-offs (Ingram, 2011), communicate what a food system is, and even what a person means by the term. Difficulty in describing and explaining food systems is further compounded by trying to plan, coordinate and implement intervention strategies potentially across multiple scales and diverse stakeholder groupings (Ingram, 2011). Because a person can only ever see a partial representation of the system, and people have different skills, capabilities and interests, there is a tendency to work in silos, generating unintended consequences and missing genuine system-based solutions. So far, a siloed way of working and learning has led to a food system that is vulnerable and greatly impacted by extreme events, such as severe weather, earthquakes, and pandemics (Gaupp, 2020). The food system's size and reach mean that it has major impacts on the economy, society, politics, health and the environment (Lang

et al., 2009). Profit is commonly a major driver at all levels of operation (Stuckler and Nestle, 2012; Sanderson Bellamy, 2018), but is often counteracted by new rules, norms and regulations or social movements and boycotts that aim to promote a healthier and more sustainable system. Nevertheless, ongoing systemic problems like food insecurity, public health, and climate change continue to worsen.

To link people in the food system and expand knowledge collectively in a more holistic manner, different ways of learning are needed to give people the tools and skills to tackle food system challenges. These needs have been clearly recognised and described by several groups of authors, such as Ericksen (2008), Ingram (2011), Ison and Straw (2020), Ingram (2020), Krathwohl (2002), and Valley et al. (2018). Scientists, researchers, policymakers, and citizens are seeking to address food system challenges in a collaborative and interdisciplinary manner through adopting a holistic food systems perspective (Tu et al., 2019). "Interdisciplinary learning" is different from "integrative learning". The latter entails generating a curriculum and working environment where students can integrate their learning and make connections across different contexts and time periods (Huber and Hutchings, 2004). Interdisciplinary learning, in contrast, is a way for learners to understand multiple sources of knowledge (e.g., from different disciplines and areas) and find a way to integrate them to generate understanding and new knowledge. Typical competences to be achieved are an ability to synthesise, an appreciation of diverse perspectives, and flexible, critical thinking. While several interdisciplinary learning programmes exist for topics such as health and water, food systems present a wider cross-sectoral challenge that cannot be covered by one discipline or institution alone. Institutional structures often have established knowledge silos (Ebel et al., 2020) with theoretical concepts and specialisms in distinct areas of the food system. There are further challenges for institutions to integrate experiential learning and workplace or sector knowledge into their programmes, which are known to provide relevant and meaningful learning opportunities (Parr and Trexler, 2011). The latter are essential in transdisciplinary learning, where knowledge from all areas of a system is integrated and linked to real-life challenges, and learners ensure that the knowledge produced is valuable to a wide range of actors within the system (Tàbara and Chabay, 2013).

Co-production of learning programmes with actors in the food system, and the appreciation of other types of knowledge beyond academic knowledge are emerging as two practical and ethical principles to achieve food system sustainability (Ison, 1990; Francis et al., 2013). However, operationalising a food

systems approach to address food system challenges is not a guarantee of success or positive outcomes. This is largely due to the partiality inherent in taking a systems perspective, and the difficulty in communicating these different perspectives among stakeholders. Simply incorporating diverse stakeholder perspectives is not enough to plug knowledge gaps and studies need to go further than simply describing generic food systems' constituent parts and relationships as outlined in food systems frameworks such as GECAFS (2005) or SUSFANS (Gustafson et al., 2014). These gaps need to be bridged by ensuring that anybody working in the food system can be food systems literate, i.e., have a basic set of skills and knowledge that can facilitate effective interdisciplinary approaches. Such a food systems literacy needs to build on an innate systemic sensibility (Ison and Straw, 2020)—the ability to be aware of and engage in relational thinking. This is distinct from literacy as a technical competence, or food literacy that tends to focus on strengthening dietary resilience over time (Truman et al., 2017). A functional food systems literacy is required to aid people in communicating and collaborating on food system problems within dynamic learning networks. These are networks "formally or informally set up for the primary purpose of enabling any kind of learning to take place over the time for building capabilities, managing change [...]" and have the ability to adapt their learning based on changing needs (Romano and Secundo, 2009, p. 6). The learning targets are defined by the network, adaptation mechanisms exist, boundaries for participation are defined, and network structures enable participative learning (Romano and Secundo, 2009).

While everybody working in food systems should have opportunities to acquire a food systems literacy, the obvious starting point for food system education is the existing education system. Early knowledge acquisition benefits people throughout their careers (Allen and van der Velden, 2009). Increasingly, tertiary educators, particularly in the fields of sustainable agriculture, environmental sciences and health are calling for pedagogies that are interdisciplinary, co-creational, problem solving and skills-based, and include systems thinking approaches which aim to develop learners into competent change agents (Galt et al., 2013; Reed et al., 2017; Brekken et al., 2018; Carr et al., 2018; Klaassen, 2018; Valley et al., 2018; Ingram et al., 2020). Whilst there is no one framework for achieving this, sharing best practice facilitates learning across disciplines and institutions. To foster integrative and effective engagement on food system challenges we propose to define a functional food systems literacy—a theoretical minimum that can aid diverse stakeholders to explore and intervene in food systems through more effective communication, mutual understanding and collaboration.

We provide a framework that disaggregates functional food systems literacy according to four knowledge types (Krathwohl, 2002) and include examples of skills and activities that can be used to support learning in these different domains. While the proposed literacy has been developed specifically for food systems, its core elements can be customised to support stakeholder collaboration on other complex adaptive systems. With these goals in mind, this paper is structured as follows. The section A Framework for Food Systems Literacy—a Functional Minimum elaborates on our proposed framework for food systems literacy, setting out the four forms of knowledge on which the idea is based. The section Developing Food Systems Literacy—the Example of the IFSTAL Programme provides an example of this framework in action by using the example of the Interdisciplinary Food Systems Teaching and Learning (IFSTAL) programme, working with hundreds of postgraduate students from across seven different UK higher education institutions between 2015 and the present day. This section also covers the method followed to assess the evaluation of IFSTAL activities against the food systems literacy framework proposed. The section Discussion reflects and draws conclusions on the key learning points from our experience of running the IFSTAL programme in terms of the extent to which it has engaged with, and enhanced, different forms of knowledge about the food system.

A FRAMEWORK FOR FOOD SYSTEMS LITERACY—A FUNCTIONAL MINIMUM

Valley et al. (2018) observed that a food systems pedagogy should disrupt the usual ways of learning and acquiring knowledge, and question how knowledge is being generated, who holds it and how it is evaluated. Further, they stated that students should have a good awareness of their skills and different cultures of learning and knowing, be able to discuss the limitations of academic knowledge, and embrace and handle pluralism. These are also important cornerstones of transdisciplinarity, where multiple sources of knowledge and experience are used to co-produce new knowledge, usually focusing on challenges of the real world, and using collaborative processes that include actors from government, industry, NGOs, academia and the wider society. Because of the combination of different perspectives and integration of knowledge across actors and sectors, a high level of reflectiveness is also required.

In considering food systems, we are confronted with a vast domain of different knowledges, disciplines, facts, constituent parts, relationships, and competing perspectives and priorities (Cabrera et al., 2008). Food systems can therefore be confusing to navigate, especially when we consider that, as humans, we are not omniscient or omnipotent—there are limits to what we as individuals can know or do. It can be helpful to think of these limits in the following terms:

1. *Limited knowledge*—we cannot know the totality of the potential information of any given food system we choose to define (Ulrich, 1993).
2. *Limited cognition* (processing and bias)—of the information that we do know, we can only consider a limited range of information in our working memory (7 ± 2) (Miller, 1956), much of which is subject to bias and processing errors (Haselton et al., 2015).
3. *Limited agency* (ability to intervene)—depending on the individual or organisation, there are limited degrees of freedom with which to intervene in a system, and even

then the desired end result may still not be realised (Otto et al., 2020)[1].

These limitations exist whether we like or choose to engage with them or not. Each of the three limitations points to a need to collaborate and communicate well with others. If we have incomplete knowledge, we should engage with others who can help us to fill in the picture. If we are uncertain about our cognition, we need to check its congruity with others. If we are to overcome our individual limited agency we need to work well with others in the food system to effect change.

Given that our individual understanding of food systems can only ever be partial, when we try to communicate with other people about food systems, we find that we might not be referring to the same thing (Midgley, 2000). People may use the term "food system" in a variety of different ways:

- **1**—they refer to *the* food system, but what they really mean is the food system that appears to them - a composite of information derived from their personal and professional histories and worldview.
- **0**—they believe there to be no such thing as a truly knowable food system, so the term, as it is commonly used, is at best meaningless and, at worst, potentially misleading.
- **∞**—they understand that there are as many different possible food systems as there are minds to perceive them, and perspectives or viewpoints to selectively present them.

While all three positions are potentially valid, if we are to use the food system term, we have to find a way to accommodate these differences in order to arrive at a shared understanding of what we are talking about or referring to. In systems thinking, this is referred to as the interrogation of boundary judgements through the process of boundary critique (Ulrich, 1996, p. 15; Helfgott, 2018, p. 855). Boundary judgements involve making explicit to all concerned the facts and values that are to be considered, and those to be left out of the system in question (*Ibid.*). It also involves recognising and declaring the positionality of all relevant stakeholders who are analysing and attempting to intervene in the system, or who will be affected by the intervention.

Building on the definition of systems literacy (Ison and Straw, 2020) as "the extent to which systems concepts, traditions, methods, and approaches are appreciated and understood by a practitioner", we define food systems literacy as the degree of competence that an individual has with respect to analysing, communicating about and intervening in food systems. This definition implies that there is a scale of literacy with a minimal set of criteria denoting a functional food systems literacy, or minimal level of competence, at one end and a high degree of capability or expertise at the other.

A food systems literacy is functional if it allows individuals to understand and engage in food system analysis and intervention activities with others. In order to do this, and foster collaboration, participants need to understand that different people see the food system differently and have their own ways of navigating this

intersubjectivity. This understanding is particularly important for diffuse networks of food system actors to coordinate and cooperate with each other. The food systems literacy enables transdisciplinary work and collaboration across food systems to support food system change.

Given the limitations and partiality involved in thinking about food systems, a functional food systems literacy can help individuals to know what knowledge is essential to facilitate discourse and cooperation between different actors working on food systems issues. As people seek to collaborate with others on issues that they cannot solve at an individual or organisational level, we envisage the community of people working on food system issues as an informal dynamic learning network, which seeks to understand not only the nature of food system issues but novel ways of developing better food system outcomes.

Learning concerns processes involved in the acquisition, use and reflection of knowledge. Krathwohl (2002) describes four different categories of knowledge based on Bloom's Taxonomy: factual, conceptual, procedural, and metacognitive (**Table 1**).

The content and types of food systems knowledge that will be useful will vary depending on the individual, their personal and professional backgrounds, and the situation they find themselves in. A functional food systems literacy therefore must provide a framework that allows for effective integration of knowledge across disciplines and interaction between actors within the food system. To that end, we conceive of there being different knowledges and skills that when used together can help facilitate collaboration between stakeholders, while also allowing different perspectives to be surfaced, explored and incorporated into

TABLE 1 | Structure of the knowledge dimension of Bloom's revised taxonomy.

Knowledge type	Description	Knowledge subtypes
Factual	The basic elements that students must know to be acquainted with a discipline or solve problems in it	• Terminology • Specific details and elements
Conceptual	The interrelationships among the basic elements within a larger structure that enable them to function together	• Classifications and categories • Principles and generalisations • Theories, models and structures
Procedural	How to do something; methods of inquiry, and criteria for using skills, algorithms, techniques, and methods	• Subject-specific skills and algorithms • Subject-specific techniques and methods • Criteria for determining when to use appropriate procedures
Metacognitive	Knowledge of cognition in general as well as awareness and knowledge of one's own cognition	• Strategic • Cognitive tasks, including appropriate contextual and conditional knowledge • Self-knowledge

Source: Krathwohl (2002).

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[1]See also Ashby's Law of Requisite Variety: the degree of control that one has over a system is relative to the amount of information on it that you have (Ashby, 1958).

TABLE 2 | Overview of the proposed functional food systems literacy comprising four levels of knowledge.

Knowledge type	Functional food systems literacy	Purpose and rationale

Factual	• Food system definition
	• Components of food systems:
	  ○ Actors and activities
	  ○ Drivers and relationships
	  ○ Outputs and impacts
	  ○ Food environments
	• Overview of disciplines or professions involved
		• Foundational knowledge to facilitate an ability to communicate across disciplinary boundaries
		• Food systems definition is important as infers more than just, for example, value chain
		• Knowledge of core components and relationships in a food system allows for basic understanding of food system configuration and dynamics
		• Knowledge of key disciplines attunes the thinker to different stakeholders/actors, alternative ways of viewing the system, and potential intervention pathways and strategies

Conceptual	• General overview of food system challenges/problems (e.g., biodiversity loss, food waste) • General overview of food system goals and values (e.g., nutritional security) • Underlying nature of food system challenges (e.g., emergence, lack of cooperation, time discounting, feedback, cost/benefit sharing)	• Allows stakeholders to diagnose and address challenges • Allows stakeholders to visualise and work toward positive outcomes • Allows stakeholders to understand the underlying patterns that govern or underlie food system issues—providing depth to analysis and intervention approaches

Procedural	• Interdisciplinary working
	• General communications skills
	• Understanding and reconciling differences in perspectives
	• Systems thinking:
	  ○ Distinctions, systems, relationships, and perspectives (DSRP) framework
	  ○ Boundary critique
	• Intervention approaches (e.g., theory of change, design thinking, stakeholder analysis, various systems methodologies)
		• Ability to work with others in the food system who hold different professional and personal knowledge
		• Ability to communicate effectively and be understood
		• To help incorporate and address different partial understandings and prioritisations of food system issues
		• To structure thinking around systems so as to provide a means of creating and critiquing conceptual representations of food systems
		  ○ DSRP is a simple framework that can be used to map system components, relationships, boundaries and perspectives
		  ○ Boundary critique provides a means for understanding and interrogating physical and conceptual boundaries
		• Intervention approaches take how we see the system and allow us to design appropriate products or processes

Metacognitive	• Awareness of limits and partiality of thinking and cognition in self and others • Reflexivity	• Awareness of one's own thinking is central to understanding our limited partial conceptualisation of systems, and forms the basis for incorporating diverse perspectives into a more accurate amalgamation • Reflexivity is the process by which the individual iteratively reflects on the aspects of self and other in the construction of knowledge

systems analysis and the design of different interventions. **Table 2** presents our proposed key knowledge dimensions and contents that would facilitate this kind of stakeholder engagement and effective food systems learning.

Becoming food systems literate is a process that takes time and commitment in developing a suite of knowledge and skills that will allow effective working with others for a better understanding of food systems and how to intervene in them. Food systems literacy is not only concerned with gaining knowledge of the food system (i.e., the acquisition of facts), it is the acquisition of knowledge that will help to organise, investigate and critique food system facts and values. This is indicated in **Table 2** in which 'factual knowledge' is focused on definitions, and components of food systems as well as knowledge of different disciplines/professions involved in the food system. We focus on the knowledge that would help to organise, investigate and critique food system facts and values.

As well as gaining factual knowledge, there are many different systems thinking methodologies that we argue are useful in better understanding food systems (Checkland, 1981; Midgley, 2000; Kurtz and Snowden, 2003; Ison, 2017; Jackson, 2019). However, we have chosen to focus on two complementary approaches that can be used together to quickly generate systems insights

(Cabrera, 2006). The Distinctions, Systems, Relationships and Perspectives (DSRP) framework is an attempt to simplify the diversity and proliferation of systems approaches into four key interconnected concepts that are core to systems thinking and thinking processes in general (Cabrera et al., 2008). The "distinctions" aspect of DSRP is closely linked to the boundary concept, and judgements on boundaries, or in other words, boundary critique is complementary to DSRP (Midgley, 2000). Taken together, DSRP and boundary critique provide a simplified means for better understanding how we as individuals, and others, view the system in question.

There are several implications of this food systems literacy framework for food systems pedagogy. Firstly, food systems literacy is focused on the minimum knowledge required for effective collaboration between different food system actors analysing and intervening in food system issues. In the context of pedagogy, it contains a normative premise that argues that student learning on food systems should have utility and foster their abilities to more skilfully and effectively analyse and intervene in food systems. Secondly, in order to support this outcome, educators should focus not just on food system facts and a variety of food system problems or challenges, such as food waste (factual (F) and conceptual (C) knowledge types), but the

procedural (P) and metacognitive (M) knowledges necessary for the critical interrogation and manipulation of these data (See **Table 2**). These P and M knowledge types, such as reflective exercises, communication skills and systems thinking methods, take longer to develop than F and C knowledges, and should be integrated longitudinally throughout the curriculum so that students have multiple opportunities to learn and progressively develop these skills over time. Thirdly, if food system literacy is to be an intended learning outcome, and given that food systems education can never be truly complete, students would benefit from being explicitly taught the framework so that they have a roadmap with which to continue their individual food systems learning journeys themselves, independently, beyond the educational setting.

The "functional minimum" aspect of the food systems literacy allows for the framework to be applied in diverse contexts, while providing educators with the opportunity to elaborate on it as they see fit within their respective institutions. There are undoubtedly a variety of areas that could benefit from further elaboration. For example, there are differences between food systems as they present to different people around the globe with questions pertaining to social justice, environmental impact, access, and cost/benefit sharing among actors. For each context, the factual and conceptual knowledge relevant will be determined by the challenges presenting within the system in question; for example European countries focusing on the negative impacts of livestock food systems and sub-Saharan African countries concerned with rural livelihoods and food and nutrition security. The food systems literacy framework does not specify the totality of what should be taught, rather what is needed to promote effective collaboration between disparate food system actors. Issues such as power and social justice, although not mentioned explicitly, are present within the framework through the processes of understanding and reconciling different perspectives, boundary critique, and developing awareness of limits and partiality of thinking and cognition in self and others. Therefore, the food systems literacy framework provides a foundation for the types and categories of knowledge and skills required for food system actors to collaborate effectively together.

Utilising these four knowledge types effectively can enable us to better generate dynamic learning networks comprising multiple individuals and institutions that represent different parts and experiences found within the food system and develop capacities for collaboration reaching far beyond academic structures to wider food systems actors. In the next section, IFSTAL is used to show an example of food systems literacy in action.

DEVELOPING FOOD SYSTEMS LITERACY—THE EXAMPLE OF THE IFSTAL PROGRAMME

IFSTAL Overview

The IFSTAL programme provides a suitable case study with which to reflect on the application, staff and student experience and outcomes of operationalising a food systems literacy and formulate recommendations for other food system dynamic learning networks. The core principles of IFSTAL include: easy-to-learn independent, facilitated and peer-to-peer learning; interactive and active learning; and an enabling environment. IFSTAL is an extra-curricular, optional programme offered to students with an interest in food systems across five (previously seven) higher education institutions in the United Kingdom that cover different disciplines and areas of the food system and institutional cultures[2]. While inter-university research projects are not uncommon in higher education in the United Kingdom, inter-university teaching across programmes and disciplines are rare, and this makes IFSTAL unique. The programme has been running since 2015 with the aim to generate a dynamic learning community that allows students to gain skills that are needed to work effectively with others in food systems.

IFSTAL's approach to teaching recognises that the complex challenges facing the food system are crosscutting, requiring transdisciplinary approaches to unpack them, and more importantly, tackle them. IFSTAL encourages students to think beyond the methods and problem-understanding perspectives of their own disciplines, to consider real life challenges they might encounter in their research and workplaces (Ajates Gonzalez and Wells, 2016).

Being a voluntary programme for a diverse cohort composed of students at different levels of their postgraduate education, from a wide range of disciplines, and potentially joining at any time of the academic year, the content had to be carefully designed to allow flexibility and maintain participation. The programme offers students different levels of engagement through a diversity of channels: face-to-face events of varying lengths and formats to meet students' different learning styles, content preference and time availability. A blended learning model was considered appropriate, as it has been used previously to promote interdisciplinary teaching and learning within higher education contexts (Cooner, 2011).

IFSTAL includes a flipped classroom model based on online units combined with full-day interactive workshops, webinars, lectures, a network of workplace contacts, a summer school, an alumni network, and internship opportunities. Throughout the year-long programme, opportunities are created for students to work in groups of mixed disciplines and to apply theory to real-life examples often interacting with workplace representatives. Integration of multiple technologies in an interactive teaching and learning environment was promoted to support interdisciplinary learning. A detailed description of the IFSTAL programme, its approach and activities can be found in Reed et al. (2017) and Ingram et al. (2020).

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[2]London City University, University of Oxford, University of Reading, University of Warwick, London School of Hygiene and Tropical Medicine (LSHTM), the School of Oriental and African Studies (SOAS) and the Royal Veterinary College (RVC). The University of Reading is now working with EIT Food to deliver food system education through the European Food Systems Education and Training (EFSET) programme to partners across Europe.

Scoring of IFSTAL Instruments

With the aim of determining which instruments were most effective at facilitating learning in the different knowledge types, using the proposed functional food systems literacy framework, we compiled a list of all IFSTAL instruments and scored them against the four levels of knowledge. To generate the list of IFSTAL instruments, all teaching and learning activities used in IFSTAL were collated from reports and project records and then categorised systematically as:

- synchronous or asynchronous
- online or face-to-face
- interactive or independent

For each teaching and learning instrument, a short description of purpose and examples were provided. The list was given to all current and past IFSTAL staff members who were asked to score each teaching instrument on how well it was able to deliver the four knowledge types. For each instrument, 14 scorers gave a score of what they perceived to have been achieved in practice using four categories (0—none; 1—very little; 2—some; 3—a lot). Further, they provided a reflection on the instruments to explain their scores. All scores were collated and the modes identified in order to examine the emerging patterns (**Table 3**). This enabled us to visualise which instruments were perceived to be the most suitable and impactful in delivering the specific type of knowledge intended. In addition, we conducted a narrative analysis on the open text which provided further explanation and reflection.

Scores and Reflections

The aggregated responses and mode of the scores show a consistency of opinion around the effectiveness of meeting all four types of knowledge across the IFSTAL teaching instruments (**Table 3**). In the following paragraphs, some critical patterns are described, reflections shared, caveats and areas for improvements explained. Quotes from the scorers are used to highlight pertinent arguments.

Three instruments emerged as scoring a 3 in all four types of knowledge, namely synchronous face-to-face interactive workshops [J]; synchronous face-to-face interactive project work [M] and synchronous face-to-face interactive offsite experiential learning [P]. These three instruments are experiential, whether onsite or offsite, and build on a foundation of shared factual knowledge taught or learnt earlier in the programme year. The structure of these instruments all involved the layering of knowledge, tools and methods; the opportunity to practise these and build skills; and reflection on the process in interdisciplinary groups. Workshops and group work were tightly planned in managed environments. Overall group size was ∼40 students, with each individual working group limited to 5 or 6 people to facilitate active collaboration between group members. Each group was purposefully created to maximise the diversity of individuals present who had a range of different personal, professional and disciplinary backgrounds. These arrangements allowed everyone to understand their position in the system, and how their respective contributions count toward collaborative problem solving:

> [M]_R11[3]: *Intense group working on a problem that has importance and which all group members are able to provide parts of the solution. Knowledge brought to the table combines disciplinary knowledge which is shared with the group but also shares knowledge of analytical methods which make collaborative problem solving manageable.*

This may have been less evident in the interactive offsite experiential learning (e.g., field trips or volunteering activities), but the reflective activity built into each of these instruments help to embed the metacognitive elements.

The acquisition of factual and conceptual knowledge scored highly in the reflections and it appears from the analysis that these types of knowledge are most successfully accessed through the application of certain teaching instruments which exhibit some bias toward traditional methods such as lectures. Four of the examples scored highly in factual and conceptual knowledge, but low in procedural and metacognitive knowledge. These are: Asynchronous online independent curated content [A]; synchronous face-to-face independent lecture [G]; synchronous online and face-to-face independent lecture [Q] and synchronous online interactive webinar [R]. The use of online units for basic one-way learning is effective as a primer for workshops, where participants can gain a foundational knowledge in the topic of the workshop, therefore being more prepared to access the practical and collaborative learning available. The online units help to give students a common basis upon which to build effective communication:

> [A]_R11: *Online units focus on introducing students to specific language and terminology, definitions and explanations feature high in the material, help[ing] in collaborative work later as shared meanings and understanding can help communication. The units explain key principles of systems thinking and encourage students to recognise that their knowledge is partial and can exist in a disciplinary vacuum. There is a strong steer in the material to encourage students to understand interrelationships in the food system. Asynchronous accessibility enables students to learn in their own time.*

Asynchronous methods support the attainment of higher levels of knowledge, as learning materials can be revisited, or used as part of a structured reflective activity. They also allow students to process learning in their own time and facilitate reflective activity.

Standalone lectures and webinars also involve speakers with specialist knowledge. In some cases, these instruments are coupled with others to bolster the other types of knowledge. For example, asynchronous online independent assessment tools can cover a broader range of knowledge, by having an application and reflective element to the quiz.

Improvements in developing approaches to support procedural and metacognitive knowledge could be achieved by more regularly prompting students to respond to specific questions, for example regarding their perspectives and positionality throughout the unit and encouraging reflection

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[3]The letter refers to the instrument as listed in **Table 3** and the Rx to the respondent (R) and its number (1–15).

TABLE 3 | IFSTAL teaching instruments and their contribution to food systems literacy.

Ref	Instrument	The intent of the IFSTAL instruments to deliver learning and achieve type of knowledge—the focus is on the instrument, not the content (example)	Food systems literacy			
			Factual	**Conceptual**	**Procedural**	**Metacognitive**
A	Asynchronous online independent curated content	Knowledge transfer on core food systems related topics concerning food issues and how to analyse and intervene in them (portal units)	3	3	1	2
B	Asynchronous online independent assessment tools	Self-assessment of learning, promoting further reflection and consolidation of learning (portal unit quiz)	3	1 2	1 2	1
C	Asynchronous online independent resources	Independent visual and audio learning of mainly factual concepts; "on demand learning"; access and exposure to topics and perspectives different than those available on enrolled course, gaining wider knowledge on issues concerning food (portal lecture recordings, website)	3	2 3	1	1 2
D	Asynchronous online independent reflexive activity	Developing reflective and critical thinking practice; document personal learning; development of writing skills; career and professional development planning. Student survey feeds back student experience of the course offering possibilities for staff reflection and course adjustments, benefiting future learners (journey document, student survey)	0	0	1	3
E	Asynchronous online independent push communications	Regular communications to prompt action, raise awareness of events, links, roles and signposting for recordings of other asynchronous events. Opportunities for participants to contribute to content (newsletters, blogs)	2	1	0	0
F	Asynchronous online interactive forums, discussion groups	Opportunity to share perspectives, information and discuss topics, meet other participants, alumni and workplace individuals (portal forums, IFSTAL social media)	1 2	1	1	2
G	Synchronous face to face independent lecture	Traditional form of knowledge-sharing from academics with opportunities to enhance learning through asking questions, listening to responses, and peer discussion during the session and in breaks (Summer School lecture, symposium lecture)	3	3	2	2
H	Synchronous face to face independent external speaker	Traditional form of knowledge-sharing from experts with opportunities to enhance learning through asking questions and listening to responses, and peer discussion during the session and in breaks. Can be in lecture or roundtable format (public lecture, meet the workplace)	3	2	2 3	2 3
I	Synchronous face to face independent reflexive activity	Personal reflection on students' position in the food system and learnings from course activities (journey document, personality tests)	1 2	1	2	3
J	Synchronous face to face interactive workshop	Practical application of concepts, theories and methods from online units in collaborative group work with peers to foster skills development (away day workshops, summer school workshops)	3	3	3	3
K	Synchronous face to face interactive discussion	Discussion with course peers, external speakers and faculty on food systems related topics (symposium group discussions)	1	3	3	3
L	Synchronous face to face interactive tutorials	One-to-one tutorials with faculty offering student support on food systems related topics and student development (career coaching)	1	1	3	3
M	Synchronous face to face interactive project work	Interdisciplinary group work to implement and practice food systems analysis and intervention approaches to address real-world problems. Students also required to develop reflexive capacity through active reflection on team dynamics, the task they are addressing, and evaluation of the methods and approach they have chosen to use (summer school projects)	3	3	3	3
N	Synchronous face to face interactive networking	Introductions, team building and networking (social activities, alumni events)	0	1	1	2

(Continued)

TABLE 3 | Continued

Ref	Instrument	The intent of the IFSTAL instruments to deliver learning and achieve type of knowledge—the focus is on the instrument, not the content (example)	Food systems literacy			
			Factual	Conceptual	Procedural	Metacognitive
O	Synchronous face to face interactive reflexive activies	Reflections on use and outcomes of personality assessment tools, and professional development (personality instruments discussions)	0	0	0	3	3
P	Synchronous face to face interactive offsite experiential learning	Practice-orientated learning based on exposure to real-life activities and processes in food system businesses/NGOs/organisations/institutions with the opportunity to explore the workings of the system and thereby make a connection between concepts and knowledge, deepen learning and develop all four levels of knowledge (field trips, volunteering)	3	3	3	3
Q	Synchronous online and face to face independent lecture	Knowledge transfer on core food systems related topics, individual receiving of teaching content, exposure to different ways of thinking/cognitive structures/storeys/contexts (from speaker and audience), making connections with one's own knowledge, deepen learning, expand boundaries (launch events, public lecture)	3	3	2	1
R	Synchronous online interactive webinar	Knowledge transfer and/or application of knowledge on a particular topic with the opportunity for interaction between the audience and the presenter in the form of questions and discussions. Low barrier format to asking questions and making contributions, everybody can contribute given they have an internet connexion. Constructive discussions can take place in chat function that help with knowledge exchange and formulation with arguments (webinars)	3	3	1	2	2

The scores reflect to what degree the instruments were perceived to achieve the type of knowledge in practice: 0 (purple): none; 1 (yellow): very little; 2 (orange): some; 3 (teal): a lot.

and application of understanding. Also, coupling more formally with the quiz, setting expectations with respect to why the quiz is being performed, and using it as a learning tool rather than as a steppingstone. For lectures, whether synchronous or asynchronous, these could be improved by better use of interactive activities such as breakout rooms, or discussion in pairs. In essence, the focus is the necessary factual knowledge as part of a holistic programme, recognising that this is a minimum to be able to move onto the other types of knowledge.

In identifying what instruments were most effective in delivering procedural and metacognitive knowledge, three examples demonstrate the instruments which scored high for procedural and metacognitive knowledge but low for factual and conceptual knowledge. Examples of instruments used were: Synchronous face-to-face independent reflexive activity [I], Synchronous face-to-face interactive tutorials [L] and Synchronous face-to-face interactive reflexive activities [O]. These activities comprise very specific "built-in" reflective moments detailed in the learning journey which encourage students to apply and develop their ideas as they reflect on their learning. In addition, instruments and teaching points were utilised to weave in reflections on students' personal career paths, skills, and attributes and opportunities to discuss with and seek advice from professionals in the food sector.

A key challenge found in this reflective work is assessing metacognitive knowledge. Consensus amongst the respondents demonstrates that although metacognitive knowledge has high intent built into the learning activity, it is not always possible to

determine the actual effectiveness with the mechanisms available. A key reason for this may be due to the activity being carried out privately and there being few opportunities for facilitators to determine the learning outcomes of these activities via, for example, observing participants collaborating or demonstrating their learning through presentations. Building more explicit and directed learning opportunities into these activities so that they focus not only on the action but also explicitly the intent, such as providing instruction on "how to reflect" may make this more effective. Moreover, this could potentially result in an increase in Factual and Conceptual knowledge as students are made more aware of the rationale and methods of these instruments and how they can be used and developed.

> [O]_R3: 3. This learning method (??)(sic) is not targeting or is not suited for factual, conceptual or procedural learning. If directed well it can help the learner with his/her metacognitive understanding and abilities and therefore this is the area where I expect I would gain the most with this learning method

Evaluating the qualitative reflective comments from respondents, several commented on the importance of having recursive activities that touch on themes regularly and reinforce key messages and principles multiple times throughout the course. Over time, different types of knowledge are gradually achieved, greatly helped by the interaction from multiple perspectives among students, which shapes and reshapes their thinking and changes their awareness. Throughout the course, there is an

increasing realisation that there is a limit to one's own knowledge and the acquisition of further factual knowledge and that the networked approach to solutions is a way to dealing with individual knowledge boundaries:

> [A]_R10: The basic language and concepts used - what is a system, wicked problems, how components interact, etc. were evidenced through increasing and continual use throughout the course, there was a gradual building of the knowledge that worked in sync and complemented by the interactive workshops.

A further aspect evidenced in the analysis was the importance attributed to the overall delivery of the IFSTAL programme, the learning environment plays a vital role. This is difficult to observe in the scoring but came out strongly in the comments. Instruments such as Synchronous face-to-face interactive networking [N] and Asynchronous online independent push communications [E] scored relatively low. However, the use of these to create a community and sense of belonging is vitally important to then enable deeper learning via other instruments. This is further observed by adding all the elements of the summer school together [G]+[J]+[M]+[P].

> [N]_R10. Whilst these were not so important for specific knowledge and skills (and score lower here), the value of developing, being aware of and appreciating the networks built through participation in the programme (and subsequent ideas sharing) was really valuable to interdisciplinary systems work and not to be underestimated (hard to capture with the grading here)

In addition, the summer school, which is limited to 30 places and requires application based on completed course elements, provided the opportunity to instil a sense of community and ongoing commitment and attendance of the cohort.

> [N]_R4: This type of opportunity was one of the unique benefits granted to IFSTAL students. IFSTAL facilitated the creation of contacts and networks within and across universities and disciplines.

The learning environment created by the interdisciplinary team is an important element in facilitating, encouraging and modelling collaboration and group cohesion, despite their diverse academic backgrounds. In addition, by creating multiple types of learning environments which span formal, informal, social and individual learning, the participant is exposed to multiple layers of learning, each building on the other. This scaffolding of skills, knowledge and authentic collaborations and interactions results in more holistic learning and creates the social and mindset foundation of the cohort to go on to attain high levels of knowledge across the scale. In a classic educational structure, the educator is often set outside of social activities that form part of education. However, by dismantling these barriers and generating a learning space for all, more room is made for the social immersion required to achieve metacognitive knowledge.

Skills-based learning also requires practise (P) and students have the opportunity to do this by working on "food system challenges" provided by food sector professionals. Co-creating the curriculum with these actors means that the skills identified by consulting with workplace representatives have a real-life anchor and relevance that supports students' learning (Kember et al., 2008). This, in turn, increases interest in the programme among students, pushing up enrolment at the start of the programme and engagement during it. The use of food system challenges, which are co-created with workplace partners, are particularly powerful in enhancing procedural forms of knowledge. This is because students not only utilise facts and concepts, but must also devise their own ways of working as an interdisciplinary group before these can be applied.

DISCUSSION

In this paper we propose a functional food systems literacy that can achieve more effective collaboration in food systems and illustrate its operationalisation through the example of IFSTAL. The theoretical minimum proposed using four knowledge types can be interpreted as the base level of "common knowledge" that each food system change maker should be cognisant of. In addition to the factual and conceptual knowledge, which are most commonly associated with addressing food system problems, we have stressed the crucial roles of procedural and metacognitive forms of knowledge. Procedural knowledge is important given the complexities of the food system, the wide variety of actors involved, and the wide geographical areas covered. Recognition that there is no "right" way to address food system problems and gaining skills in communication and multi-participatory methods are shown to be valuable attributes in food systems literacy. Moreover, metacognition is essential to recognising that no particular actor can claim to represent the "truth" in tackling intractable food system-related problems and that "solutions" are, at best, generated from a milieu of partial perspectives, understandings and experiences. This might be difficult to understand and put into practice at first, especially for those students based in the positivist natural sciences. Nonetheless, it is important if progress toward finding common solutions between diverse actors is to be achieved.

Due to the holistic, interconnected, interdependent and emergent nature of challenges and issues in food systems, their relationships to other systems such as public health and the biosphere, and the fact that food is a basic need, it is important to develop a concomitant understanding that enables cooperation between different actors. Moreover, because individual institutions and disciplines are partial in their knowledge, they need to be connected to others to make use of collective knowledge and innovation potential. This is also true for educational institutions that cannot cover all aspects of food systems in their curricula. Thus, cross-institutional, connective programmes such as IFSTAL can offer an opportunity to go beyond what is possible at the institutional level and thus capitalise on shared resources and expertise (de Róiste et al., 2015). Further, reflexivity, curiosity, collaboration and empathy are important skills that IFSTAL has sought to cultivate in its food systems change makers. This has been achieved through the inter- and trans-disciplinary nature of the programme;

carefully designed activities (e.g., online basic concepts, mixed group work applying theory to "real world" problems, personal journey logs); and experiential learning (Kolb, 1984) as part of a "scaffolded" curriculum (Vygotsky, 1978). Further, there has been attentive facilitating, employing for example discrepant questioning (Rea-Ramirez et al., 2009) along with training in communication skills. These have been crucial to promote reflection of one's place as a food system actor; the limits of one's knowledge and worldview; understanding the multiple positions and perspectives that different actors in the food system come with; the array of different knowledges and facts there may be to grasp or, as a minimum, acknowledge and be aware of, and flexibility to tackle the complexities and deal with trade-offs and unintended consequences.

IFSTAL, with its external start-up funding and non-credit bearing set-up, has given us the opportunity to experiment with different instruments and gain important insights concerning what works and what does not when trying to enhance different forms of food system knowledge. We have learned that while IFSTAL's extra-curricular structure provides the flexibility needed to run a programme across very different institutions, it also generates a learning environment that is appealing and valuable to the students. Our experience has also taught us the importance of having a strong scaffolding concept that allows cumulative learning over time and the use of concepts to then drive application. We argue that a holistic approach built on sound pedagogy is needed to encapsulate and facilitate the learning of all the types of knowledge required. IFSTAL has shown that the full value of food systems literacy can only be realised by a comprehensive package of teaching and learning—a model that we have replicated successfully at a smaller scale in international 1-week training schools.

IFSTAL has also been informed by adult-learning theory or andragogy principles (Knowles, 1984) to be able to cater to its high number of mature and professional students. When designing activities, the use of the interdisciplinary character of the subject of study fostering multiple perspectives is a key lever to engage students and connect to their prior knowledge and professional experience (Lattuca, 2001). Examples include providing essential vs. recommended reading or activity, to enable students to delve deeper into the subjects more relevant to their interests, time and previous experience. This approach is closely linked to the careful design of the content to make sure it was accessible to students new to certain topics, while appealing enough to students more familiar with the subject at hand. Pedagogically speaking, IFSTAL enables students to become proactive actors in identifying and stretching their own zone of proximal development (Vygotsky, 1978; Kilgore, 1999).

While the individual instruments used in the IFSTAL programme are not new and are relatively common in educational practice, it is when they are utilised simultaneously that they become most effective in delivering a food systems literacy. For example, setting up online learning units can be useful for factual and conceptual knowledge, but will need to be expanded or complemented with other instruments to also cover procedural and metacognitive knowledge. Instruments are not the only aspects to consider here, however, as there are other

factors that are also important. In IFSTAL, we use a range of good practises to support the programme, such as consulting regularly with a range of professionals across the sector, receiving letters of support from stakeholders, lining up internships and work-based learning experiences, and workplace workshops to ascertain skills gaps and relevance of the current teaching. These activities help us to generate a programme that is topical and of relevance to the food system workplace; that relevance, in turn, is important for student motivation and the real-life aspect of transdisciplinary learning (Kember et al., 2008). Further, we pay close attention to the calibre and career stage of speakers, striving for a mix of different levels of seniority so that students can make connections between different levels of operation in the workplace.

When we leave behind ideas of classroom, curriculum and hierarchy, and exchange, share, appreciate and create knowledge in dynamic learning networks that make use of collective knowledge, collective expertise, and collective vision, we are bound to make positive changes in our food systems. The food system needs adaptive learning networks that can be shaped and structured by participants according to the needs of the system, and the expertise of the people positioned within it. For this reason, the IFSTAL programme was co-created through consultation with multiple stakeholders including sector professionals and academics from different disciplinary areas. In theory, everybody can contribute to the shaping of such learning networks, but our work in IFSTAL has also shown that effective acquisition of the functional food systems literacy relies on a strong pedagogical approach, the establishment of which requires particular skills including the educational expertise often found in educational establishments, such as universities. These are, in turn, increasingly run with business-like structures where there is little room for extra-curricular activities like IFSTAL that do not earn large sums of money and are not well-suited structurally for credit-bearing programmes. Thus, food systems education faces the dilemma of not having suitable structures in academia to support programmes for food systems literacy and other stakeholders, such as NGOs and industry, not having education as their primary focus.

Ultimately, the individuals that enter the food systems education sphere are aiming to engage with the food system in some way, and the assumption is that this will be more than as a citizen or consumer, and may lead to a career in this complex system. Currently, there is a call for the food system to transform, moving away from the status quo (Webb et al., 2020). For transformation to transpire, it is commonly accepted that trade-offs and disruption will occur and that all actors of the food system will need to be involved, emphasising a collaborative approach and the skills and knowledge needed to achieve this (Kennedy et al., 2021). A functioning food systems literacy allows not only the acquisition of knowledge and reflection, but also the development of the skills and understanding necessary for holistic systemic thinking when addressing complex problems that demand the inclusion of many different perspectives and leadership to drive change. The presence of a functioning food systems literacy with the addition of a global definition of food system leadership allows the development of these skills for global sustainable systems change.

CONCLUSION

Food systems literacy with four key knowledge dimensions (factual, conceptual, procedural and metacognitive), provides the basis for a holistic learning framework that facilitates interdisciplinary and stakeholder engagement for effective food systems learning. It can equip students with the necessary knowledge and skills to participate and act in transformative ways in the food system, and contributes to food system pedagogies that share this goal.

The IFSTAL reflective study shows that it is possible to acquire all four knowledge types by way of instruments which provide experiential learning (synchronous face-to-face interactive workshops, synchronous face-to-face interactive project work and synchronous face-to-face interactive offsite experiential learning). However, their success in students acquiring these four knowledge types relies heavily on the scaffolding method which lays a foundation of shared factual knowledge taught or learnt earlier in the programme year.

We find that built-in and supportive reflective learning is a key component of successful metacognitive learning. Moreover, the learning environment and culture is vital in supporting students to develop skills in listening, collaboration and reflective learning. The mixed, cross-institutional team is able to facilitate learning from different perspectives and fosters an environment of knowledge sharing, where teaching staff can act as guides and provide opportunities for students to articulate and contribute their knowledge and experiences which aids active learning and collaboration.

Collaborating is essential to working on the betterment of food systems. We have reflected on what knowledge and skills are necessary for effective food system collaboration, and what delivery methods can best contribute to learning. Our findings suggest that while it is possible to learn about food systems as an individual, learning how to collaborate with others needs structure and facilitation and consideration of all types of knowledge.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

HP, AdeF, RW, RB, RC, and BH conceptualised the study and wrote the first draft. HP and AdeF gathered co-authors feedback and produced the revised manuscript. All authors completed the scoring and shared their reflections, gave input into the manuscript writing, and approved the final version for submission.

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Campus Food Provision as Radical Pedagogy? Following Students on the Path to Equitable Food Systems

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On campuses across North America, students are actively prefiguring alternatives to the fundamental inequities and unsustainability of the capital-intensive, industrialized food system. While rarely recognized as such, these Campus Food System Alternatives (CFSA) are intensely pedagogical spaces, and often—importantly—are student led and directed. We make the case that CFSA are sites for a "pedagogy of radical hope" that (a) centre student agency, (b) through informal and prefigurative learning. So far these spaces have received scant scholarly attention, though inasmuch as they constitute pathways toward more equitable and sustainable food systems, while informing liberatory pedagogical practice, we argue that it is high time for CFSA to be taken seriously.

Keywords: critical food systems education, campus food systems, campus food initiatives, informal learning, social and ecological change

INTRODUCTION: FROM SCHOOLS OF DEATH TO LIBERATORY LEARNING

In his recent forceful condemnation and reimagination of higher education, Gannon (2020) invokes Nikolai Frederik Severin Grundtvig, one of the founders of the Danish folk school movement. Writing in the mid-19th Century, Grundtvig castigates the educational orthodoxy of his time and place as an elitist pursuit that simply reproduced conventional power relations. Grundtvig insisted that these "schools of death" (quoted in Gannon, 2020, p. 11) were overly fixated on haughty (and irrelevant) scholarship, and he called for a new paradigm—"schools for life"—that were inclusive, applied, and focused on teaching and learning for civic engagement. At roughly the same time in the United States, Black leaders including Booker T. Washington, George Washington Carver and W. E. B. Du Bois were prefiguring new worlds at the intersection of agriculture and Black liberation through the founding of Tuskegee University (see White, 2018). Within this context, agriculture and agricultural education were framed as radical, as resistance, and as liberatory.

As underscored elsewhere (including in this collection), the stakes for food systems transformation could not be higher. The fundamental social inequities and ecological devastation wrought by the contemporary, capital-intensive food system are destabilizing the prospects for planetary survival (Holt-Gimenez and Shattuck, 2011; Altieri and Nicholls, 2020). Within this firmament, (re)education is an essential focal point and, like Grundtvig, Washington, Carver, Du Bois and others have observed, an essential element in food systems and broader socio-ecological transformation.

Dimension	Exemplars
Promote sustainable production (agroecological, organic, local, etc).	• UW Farm Market (University of Waterloo) is a student-run market featuring 100% local and sustainably-sourced products. • The Tea Room (Queen's University) is a student-run café that sources socially just and ecologically sound products. • Dig In! Campus Agricultural Group (University of Toronto) is a network organization meant to support and empower sustainable, small-scale food production on campus.
Provide education (focused on social and environmental justce)	• Caffiends (University of Toronto) is a student-run cafe that educates on social and environmental justice. • BIPOC Growing Collective (Trent University), is a production collective informed by abolitionist and decolonizing practice, dedicated to reviving ancestral and cultural practices with respect to land and food. • The Trent Apiary (Trent University), is a student-run apiary dedicated to educating about bees and their ecology.
Foster inclusive community and student leadership	• The People's Potato (Concordia University) serves free meals to students, staff and faculty and provides accessible anti-oppressive community space. • Embark Learning Garden (University of Victoria) seeks to create just and equitable growing spaces on campus rooted in food justice and climate equity.
Support student food security	• People's Republic of Delicious (University of Ottawa) is a student collective that rescues blemished/nearly expired food and serves it for free. • The Hive Café Solidarity Co-op (Concordia University) is a student-run café meant to provide students with affordable, socially-just and ecologically-sound food. • King's Galley (University of King's College) is a student-run canteen that offers ethically-sourced, and affordable food to students. • IGNITE Soup Bar (Humber College) is a student union-operated, pay-what-you-can soup bar.

In this short perspective piece, we theorize Campus Food System Alternatives (CFSA)—that is, initiatives that exist as counter-points to conventional campus food services—as crucially important pedagogical spaces from which to wage food systems transformation. In developing this perspective further, we briefly (a) situate how we think about pedagogy, (b) provide a typological sketch of CFSA by summarizing some key themes emerging from our ongoing work, and by way of conclusion, (c) offer some recommendations related to supporting CFSA through future research and action.

The paper draws empirically on two interrelated studies. The first includes a detailed scan of Canadian postsecondary

institution websites for mention of various campus farms in Canada ($N = {\sim}80$) and a Canada-wide survey of students ($N = 65$) engaged in campus farms across Canada, worked conducted by the first author and a research assistant (see Classens and Burton, in press). The second study includes an initial Internet scan for mention of various food initiatives, beyond farms, on campuses across Canada ($N = {\sim}72$[1]) which led us to postsecondary institution websites from across the country, social media pages, food initiative websites[2], and online news articles. We then conducted interviews with 24 leaders of initiatives identified in this latter scan. This work was conducted by the first, second, fourth and fifth authors. This paper also draws on our respective embodied experiences working within CFSA as students, advocates and faculty, and is inspired by the student leadership and innovation that creates such transformative potential within CFSA.

ON (CRITICAL) PEDAGOGY

When we conceptualize pedagogy, we frequently envision a space with neat rows of desks and one singular expert educator at the head of the class, conveying information on a discrete subject to an uneducated audience. The banking method of education, which Freire (1968) so fiercely critiques, whereby education is reduced to a single expert filling the empty minds of pupils, is so pervasive in contemporary postsecondary institutions that the opportunities within non-traditional, informal pedagogical spaces such as CFSA often go overlooked. Institutionally endorsed learning, such as lecturing, is often administered in temporal and geographic spaces that have been so designated (i.e., a school classroom or a university lecture hall). This dynamic can even be reproduced within CFSAs, for example when planned experiential learning activities within the context of a class (such as a class trip to a campus farm) are understood as the pedagogical limits of these spaces.

Following the work of Freire (1968), Hooks (1994), and others, we conceive of pedagogical spaces as any temporal or geographic space that functions to bring collaborators together in a shared endeavor where learning will inevitably happen. Learning can be formal and scheduled, but is also—importantly—informal and unexpected (Crouthers, 2021). This approach understands that contextual and experiential education is often the most impactful (Carrier, 2009; Chawla, 2015). Although students may initially gather through a CFSA for a singular purpose, such as the need for food access or a desire to gain practical

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[1]We are reporting on preliminary and ongoing work. As such, we have yet to determine if all of the identified food initiatives from our initial Internet scan are still active. We note here that there are an additional 57 initiatives for which we found some online presence, though we have yet to verify whether these projects are currently active. Given the particular disruption of COVID-19, and the more general issue of continuity with student-run organizations, it is likely very difficult to arrive at a definitive, permanent list of CFSA. Some social media pages have not been updated in several years, some social media pages or websites were no longer in service, and some of their email addresses bounced when we contacted them for interviews. Future dispatches will report on refined results and a firmer typology as we continue the process of confirming, and better understanding, active initiatives.
[2]See **Table 1** below for examples of initiatives.

farming skills, participants experience a much wider range of learning through interactions among members, between CFSA members and host institutions, external community members and allied organizations.

A radical pedagogical approach does not begin with a set curriculum; rather, it relies on inviting and platforming the exchange of embodied funds of knowledge (Gonzalez et al., 2005; Cruz et al., 2018). Funds of knowledge is a "community-oriented pedagogy" (Moll, 2019, p. 131), grounded in the idea that community members (particularly traditionally marginalized community members) have developed a wealth of lived experience, and produced and acquired knowledge through "the living of their lives" (Moll, 2019, p. 131). These funds of knowledge represent unlimited rich and diverse potential curricula. Each community member is a co-creator of knowledge, both a teacher and a learner. It is through these pedagogical spaces that hope, empowerment and resistance may be developed. A radical embodied pedagogy allows collaborators to envision systems beyond our current realities; it is the "belief in possibilities…the unlimited potential of practical problem solving and the transmission of knowledge and values" (Battiste, 2013, p. 175).

CAMPUS FOOD SYSTEM ALTERNATIVES

On-campus learning environments, outside the classroom, have been the subject of pedagogical inquiry for quite some time. In particular, wellness centres (Mirwaldt, 2010) and residences (Vetere, 2010) have been demonstrated as formative sites of learning through informal pedagogical experiences (see also Keeling, 2006; Buddel, 2015). Food systems scholars have also demonstrated the value of discrete spaces on-campus, beyond the classroom, that promote critical food systems learning. Roberts-Stahlbrand (2020), for example, makes a compelling case that informal food systems learning is an inherent—and crucial—element of the dining hall experience. Campus food growing spaces[3] have also been identified by scholars as important sites of food systems education. In the United States, campus food growing spaces ballooned from just 23 in 1992 to an estimated 300 by 2016 (LaCharite, 2016, p. 521). In Canada, meanwhile, research suggests that there are upwards of 80 postsecondary campuses with some kind of campus food growing space (Classens and Burton, in press).

By and large, these campus food growing spaces stand as a counterpoint to the conventional agricultural system and associated education paradigm (Barlett, 2011; Sayre and Clark, 2011). These spaces provide opportunities for experiential and informal learning through social organizing and agroecological experimentation—they serve as "insulated spaces for the growth of new nodes, actors and institutions in the food chain" (Barlett,

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[3]We use "campus food growing space" here to denote a variety of configurations, from small box planters (seen on many campuses) to farms of several dozen acres (such as at the University of British Columbia, or Trent University). There is, as yet, no exhaustive typology of these kinds of spaces in Canada (see LaCharite, 2016 for the American context). Our phrase here is meant to convey that the spaces exist on campus and are used to grow food.

2011, p. 103). Farms and gardens on post-secondary campuses "provide an alternative to the traditional model by focusing attention to sustainability initiatives and student leadership, as well as social dynamics such as food justice and community access to fresh produce" (Morris, 2017, p. 22). Classens and Burton (in press) demonstrate how campus food growing spaces constitute a paradigmatic pedagogical break from conventional agricultural education, while enabling students with the time and space to prefigure more equitable and ecologically rational food systems.

The notion of CFSA is informed by and builds on this work through a food systems lens. While work by Barlett (2011), Meek and Tarlau (2016), and Roberts-Stahlbrand (2020), and others demonstrate the learning opportunities of discrete spaces on campus—dining halls or campus farms—the CFSA analytic seeks to enable a broader focus in order to highlight the prefigurative and informal pedagogical value throughout the (alternative) campus food chain. In other words, we seek to theorize the moments all along the campus food system, from production through to disposal, as fundamentally pedagogical. Furthermore, by emphasizing the informal character of the learning opportunities afforded within CFSA, we seek to reveal how students are learning through the prefiguration and enactment of non-conventional food systems. Students have long been at the forefront of calls for socio-ecological change—from anti-apartheid politics, and the civil rights movement, through to fair trade and fossil fuel divestment policies (see Morgan and Davis, 2019). We see reflected within the context of CFSA glimmers of past and current student movements, as we seek to highlight and interrogate the pedagogy of these configurations.

An exhaustive qualitative and quantitative accounting of CFSA is beyond the scope of this short perspective piece, however we offer here a categorization schema that captures some of the diversity of these initiatives. It is worth noting that there is overlap between these categories, and the exemplars we feature here may express multiple dimensions within our schema.

To be sure, campus farm projects are the most common intervention, however our preliminary research reveals a rich diversity of allied initiatives that provide critical food systems learning opportunities along the food chain. As an example, the Seasoned Spoon Café at Trent University in Peterborough, Ontario, Canada is a co-operative café on campus that is run independent of the Chartwell's managed food system. The Seasoned Spoon provides paid and volunteer opportunities for students, they host a variety of food justice workshops and events, and importantly, they source over 50% of the food they sell in the café from a sister organization on campus - the Trent Vegetable Gardens. The remaining half of the food is sourced from local farmers or other co-ops in the area, demonstrating the contributions to sustainable local food systems CFSA make beyond the campus.

In some cases campus gardens provide food to culinary classes at their respective postsecondary institutions. For example, a portion of the food grown at the Humber College Food Learning Garden goes to The Humber Room—a student-run campus restaurant at Humber College. Similar partnerships take place with the Conestoga College Gardens and Conestoga's culinary

classes as well as the Loyalist College Garden and the culinary program at Loyalist College.

DISCUSSION AND CONCLUSION

These examples, and others, gesture at the abundance of informal critical food systems learning occurring on campuses across Canada, and beyond. While we find some cases where opportunities within CFSA are deliberately integrated into course curricula, significant learning opportunities exist independent of formal programs. However, the character of many (critical) food systems programs provide fertile ground for supporting and encouraging greater formal integration of CFSA into course curricula. For example, Meek and Tarlau (2016, p. 238) observe that "at the university level, food system educators distinguish themselves from other pedagogical approaches by incorporating systems-thinking, group learning, and a direct connection between theory and practice." Furthermore, food systems courses and programs at post-secondary institutions are often "disruptive of common beliefs and practices about knowledge and learning" (Valley et al., 2017, p. 477). Experiential and service-learning opportunities within CFSA can expose students to the *realpolitik* of alternative food systems and student organizing, within the structure and support of a class. At the same time, the goal of faculty or programs ought not to be a full formalization of the informal learning within CFSA. Some degree of autonomy and student leadership are essential to the vibrancy and creativity of these initiatives—and researchers have much to learn about pedagogy of these spaces as they exist on their own terms. Building alliances, outside the classroom, with student-led campus food systems initiatives is one way of enacting Freirean praxis—of destabilizing the staid foundation of the educational orthodoxy toward the realization of more equitable and ecologically rational food systems.

Finally, it must be said that although our outlined approach to pedagogy may be unconventional in a colonial context, this is how many Indigenous peoples have always conceptualized education (Cajete, 1993; Anderson, 2002; Bell, 2013; Bell and Brant, 2015). Further, CFSA leaders are not automatically radical pedagogues by virtue of their surroundings: the type of work, whether it is fairly paid, what is grown, methods of distributions, and leadership and decision-making are all areas for conventional pedagogy to influence. Failure to acknowledge and actively work against this leaves CFSA collaborators vulnerable to reproducing white supremacist, colonial relationships in pedagogical spaces (Dei, 1996; Friedel, 2011; Tuck and Yang, 2012; Mclean, 2013; Tuck and McKenzie, 2015; Aikens et al., 2016; Lowan-Trudeau, 2017). If CFSA collaborators occupy and use land to achieve their ends without an interrogation of historical and ongoing land theft in Canada and of the University's position as "an essential part of the colonizing process" (Smith, 1999, p. 65), they have doubly colonized the land that they operate on. This double-colonization is emblematic of the colonial state's project of ensuring settler futurity (Tuck and Gaztambide-Fernandez, 2013; Tuck et al., 2014), which also includes the repression of alternative food systems. Any form of education that does not explicitly centre the lived realities of Indigenous peoples, as well as Black and other racialized peoples, is a technology of settler colonialism and must be actively resisted.

CFSA that wish to embody radical pedagogy and resist settler colonialism must thoroughly examine their structures and processes. CFSA collaborators should center Black, Indigenous and racialized leadership and look for alternative methods of decision-making and distribution that rely on collectivity and mutuality. The lessons of Grundtvig, Carver, Du Bois and Washington echo in the work of (some) CFSA—but in order to realize the transformative potential of these spaces our radical pedagogy must be made explicit and deliberate (see for example Green, 2021).

Ultimately, in these fraught and uncertain times, we find hope and potential in CFSA. The students, staff and faculty committed to these initiatives are simultaneously forging more just and equitable food systems, while prefiguring new pedagogical paradigms. As we reckon with ongoing social inequity, global pandemics and climate chaos, Campus Food System Alternatives may serve as one crucible from which meaningful and lasting change emerges.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The project has been approved by the Trent University Research Ethics Board. The project follows the standards of the Canadian Tri-Council Research Ethics guidelines. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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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
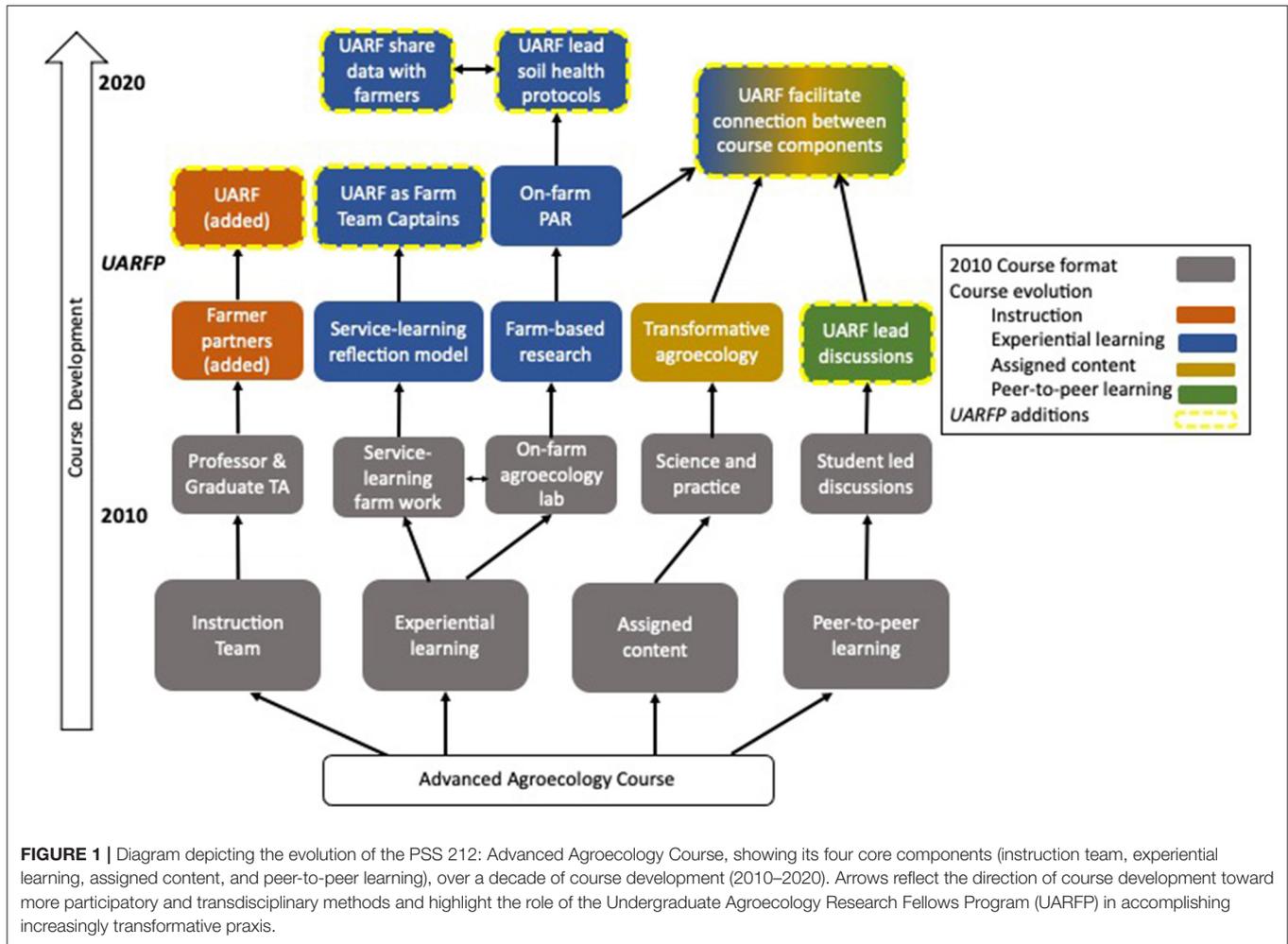
FIGURE 1 | Diagram depicting the evolution of the PSS 212: Advanced Agroecology Course, showing its four core components (instruction team, experiential learning, assigned content, and peer-to-peer learning), over a decade of course development (2010–2020). Arrows reflect the direction of course development 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
Module 1: Leadership, teamwork, and communication **Guiding question: What is an effective leader?**		
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
Module 2: Agroecology, transdisciplinarity, and participation **Guiding question: How can we best apply transdisciplinary methods for sustainable change?**		
	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
Module 3: Soil sampling and analysis **Guiding question: What is healthy soil?**		
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)	*Curricular work samples**	Five *reflective essays* and *transdisciplinary lab reports**	
	Document review	Farmer dinner notes	PSS seminar presentation
	*Interviews** (individual and group)	Five *individual interviews* and one *focus group**	One *focus group**
	*Facilitated reflection meetings**	One *facilitated reflection meeting**	*One facilitated reflection meeting**
	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)	Individual *interviews**	*One individual interview** per farmer (5 farmers)	
	Participant observation	*Farmer dinner**	
	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
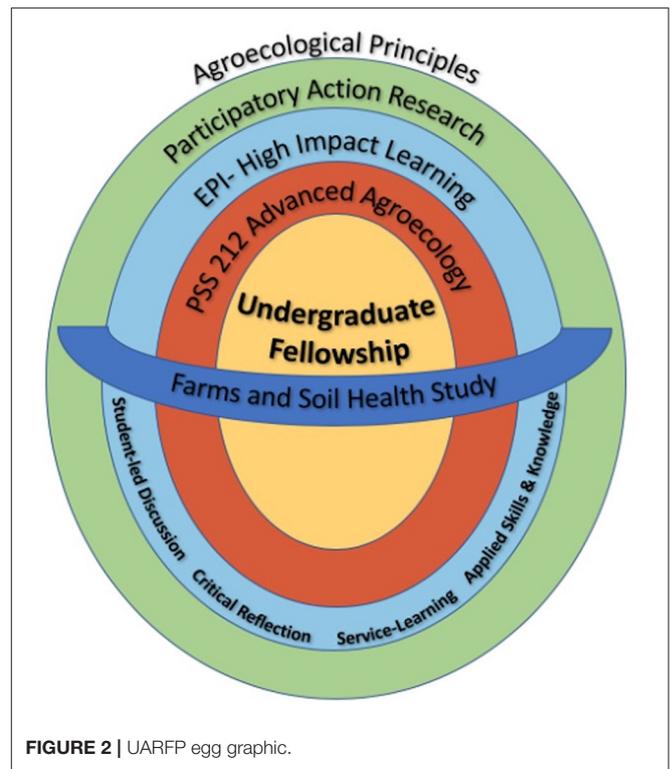
FIGURE 2 | UARFP egg graphic.

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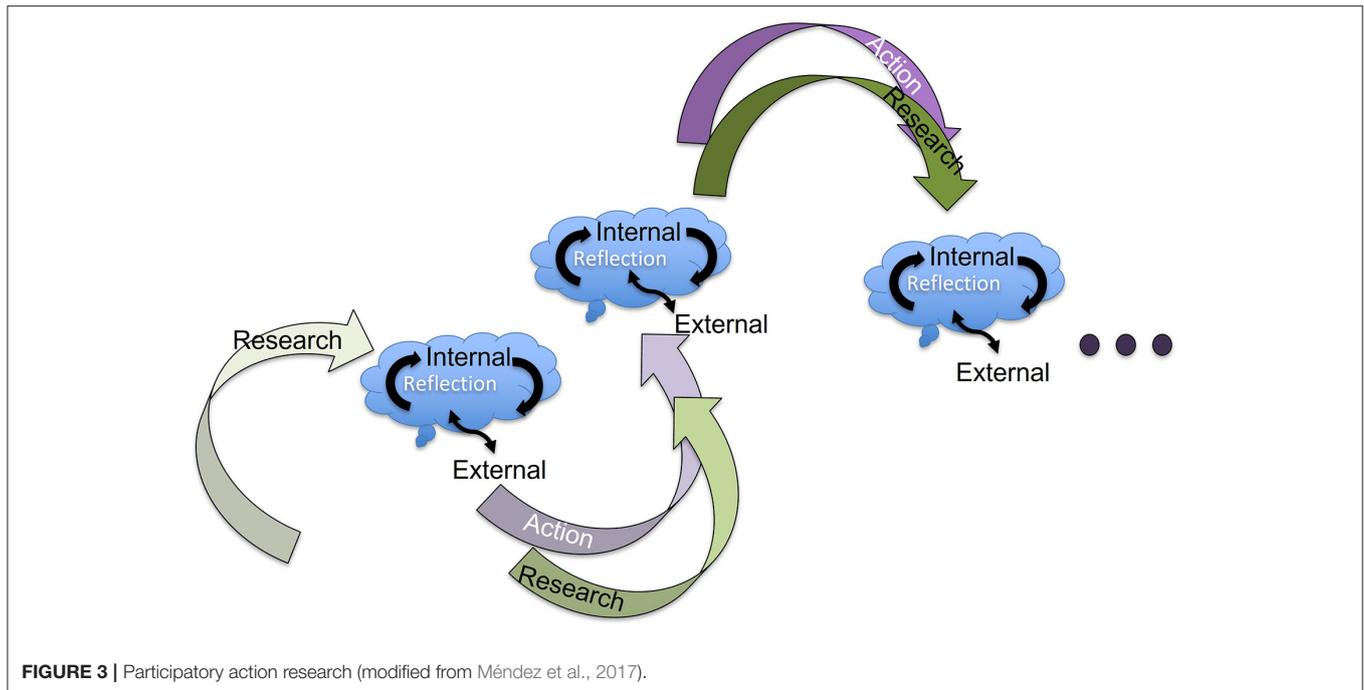
FIGURE 3 | Participatory action research (modified from Méndez et al., 2017).

gather data, to recover from mistakes, and to communicate results to move forward within a research process." From pre-flection, 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-oriented 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 UARFs 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.

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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Growing Opportunities for Equitable, Interdisciplinary Undergraduate Food Systems Education: A Review of Food Systems Education at Land-Grant Institutions and Development of Open-Access Materials

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Post-secondary coursework related to agriculture and the food supply has been at the core of the United States' land-grant system for more than 150 years. However, as the complexity of food systems has grown, so too have critiques that the education provided in these programs is too narrow to adequately prepare graduates to address pressing food systems issues. In response, some higher education institutions have developed degrees in food *systems*. To support development of this burgeoning field, we created, tested, and refined four evidence-informed, interdisciplinary, equity-oriented, open-access teaching modules. These modules are based on our experience conducting a multi-site, multi-year transdisciplinary investigation of subsidized, or "cost-offset", community supported agriculture and a survey asking instructors at land-grant institutions ($n = 66$) about topic offerings and current unmet needs for instructional materials. Our collaboration illuminated the potential and challenges of food systems research; underscored the value of transdisciplinary research teams; and identified several equity-oriented topics related to the design, implementation, and evaluation of local food initiatives suitable for advancing sustainable foods systems education. Instructors reported that the most helpful teaching aids would be case studies, lesson

plans with active learning components, and reference lists with relevant peer-reviewed publications. The final modules seek to shed light on the complexity of food systems projects and build knowledge, vocabularies, and skills across disciplines engaged with food systems. Per instructor-defined needs, each module features a case study, active-learning activities, and references. We anticipate that the adaptable modules will be suitable for a wide range of students and courses.

INTRODUCTION

In the U.S., there has been a long tradition of agricultural education that dates back to the Morrill Act of 1862 and the establishment of the land-grant system. By its mandate, the land-grant system was uniquely designed to provide educational opportunities to future farmers, tradespeople, and food system leaders (Schuh, 1986; Barrick, 1989; Grant et al., 2000; Parr et al., 2007). Initially intended to integrate technical education and the liberal arts and to translate research into practical applications, over the twentieth century agricultural education became increasingly specialized and technical in response to population growth and rapid scientific advancements (Schuh, 1986; Grant et al., 2000).

In recent decades, recognition has grown that addressing the complex issues facing food systems requires a workforce equipped with disciplinary expertise and a transdisciplinary focus. Necessary skillsets include technical and technological skills, systems thinking, and facilitating collaborative processes and decision-making that engage diverse stakeholders and enhance equity at all stages of the food system from production to distribution (Anderson, 2013; Ebel et al., 2020; Ingram et al., 2020). The next generation of food system professionals will be expected to possess more advanced social, emotional, cognitive, and technological skills than prior generations (Akyazi et al., 2020). Many traditional agriculture and food-related programs may be too narrowly focused and highly specialized to adequately prepare graduates to deal with the complexity in food systems. Thus, some colleges and universities – including land-grant institutions (LGIs) – have endeavored to meet this need by building food systems educational programs that teach students about the full range of people and activities involved in producing, supplying, and consuming food, as well as how these are interconnected.

As the field has evolved, several scholars have sought to characterize food systems education at the undergraduate level and identify best practices for faculty and essential skills or competencies for students (Mendes et al., 2011; Galt et al., 2012a, 2013; Clark et al., 2013; Galt, 2013; Jordan et al., 2014; Hartle et al., 2017; Valley et al., 2017, 2020; Brekken et al., 2018; Ebel et al., 2020). Most of this work has been based on experiences developing food systems courses and degree programs, often framed as sustainable food systems education (SFSE). In tandem, professional societies dedicated to advancing teaching in this area have emerged to support the development and exchange of teaching and learning practices. These professional societies include, among others, the Community of Practice on Teaching Food Systems, the Sustainable Agriculture Education Association [Teaching Food Systems: Community of Practice (CoP), 2021], and the National Collaborative for Food, Energy, and Water Education (Welcome to NC-FEW, 2021). Yet, despite these efforts, there is still a gap in information on the instructional support needs of educators in this field. Additionally, the availability of rigorous, open-access teaching resources for SFSE remains limited, especially resources that are transdisciplinary, evidence-based, and contain equity-oriented topics and processes that explore social justice themes.

With the goal of contributing to the development of SFSE, this paper has three objectives. The first is to briefly describe the current landscape of undergraduate food systems programs at LGIs and identify the types and formats of teaching materials needed by instructors of food systems courses. The second is to describe how the Farm Fresh Foods for Healthy Kids (F3HK) study, a transdisciplinary research collaboration that investigated the effects of subsidized community-supported agriculture programs on diets, farm businesses, and local economies (Seguin et al., 2017), informed the development of SFSE teaching materials. The third objective is to describe how we used the lessons learned from our research to develop open-access, evidence-informed, equity-oriented teaching materials for food systems-related courses.

LANDSCAPE REVIEW AND INSTRUCTOR SURVEY

To understand where food systems degrees were available and the needs of instructors, we conducted a landscape review of undergraduate programs at LGIs and deployed a survey for course instructors. For feasibility, we limited the scope of work to LGIs due to their historic emphasis on agriculture and community development, their wide reach, and lower costs relative to comparable private universities [de Vise, 2012; IPEDS (Integrated Postsecondary Education Data System), 2021]. We focused on undergraduate programs since most post-secondary degree students are enrolled at the undergraduate level (Schmidt, 2019). In 2017, we used the Carnegie Classification of Institutions of Higher Education to identify LGIs offering a four-year degree ($n = 89$). For each LGI, we accessed at least one undergraduate course catalog from the academic

years encompassing 2016-2018 and screened course titles and descriptions to identify those courses addressing food systems (i.e., course containing the phrase "food system" or a synonym in the course title or description). For each relevant course, we identified the instructor of record by searching online or contacting the university. In 2018, we sent a survey on course content and instructional needs to the 241 identified instructors.

Twenty-seven percent ($n = 66$) of instructors invited to the survey responded to at least one question and were retained for analysis. To assess course content, the survey asked participating instructors about the disciplines integrated into their food systems course(s) and the geographical contexts of their courses. The survey also included two questions to assess instructional needs. First, respondents were asked how helpful the following course materials would be on a 4-point scale ranging from "Not Helpful At All" (1) to "Very Helpful" (4): (a) reference lists for current peer-reviewed publications on specific food systems topics; (b) PowerPoint slide modules addressing specific food systems topics; (c) case studies to illustrate food systems topics; (d) reflection exercises for service learning; and (e) lesson plans addressing specific food systems topics that integrate active learning strategies, such as peer instruction, problem-based learning, and flipped classrooms. Next, respondents were asked to indicate if materials in any of 14 topic areas would be useful for their undergraduate teaching (see **Table 1** for complete list). Questions were developed with expert input from instructors at LGI and non-LGI institutions to reflect materials and topics relevant for a range of food systems courses. The survey was approved by the Institutional Review Boards (IRBs) at the University of Vermont and Cornell University.

Nearly all respondents (92%) reported that their courses cut across two or more disciplinary focal areas (data not shown). In fact, over half (54%) reported incorporating content from five or more focal areas. The five most common focal areas were environmental studies or science (55%), nutrition (52%), public health (49%), applied economic or community development (49%), and food safety (43%). The three least common focal areas were veterinary science (5%), journalism or communications (11%), and bioengineering (14%). Most courses (83%) focused at least somewhat on the U.S. food system.

Respondents reported that the most helpful materials would be case studies to illustrate specific food systems topics, lesson plans that integrate active learning strategies, and reference lists for current peer-reviewed publications (**Table 1**). Among the most sought teaching materials were those focused on introducing basic food systems concepts, and community and social sustainability in local food systems.

In 2020, we searched the websites of all LGIs offering a four-year degree to identify undergraduate food systems majors, minors, associate degrees, and credit-bearing certificate programs. To be included, programs had to integrate interdisciplinary content from "farm-to-fork" using a systems perspective that focuses on the whole picture and context, and interactions between dimensions of the system [IOM (Institute of Medicine), 2010]. Thus, programs that centered on one dimension (e.g., agriculture, food science, nutrition) were not eligible. We compiled a list of potentially relevant

programs and augmented this list with SFSE programs at LGIs identified by Valley et al. (2020) in 2019. Two co-authors then independently applied our inclusion criteria to the list and resolved discrepancies through discussion. For programs that met our criteria, we compiled basic information (institution; department, school or program; degree name; and degree awarded).

We identified 53 programs at 34 institutions (**Supplementary Table 1**), representing a growth in the number of programs and LGIs offering programs since reviews in 2015 (Hartle et al., 2017) and 2019 (Valley et al., 2020). Mapping the density of food systems programs at LGIs, we identified geographic differences (**Supplementary Figure 1**), with few programs available at LGIs in the southern U.S. and none offered at LGIs in the south-central U.S.

THE FARM FRESH FOODS FOR HEALTHY KIDS STUDY

Although modern industrial food systems often result in highly efficient production and less expensive food for consumers, the externalized costs on the environment and public health are well documented [IOM (Institute of Medicine) and NRC (National Research Council), 2015; Campbell et al., 2017]. In recent decades, local, community-based systems have reemerged as alternatives that offer farmers and consumers opportunities to engage directly about their foods. Because SFSE programs aim to prepare students to contribute to the creation of healthier, more sustainable, and more equitable food systems, they often emphasize progressive and alternative models of food production, distribution, and consumption (Valley et al., 2017). Community supported agriculture (CSA) is one such direct-to-consumer marketing model that has grown in popularity (Woods et al., 2017). In CSA, community members pay for a share of the farm's crop prior to the growing season and then receive fresh produce on a regular basis throughout the season. CSA participation has been linked to positive diet and health outcomes (Ostrom, 1997; Perez et al., 2003; Cohen et al., 2012; Minaker et al., 2014; Arbuckle, 2015; Curtis et al., 2015; Vasquez et al., 2016; Allen et al., 2017; Galt et al., 2017; Rossi et al., 2017; AbuSabha and Gargin, 2018) and may provide better economic returns to farmers (Sabih and Baker, 2000; Stagl, 2002; Saulny, 2008; LeRoux et al., 2010; Paul, 2019). CSA farmers often report the advancement of social and environmental commitments as primary motivations for pursuing CSA (Galt et al., 2012b; Morgan et al., 2018). However, recruiting and retaining lower income members has been identified as a challenge (Morgan et al., 2018), leading to mostly higher income membership and critiques that the marketing model perpetuates inequalities in access (Galt et al., 2017). To address this critique and support more equitable participation, some farms have developed mechanisms to offset the costs of membership, hereafter referred to as cost-offset CSA or CO-CSA. CO-CSA models take diverse forms, but share the common feature of reducing the large up-front costs to membership as a way to create a more just food system.

TABLE 1 | Instructors' needs for food systems-related teaching materials (*n* = 66).

Types of teaching materials on a scale of 1 (not helpful at all) to 4 (very helpful)	Mean (SD)
Case studies to illustrate specific food systems topics	3.4 (0.9)
Lesson plans addressing specific food systems topics that integrate active learning strategies, such as peer instruction, problem-based learning, and flipped classrooms	3.2 (0.9)
Reference lists for current peer-reviewed publications on specific food systems topics	3.1 (1.1)
PowerPoint slide modules addressing specific food systems topics	2.9 (1.1)
Reflection exercises for service learning	2.9 (1.1)
Topics for teaching materials related to the U.S. food system	**n (%)**
What is a food system?	47 (71.2)
Community and social sustainability in local food systems	44 (66.7)
History of local food systems/movements	40 (60.6)
Ethics relating to local food systems	38 (57.6)
Food distribution in local food systems	38 (57.6)
Impacts of local food systems on community development	38 (57.6)
Impacts of local food systems on nutrition and health	38 (57.6)
Methods for analyzing impacts of local food systems on diets and nutrition	31 (47.0)
Case study: impacts of subsidized CSA on diet, health, and local economies	31 (47.0)
Methods of economic analysis of local food systems	30 (45.5)
Food safety in local food systems	28 (42.4)
Engaging a broad range of stakeholders in local food systems	26 (39.4)
Laws pertaining to local food systems	26 (39.4)
Introduction to agroecology	23 (34.8)

In the absence of evidence on the impact and feasibility of CO-CSA models, the F3HK study was implemented by researchers with expertise in four disciplines relevant to food systems: public health, nutrition, applied economics, and agripreneurship (i.e., entrepreneurship in agriculture). F3HK was a community-based, randomized controlled trial to conduct rigorous between-group outcome evaluation as well as robust formative research, cost-effectiveness analysis, and economic impact assessments at the farm and community level. The project also included the creation of learning and teaching materials for farmers, community-based health educators, and university instructors. A full description of the study is provided by Seguin et al. (2017). Multiple aspects of F3HK can help advance SFSE, including the focus on an emergent equity-focused marketing model, working across disciplines, and building and disseminating evidence.

Although our team had extensive experience with community-engaged research at the onset of this five-year study, the collaboration deepened our understanding of the opportunities and challenges of transdisciplinary partnerships to address food systems issues. These included developing shared vocabularies, acknowledging disciplinary assumptions about what constitutes high-quality research and/or analytic approaches, building trust with communities and partners unfamiliar with CSA models and/or academic research, exploring diverse indicators to measure impact, learning new methods, and working through differences of opinion regarding topics such as study approaches, methods, and measures. In designing teaching materials, we wanted to integrate these experiences and lessons to provide a more nuanced and authentic perspective of food systems research.

MODULE DEVELOPMENT AND TESTING

Leveraging the findings of our research and drawing lessons from our collaboration on F3HK (Seguin et al., 2017; Becot et al., 2018; McGuirt et al., 2018, 2020; Morgan et al., 2018; White et al., 2018; Hanson et al., 2019; Sitaker et al., 2020), we developed a series of four modules for use in SFSE courses and programs (**Table 2**). The modules focus on case studies relevant to local food systems in the U.S., relate to insights that emerged from our research, and seek to help students build skills working across disciplines. Our intent was to introduce perspectives, vocabularies, and methods from different fields; provide real-world examples of equity-oriented food systems topics, and integrate core elements of SFSE pedagogy (Valley et al., 2017), especially systems thinking, collaboration across disciplines, and exploring problem-solving in situations of uncertainty. To align with the four disciplines most intensely involved in F3HK, the modules primarily draw from public health, nutrition, applied economics, and agripreneurship. The first module introduces students to some of the challenges inherent in developing local food systems interventions in communities with little awareness of the local food system and teaches how to apply a systems approach to identify local assets, strategic partnerships, and strategies to overcome obstacles. The second module aims to teach students how to evaluate the appropriateness of various dietary assessment tools for different research contexts and assess the impacts of community-based local food interventions on dietary quality. The third module introduces economic impact studies and teaches the fundamentals of economic impact assessment as it pertains to local food interventions. The final

TABLE 2 | Summary of education modules included in the "design, implementation, and evaluation of local food initiatives for farms and families" series.

Module	Objectives
1. What's a CSA? Creating a community-based local foods intervention where "local food" is a foreign concept	1. Identify ways to overcome barriers to create a successful cost offset CSA intervention in a setting not conducive to local food interventions 2. Identify ways to educate consumers to create a successful cost offset CSA 3. Identify ways to use existing systems and networks to create a successful cost offset CSA
2. Assessing dietary quality in community-based local foods interventions and evaluations	1. Describe the link between dietary quality and health, and the potential for changes in fruit and vegetable intake to alter risk for morbidity and mortality 2. Compare different ways to measure dietary quality including fruit and vegetable intake 3. Evaluate ways to measure dietary quality given specific objectives, resource constraints, and community settings
3. What is an economic impact study? Identifying how local food systems add to the economic engine of a community	1. Describe the difference between an economic contribution study and an economic impact study 2. Understand the basics of economic impact analysis, including data requirements
4. Adapting a CSA to open new markets for farmers and increase low-income families' access to local foods	1. Use basic principles of marketing when planning a cost offset CSA program 2. Describe how CSA farmers can go about developing a continuation plan to operate a cost offset CSA program

module presents the basic principles of marketing and helps students consider business decisions facing farmers interested in implementing a sustainable CO-CSA program. By prompting deep inquiry into and reflection about contextual issues and opportunities in local food systems, the modules prepare students for situations they are likely to experience as food systems professionals. CO-CSA models provide a grounding example for the first and fourth modules, while the second and third modules are relevant to a breadth of local food system models.

To help meet identified needs, each module includes background reading, PowerPoint slides (with audio narration available), a case-based classroom activity, reflection/discussion questions, and a reference list. Instructors can deliver two or more modules together, or can select the modules or module components that are best suited for their courses. We designed the modules for undergraduate courses; however, each includes suggested modifications for delivery in graduate courses.

Beta versions were drafted and piloted in spring 2019. Based on feedback, the modules were fully developed and tested during the 2019–2020 academic year. Following implementation, we asked instructors about the method of delivery of their course; whether they were teaching undergraduate or graduate students and how many; and to share their perspectives on the module(s) in free-text. We also asked students to rate their confidence in abilities related to each learning outcome before and after the session and the quality of the materials and implementation.

The modules were implemented through in-person, distance, and hybrid formats in undergraduate- and graduate-level classes across four institutions in three states (New York, North Carolina, and Vermont). Each was tested at least twice. Class sizes ranged from <10 to >50 students (median of 18 students). Instructor feedback indicated implementation was feasible and highlighted specific areas for enhancement (e.g., reducing redundant content, rearranging the order of content).

Sixty-seven students submitted surveys. For half of the learning outcomes, students' confidence in their abilities significantly improved after the lesson ($p < 0.05$; data not shown). Across the modules, students positively rated the overall

understandability, flow of information, background readings, and quality of the slides. Most felt that the lessons helped them develop intellectual and critical thinking skills and increased their ability to identify, formulate, and solve problems. Class activities and discussions were rated least favorably and identified areas that could use further development.

We finalized the modules based on student and instructor feedback. Revisions included streamlining content to better focus on the learning outcomes, incorporating new recommendations for facilitation (e.g., encourage students to read assigned materials before and after sessions, pause for discussion and to check for understanding more frequently), and adopting a uniform PowerPoint template.

DISCUSSION AND CONCLUSIONS

This paper describes how we combined our transdisciplinary F3HK experiences with research on offerings and gaps in SFSE at LGIs to develop, test, and refine four new equity-oriented, open-access, evidence-informed food systems teaching modules. Although prior efforts to understand this nascent field have cast a wider net (Hartle et al., 2017; Valley et al., 2020), our focus on LGIs enabled a more systematic approach. LGIs have been criticized in recent decades for veering away from their mission of applied research, teaching, and extension and more toward differentiation of knowledge and skills within narrowly defined disciplines (Schuh, 1986; Grant et al., 2000). This paper helps to document a shift toward interdisciplinary education within the land-grant system. However, this shift appears unevenly applied, with multiple food systems programs available to students at LGIs in some states and no programs available in others. This could have consequences for equity in the food system and ultimately impact sustainability and public health.

The "Design, implementation, and evaluation of local food initiatives for farms and families" educational modules respond to the need for teaching materials that are rigorous, draw from transdisciplinary food systems research, and use active learning approaches. In line with the open access philosophy, the modules

are freely available at www.rebeccaseguin.weebly.com/farm fresh-foods-for-healthy-kids.html. Open-access teaching resources can lighten the load of instructors facing an increasingly demanding academic employment environment (Sabagh et al., 2018). By reducing labor needs, open-access materials represent a possible cost and timesaving innovation, which may be especially relevant in emerging areas such as SFSE.

To ensure that the modules were grounded in actual research experiences and evidence, we balanced instructor preferences with lessons from the F3HK study. This means that there is not perfect alignment between the topics most preferred by instructors and the topics covered in the modules. However, a key strength of the final modules is that they respond to instructor-identified gaps in teaching resources by presenting real world research case studies alongside references to relevant peer-reviewed papers. We believe that – taken together – the content and teaching methods of our modules support all eight program learning outcomes for SFSE outlined by Ebel et al. (2020).

Future research could rigorously evaluate the modules, explore their reach and impact, and identify appropriate adaptations for different contexts and populations. These data could be obtained through tracking module downloads and surveying and/or interviewing instructors and their students. Research is still needed on the content of existing SFSE courses and how this content aligns with essential professional competencies identified by food systems practitioners. Additional modules can be developed that draw on other interdisciplinary or transdisciplinary field-based work, address unmet instructor preferences or practitioner skillsets, and incorporate other important food systems topics. We believe the core elements are the focus on systems thinking, working across disciplines, and evidence-informed problem solving to support more equitable food systems. We hope that this description of our process and the open-access dissemination of the modules will help spur further discourse, collaboration, and equitable sharing of evidence-informed food systems teaching materials.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board for Human Participant Research, Cornell University and the Institutional Review Board Committee on Human Research in the Behavioral and Social Sciences, 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

RS-F, SJP, KH, JK, AA, and MS conceptualized, designed, and led implementation of the Farm Fresh Foods for Health Kids (F3HK) research project. EB led the review of food systems courses and the instructor survey, drafted the manuscript, and made final revisions. EB and JK conducted the content analysis of food systems programs to ensure that all programs listed in this paper met the decided upon criteria. SJP, MS, LC, KH, JK, WW, and JM developed the modules and SJP, EB, LC, and KH field-tested the modules. MC, EH, and CB contributed to data collection and analysis. All authors have revised the manuscript for important content and approved the final version.

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SUPPLEMENTARY MATERIAL

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Preparing Undergraduate Students for Mentorship With Youth of Marginalized Identities: A Model for Food Systems Education

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Undergraduate programs in sustainability and food systems studies increasingly recognize the importance of building equity competencies for students within these programs. Experiential learning opportunities in these programs often place students in internships or service learning in racially, ethnically, and socioeconomically diverse communities. Many community-based organizations focus on youth development and empowerment through mentorship. Learning in these contexts can be mutually beneficial for mentors, youth and community organizations working in partnership toward a shared goal. Intentional preparation of mentors for these experiences is germane, particularly when mentoring youth with marginalized identities. Mentoring in the U.S. historically and currently rests on deficit-oriented discourses that position youth of marginalized identities as needing help, and that help is often provided by white and privileged saviors. Many programs intentionally or unintentionally employ assimilation models with white middle/upper class ideologies and expectations for success, which further lift dominant identities while marginalizing the youth of focus. These models also displace focus from systemic inequities, while placing blame on individuals. Building equity-based competencies with undergraduate mentors is necessary to avoid these downfalls that perpetuate harmful practices and discourses. Through intergenerational mentorship and urban agriculture, GNM works to advance environmental, social and racial justice in North Minneapolis. The GNM partnership was originally initiated by community members that wished to build pathways to the University and workforce for youth through agriculture, food systems, and natural resource sciences. In this study, we highlight results from our experience preparing undergraduate mentors through Growing North Minneapolis, an urban agriculture program and community-driven collaboration between North Minneapolis community elders and the University of Minnesota, focusing on youth and their communities. This case study serves as a model for building equity-based competencies in undergraduate programs. Our findings highlight (1) how the experience of collaborative mentoring in community-based internship for youth of marginalized identities can support the growth of undergraduate mentors and (2) how undergraduate mentors can be prepared to work with communities and youth of marginalized identities in critical ways within an equity-based framework.

Keywords: near-peer mentoring, critical mentoring, intergenerational mentorship, community engagement, urban agriculture, service learning, experiential learning

INTRODUCTION

Undergraduate programs in Sustainable Food Systems Education (SFSE) are emerging across many institutions of higher education in North America to address complex global socio-environmental food systems issues. Faculty and educators supporting these programs have identified knowledge, skills, behaviors, and attitudes needed by future food systems professionals to address inherently complex socio-environmental food systems issues (Valley et al., 2018; Ebel et al., 2020). Modalities of teaching, or "signature pedagogy" that address the fundamentals of a profession to students and future practitioners, have been identified for SFSE to include systems-thinking, multi-inter-and trans-disciplinarity, experiential learning, and participatory and collective action projects (Valley et al., 2018). Experiential learning activities are viewed as integral to SFSE as they integrate cognitive, psychomotor and affective domains of learning and allow students to practice collective action and transformative work.

Health and food-related inequities are disproportionately experienced by people of lower incomes and along racial and ethnic lines, underscoring the importance of understanding historic systems of oppression and bringing an equity-based approach to this work. A recent article authored by university educators identifies key domains of equity competencies for SFSE: (1) awareness of self, (2) awareness of others and one's interactions with them, (3) awareness of systems of oppression, and (4) strategies and tactics for dismantling inequity (Valley et al., 2020). Development of knowledge, skills, attitudes and practices that foster these competencies may be approached through experiential learning in SFSE. Experiential learning activities can take many forms and often include service-learning experiences, which typically include student engagement in off-campus, community-based projects with educational instruction designed to foster civic engagement and social responsibility through personal reflection on the experience (Lim and Bloomquist, 2015). However, service-learning practices have been notably critiqued as a "pedagogy of whiteness" (Mitchell et al., 2012), as these experiences often occur without proper consideration of the impacts of racism and white supremacy on under-served communities where many service projects take place. Thus, white supremacy is often reinforced as students fall into "white savior" roles, and any learning is done at the expense of communities without true benefit (Mitchell et al., 2012). Consequently, intentional discussions and reflection on impacts of systemic racism, particularly place-based and context-specific, should be integral to prepare students for engagement in service-learning experiences and are particularly aligned with the key domains of equity competencies for SFSE.

Youth mentorship programs are a form of service-learning, wherein undergraduate students are provided with preparation and guidance prior to engaging in a mentorship role with youth from marginalized communities (Hughes et al., 2012; Weiler et al., 2013). However, outcomes of these experiences are underreported in the literature. Youth mentorship programs typically claim to provide meaningful learning experiences to both mentors and mentees. Undergraduates who participated

in a university service-learning course that included guided youth mentoring practices showed positive outcomes for civic attitudes and action, self-efficacy, self-esteem, interpersonal and problem-solving skills, and political awareness (Weiler et al., 2013). In another study, undergraduates who participated in one-on-one mentoring with youth from low-income communities reported increased awareness of self-privilege, social inequities, recognition of the importance of civic action, and were better able to challenge negative stereotypes (Hughes et al., 2012). In this study the majority of the undergraduate mentors identified as white and middle-to upper-middle class while the majority of mentees were black high school students from low-income families. The role of race in socio-economic inequities was acknowledged, however, based on student responses, mentors exhibited deficit views toward mentees indicating inadequate equity competencies prior to engaging in youth mentoring. Such experiences risk harming the marginalized youth they claim to benefit, as shown by the author's conclusion that these types of service-learning experiences may be more meaningful to "economically privileged" college students than students whose backgrounds are similar to that of the mentees (Hughes et al., 2012).

While there are many documented benefits of mentoring for youth of marginalized identities—for example, socioemotional growth, academic success and developing a sense of agency (e.g., Adams, 2010; Watson et al., 2016)—there are serious concerns and risks to consider. Mentoring in the U.S. rests on deficit-oriented discourses that position youth of marginalized identities as needing help (Lindwall, 2017), often provided by white and privileged saviors (Baldridge, 2017). Many programs intentionally or unintentionally employ assimilation models with white middle/upper class ideologies and expectations for success, which further lift dominant identities while marginalizing the youth of focus (Weiston-Serdan, 2017). These models also displace focus from systemic inequities that need addressing (Weiston-Serdan, 2017), while placing blame on individuals (Noguera, 2009).

Wellintentioned outsiders may be limited in their understandings around important issues related to culture, identity and oppression. Mentor training in cultural competency has been leveraged to bridge these issues, however, such trainings are often limited in time and depth (Lindwall, 2017). Consequently, there are many mentors from privileged and white spaces working with youth and communities of marginalized identities, who are underprepared to do so effectively and responsively. This raises important questions around preparing mentors from dominant backgrounds to work with youth and communities of marginalized identities.

While research has provided some helpful guidance in preparing mentors (Lindsay-Dennis et al., 2011; Hughes et al., 2012), more research is needed in this field, particularly related to preparing mentors to work effectively with youth of marginalized identities. While research often focuses on youth outcomes, we must better understand the experiences and growth of mentors, and how to best support them. Additionally, research has not yet examined the particular challenges and opportunities in preparing mentors for community-engaged work, including the

valuable role of community partners. In these spaces, there are sometimes unique opportunities for partnership, including intergenerational and collaborative mentoring, both of which are underexplored. Our study sought to address some of these gaps in the research literature by focusing on the experiences of our university mentor participants, the impact of our preparation strategies, and the nuances of preparation for community-engaged work, including the opportunities for collaborative preparation and collaborative mentoring with community elder mentors. This work is situated in an urban food systems context within our Growing North Minneapolis summer program and discusses how this work builds key equity competencies identified for undergraduates in Sustainable Food Systems programs.

Specifically, we explored the following research questions:

- How does the experience of collaborative mentoring of youth of marginalized identities support the growth of undergraduate mentors?
- How can undergraduate mentors be prepared to work with communities and youth of marginalized identities in critical ways?

MATERIALS AND METHODS

Theoretical Framework: Critical Mentoring

The framework for our study comes from Torie Weiston-Serdan's (2017) critical mentoring. Critical mentoring rests on the belief that young people are natural revolutionaries, and challenges deficit-oriented notions of mentees. It shifts the paradigm from hierarchical mentoring relationships to participatory, emancipatory and transformative.

Weiston-Serdan acknowledges that youth, particularly youth of color, are living in racial, social, and economic toxicity. Mentoring needs to address and transform these root causes of contexts and systems, as well as treating the symptoms (i.e., academic performance, behavioral performance, etc.). Weiston-Serdan's critical mentoring rests on the central components of critical race theory to inform the central components of mentoring—to address and transform the toxic contexts in which youth live. In effect, critical mentoring supports counter storytelling, by youth and mentors, to counteract the metanarratives that are deficit-oriented, often positioning adults as saviors and youth as in need of saving. Critical mentoring incorporates difficult conversations around race, gender, class, sexuality, and ableism.

Weiston-Serdan advocates for youth centrism in mentoring, stating that "Young people have shown us time and time again that they are sound and substantial partners and leaders; it is us who refuse to recognize them in that way and who default to deficit notions of operating" (p. 25–26). Young people are at the center of critical mentoring; they must inform the work, and they must have voice, power, and choice. Critical mentoring intentionally incorporates the key components of cultural relevance—to help mentors understand how to center and use cultural assets of young people to drive meaningful experiences and engagement.

Case Context—Growing North Minneapolis

Growing North Minneapolis Summer Internship Program

This case study takes place within the greater context of a program called Growing North Minneapolis (GNM), which is a community-driven collaboration between North Minneapolis community elders and the University of Minnesota (UMN), focusing on youth and their communities. The GNM partnership was originally initiated by community members who wished to build pathways to the University and workforce for youth through agriculture, food systems, and natural resource sciences. The design of GNM comes from the firm belief that the North Minneapolis community is full of cultural assets and has rich skills and experiences in urban growing and food systems and the university can provide support with additional knowledge, skills and resources in agriculture, horticulture, and youth development.

While GNM has both a summer internship program and a school-year program, this study and context focuses exclusively on the summer internship program and related mentor training course. The summer program is an urban agricultural and environmental internship program for 14–15-year-old North Minneapolis youth of marginalized identities. This study took place during the third year of the GNM program. During the summer of 2019, 36 youth participated in the 9-week summer internship. Each group of six youth was paired with one community elder mentor and one UMN undergraduate mentor, and each group was responsible for two to three community gardens. The six UMN undergraduate mentors are the focus of this particular study. These intergenerational garden groups spent the summer growing and caring for gardens in their community, developing career skills, and learning about related topics related to agriculture and environmental sciences in contextualized ways (Livstrom et al., 2020).

Growing North Minneapolis Preparation Course

Prior to the summer experience, the undergraduate mentors participated in a 7-week preparation course—*Critical Mentoring in Partnership with Community*—designed and led by the first and second authors. The course was designed after the first summer of GNM in response to challenges experienced by the first cohort of undergraduate mentors in working across differences, deficit-oriented thinking, and white saviorism mentalities (Livstrom et al., 2018). The course was designed based on an interplay of practical findings from the first year's program, discussions with youth and community, and critical mentoring literature (e.g., Lindwall, 2017; Weiston-Serdan, 2017).

The course was aligned with the critical mentoring framework (Weiston-Serdan, 2017). The first part is to critically explore the toxicities of the world that young people of marginalized identities are growing up in. The progression of the course challenged undergraduate mentors to critically analyze and reflect upon the roots of colonization in agriculture, food systems, education, and academic knowledge production (see **Supplementary Table 1**). Systemic inequities and institutionalized racism local to their communities and nationally, such as redlining practices and the New Jim Crow

in our criminal justice system, were also explored. Next, in alignment with Weiston-Serdan's (2017) youth centrism, the mentors were encouraged to dive deeper into youth identities and intersectionality (Hooks, 2014; Weiston-Serdan, 2017), and power, privilege, and Whiteness (e.g., Baldridge, 2017; Picower, 2009). Lastly, in alignment with the critical mentoring framework, the course moved forward to culturally relevant pedagogies, critical pedagogies, and funds of knowledge (e.g., Ladson-Billings, 2006; Paris, 2012). The undergraduate mentors discussed and applied these ideas to community and youth work and in designing learning activities.

Youth centrism, critical theories and culturally relevant pedagogies were embedded throughout the course materials. Course materials included a mix of slam poetry by youth and people of color, TED Talks, podcasts, interactive computer explorations and academic articles. Course materials, including *Critical Mentoring: A Practical Guide* (Weiston-Serdan, 2017), were selected prioritizing the voices and perspectives of youth and adults of color.

There were seven in-person course sessions, each lasting 2 h, which met in the North Minneapolis community. Course sessions included interactive activities and discussions around the course material, as well as workshop sessions around youthwork, culturally relevant mentoring, community-engaged work, and garden-based lesson planning. The workshop sessions were sometimes facilitated by outside partner experts. Intentional within the design of the course, community mentors attended the majority of course sessions. This supported relationship building and intentional discussion between undergraduate mentors and community mentors. The course was kept small, to six undergraduate mentors. A course of this nature needed to be small in order to adequately support the students through the intensity of the material, intellectually and relationally. Additionally, the course instructor also had the responsibility to maintain the physical and emotional wellbeing of community partner participants.

In addition to weekly reflections, course experiences and assignments included: the initial design of youth workshops, a personal mentorship plan, and community hours. The workshops and community hours were added in the second iteration of the course. The undergraduate mentors each designed two workshops—one focused on a career development topic and one focused on a more technical agriculture or environment related topic. Workshop topics were predetermined by community mentors; undergraduate mentors chose topics they were interested in from the list provided. The mentors completed at least 30 h of work in North Minneapolis with community elders prior to the summer program. These hours allowed the mentors to build further relationships with the community mentors, to spend time in the community, and to contribute to gardening preparation.

Research Design

This study employed an explanatory, single case design. The case was bound by the 2019 Growing North Minneapolis undergraduate mentor preparation course in combination with summer mentorship program. Case study was chosen because

TABLE 1 | Undergraduate mentor participants (names anonymized) in Growing North Minneapolis program, 2019.

Pseudonym	College major	Academic status	Gender identity	Racial/ ethnic identity	Additional identity attributes
Amara	Sociology	Rising junior	Female	Asian American and Indian	Bisexual
Danielle	Environmental systems and policy management	Rising senior	Female	White	
Andrea	Environmental science	Rising junior	Female	Afro-cuban	
Emily	Agricultural education	Graduated senior	Female	White	2nd year mentor
Camila	Food systems	Rising sophomore	Female	Ecuadorian American	
Elise	Environmental systems and policy management	Rising senior	Female	White	

this methodology offers local, ecological validity and the unraveling of meaning in context (Yin, 2017). As an explanatory case study, we sought to explain how undergraduate mentors can be prepared to work with youth and community of marginalized identities in critical ways.

Participants

All six undergraduate mentors from the 2019 Growing North Minneapolis summer cohort were selected to provide depth into a variety of experiences. Information about the undergraduate mentors is provided in **Table 1**.

Data Sources

Primary data sources included weekly reflections during the preparation course, weekly reflections during the summer program, mid- and post-summer semi-structured interviews, and field notes with reflexive memoeing. Mid- and post-summer interviews and weekly reflections served as the primary data sources. Interview protocols were developed using Merriam and Tisdell (2015) guide to good interview questions and recommendations from Rubin and Rubin (2012). Interviews were designed to illuminate how participants were experiencing their summer program, with particular attention to challenges encountered and growth and learning. Weekly reflections during the course were open-ended and encouraged the undergraduate mentors to reflect on the course material and their own development through engagement in the material. Weekly reflections during the summer were also open-ended and designed to elicit information about the learning experiences as they were happening; what was working and not working, how their young people were responding, growing and developing, and overall challenges and success. Field notes were used as a secondary and supporting data source. They were recorded by the

primary author during the preparation course, at pre-program meeting sessions, post-summer meeting sessions and 2 weekly meeting sessions during the summer.

Data Analyses

Analysis of primary data sources (interviews, course reflections and summer reflections) were guided by constant comparative methods, involving iterative cycles of coding and comparison (Saldaña, 2015; Creswell and Clark, 2017). Interviews and written reflections were then analyzed through iterative cycles of deductive and inductive coding (Clark and Creswell; Saldaña). Deductive coding was rooted in the theory and literature around critical mentoring and working with youth and communities of marginalized identities. These deductive codes were used to develop an initial codebook to guide data analyses. Inductive open coding allowed themes to emerge organically from the participants. Coding was completed by the first author using Dedoose qualitative coding software to increase reliability in data analyses (Lincoln and Guba, 1986). Field notes were triangulated and analyzed to provide contextual data and to support and challenge already identified themes (Lincoln and Guba, 1986).

RESULTS

The findings are organized by research question. First, we address research question 1, *How does the experience of collaborative mentoring of youth of marginalized identities support the growth of undergraduate mentors?* through the presentation of themes related to the growth of knowledge and dispositions undergraduate mentors developed through the combination of their experiences. The findings begin with growth during the mentor preparation course and then growth during the applied summer program. Within each theme, connections are made to the second research question, *How can undergraduate mentors be prepared to work with communities and youth of marginalized identities in critical ways?,* by sharing specific experiences the mentors attributed as creating opportunities for growth. A summary of themes is provided in **Table 2**. Building off these thematic findings, in the discussion, we consider the second research question and the ways in which undergraduate mentors can be prepared to work with communities and youth marginalized identities in critical ways. Our findings are limited by our small sample size, as we sought for depth in understanding and transferability, rather than generalizability. Thus, we invite readers to make connections and applications between the elements and implications of our study and their own work. We do not claim that our findings can be generalized to broader settings or larger groups.

Growth During the Preparation Course

Growth during the preparation course focused on themes of sociopolitical and sociocultural consciousness; identity and intersectionality; from deficit to assets-based thinking; youth centrism; and culturally relevant mentoring.

TABLE 2 | Summary of thematic findings.

Growth during prep course	Growth during internship
Sociopolitical, sociocultural and critical consciousness	Sociopolitical and Sociocultural Consciousness
Embracing issues of equity and diversity	From theory to practice: Power, privilege, systemic inequities, trauma, diversity
Learning from people of color—insight into lived experiences	Challenging negative stereotypes
Deconstructing stereotypes and biases	Personal awareness of positionality and being in a space
Unpacking whiteness and white saviorism	Community work: community knowledge and cultural wealth
Identity, intersectionality and positionality	Collaborative Mentoring
From deficit to assets-based thinking and approaches	Working across differences: community work, communication, and conflict styles
Youth centrism and the power of young people	Intergenerational community learning and learning from diverse and multiple perspectives.
Culturally relevant mentoring	

Sociopolitical, Sociocultural, and Critical Consciousness

An important area of growth the mentors reported, taking up the bulk of their weekly reflections, was related to sociopolitical, sociocultural and critical consciousness. This theme includes sub-themes of: embracing issues of equity and diversity; learning from people of color; deconstructing stereotypes and biases; and unpacking whiteness and white saviorism. Particularly through the audiovisual resources, the mentors built new knowledge about global and local issues, like systemic racism, redlining, power, privilege, and reparations. Some saw this as a first step on their journeys to being responsive youth workers. Andrea reflected her growing understandings about present day systematic racism and the new Jim Crow,

> *It baffled me that the "justice system" was like an assembly line bringing people of color into jail en masse. It made me think about how the war on drugs became a systematically racist and politically-driven vehicle that circulated the idea that people of color were druggies, dangerous, irresponsible, incompetant, etc. While a white person consuming drugs was pitied and given help via treatment, the person of color was given years, sometimes decade-long sentences for mere drug possession.*

Danielle reflected on learning about power, privilege, and representation from Marley Dias—a 6th-grade African American activist and feminist. She said,

> *What resonated with me the most was her talking about having to raise money to get books featuring African American people, specifically girls. As a white woman, I have a major privilege. In this case, it manifests in being able to have as many books as I could possibly want that represent me. This is extremely sobering*

to realize that people do not see themselves in everyday books and stories...

Danielle's words also highlight the importance of learning from diverse perspectives, typically not represented in traditional education spaces.

Elise wrote about her learning around reparations from Ta-Nehisi Coates, "*The most important theme from this piece is that present-day America is (trying to) address racism, but is doing a terrible job at it because we are completely ignoring the history of violence, inequity, oppression, exploitation.*" Danielle expressed the importance of learning about issues close to her communities. She explained, "*Sometimes I find it easy to imagine that things are happening far away from me, instead of in the places that I spend time. The redlining maps were an eye opener because they showed visually how inequalities manifest within Minneapolis.*"

Embracing Issues of Equity and Diversity

All mentors wrote about their journeys in embracing material, discussions, and work around issues of injustice, equity and diversity, which some of them had largely avoided in the past. To guide their thinking, they found the most value in the TED Talks and slam poetries. For example, Elise reflected a powerful TED Talk and how it helped her grow,

> The Color Blind to Color Brave TED Talk really resonated with me because I've been in so many situations in which race is brought up and people automatically get very uncomfortable. This is so important because I want to be the person more intentional in recognizing race in these situations and help realize the strengths and power of diversity.

Andrea showed curiosity and initiative to keep exploring as she was exposed to issues of equity and diversity. She wrote, "*Watching the first video dropped me into a rabbit hole of videos on creative expression of racism, white privilege, being a black woman. It was enlightening; things I've heard before seasoned with individual personality and experiences of the poet.*"

Learning From People of Color—Insight Into Lived Experiences

Each of the mentors reflected on the TED Talks, podcasts, and slam poetries from people of marginalized identities. They appreciated the representation in voices delivering the content, the personality, the emotional charge, and the sharing of lived experiences outside of their own. Amara shared "*The slam poetries were ethnically centered and moved me deeply. We have a very limited view of how we see people of color. America shows controlling, racialized stereotypes so there are false narratives defined for people of color.*" Camila relatedly wrote on learning about the lived experiences of Muslim and Black identifying individuals,

> The poets provided a raw and emotional depiction of racism and inequalities as a non-white person living in the United States. The two Muslim poets noted that people believe they are protecting the world from terrorism behind their computer screen when in reality they are terrorizing Muslim and Arab people for simply existing.

In the slam poetry titled "Cuz He's Black," the poet described being questioned by the police like "mine field" and "war zone" because one wrong move can be detrimental. I cannot imagine the reality of being told as a child why white people may not like you or having to painfully attempt to explain uncontrollable and racist realities to a black child.

Through audiovisual content of diverse representation, the mentors were able to explore—intellectually and emotionally—lived experiences outside of their own and important to their work. This contributed greatly to their growing sociopolitical, sociocultural, and sociohistorical understandings and consciousness.

Deconstructing Stereotypes and Biases

Largely through exposure to diverse voices in representation of material and emotional connection with the poets, writers and speakers, the undergraduate mentors wrote about experiences in challenging their own pre-existing stereotypes and biases. Andrea reflected on the stereotypes of the North Minneapolis community, and the importance of not falling into these. She expressed, "*I have a lot more to learn about North Minneapolis and the history that makes it what it is today, and the importance of never assuming someone's history or perspectives. I fear this creates unbalanced, uneducated relationships and interactions.*" Elise wrote about power, storytelling and stereotyping,

> We don't always have the capability of knowing every nuance of everyone's stories. Stereotypes are the things we hold onto because for some reason it is easier for us to find differences between ourselves and others. This is so relevant to structural and institutional racism because the people and institutions in power have used these stories of difference to divide people. It will be important to be aware of the stereotypes that exist and challenge them through sharing multi-dimensional stories.

Camila reflected on the importance of embracing discomfort and deconstructing biases, particularly after viewing an impactful TED Talk. She wrote about her past response to uncomfortable situations and her future plans:

> Myers claims we all hold biases and it is important to look within ourselves in order to be willing to change. I was moved by her guidance about speaking out to benefit future generations. She gave the example of an aunt, uncle or grandparent saying an offensive or inaccurate term or stereotype at the dinner table. Rather than not commenting on it, people should correct those inaccuracies because children are also sitting at that dinner table. This has certainly happened in my family in which racist and inappropriate statements were made, yet the adults would not give a counterpoint. In the future, I plan on being more aware and reactive when incidents of silence occur in my family.

The mentors not only explicitly embraced reflections and discussions about equity and diversity regularly throughout the course, but also made commitments to do so moving forward with their young people and in their lives more generally, showing a growth in dispositions.

Unpacking Whiteness and White Saviorism

Inspired by a few articles, in conjunction with slam poetry, the mentors wrote about their developing understandings of Whiteness, colorism, white privilege and the dangers of white saviorism. Some of the mentors wrote about developing understandings of Whiteness. Amara reflected "*The slam poetry was powerful. They talked about wanting to be white. Whiteness is the ideal type in America. People of color are marginalized and not considered beautiful. When I was a little girl, I wanted to be white.*" Camila also wrote about White superiority and colorism, heavily impacted by the slam poetry selections,

> *I enjoyed seeing the two poets regain their confidence in their skin color. Their words were powerful—that they must "bathe in bleach" because their "skin was dirty." This is a metaphor of white washing in American society in which Caucasian features are unfortunately deemed as most appealing due to institutionalized racism and mass media.*

After engaging in slam poetry, Danielle reflected on her own White privilege. She wrote, "*Black folks, and folks of color are at a disadvantage from the time they are born. No matter who you are, having white skin allows you freedoms and opportunities that others do not have.*" Emily wrote on her developing understandings around White privilege in our educational systems and how this enabled her to remain unaware of important issues. She reflected,

> *I have also always incredibly benefited from the immensely obvious white-culture of the school system I was in, and my views had never been challenged; instead, the minority groups in my school always had to acclimate to my norms, instead of me having to expand my mind to understand the different background they had. I remained ignorant of other cultures and remained in a cozy bubble of privilege. My peers in minority groups, to the least degree had to understand white culture, and were potentially permanently impacted by the need to assimilate into a culture that forced them to have no other option.*

Emily demonstrates growth by acknowledging the lasting impact of growing up in a White supremacist society for both White people and people of color.

Amara reflected on an article on Whiteness and working with communities of color, and checked her own saviorism mentality that she felt she came in with. She wrote, "*I learned that when working with youth, it is important to know that you are not saving anybody. The youth are not deficient. They are here to learn and they come with many rich experiences that I should incorporate.*" Amara's words demonstrate an important shift in thinking about her role—as one of a savior to a learner. Emily's reflection also shows a recognition and shift in her thinking around mentoring and saviorism. She wrote,

> *I have grown up seeing the white person helping to 'lead troubled youth' out of their 'misguided worlds'. Therefore, I, and many Americans, have been exposed to the idea that a mentor, particularly a white mentor, fulfills their role by taking these 'at-risk' youth, engaging with them as their 'special projects',*

and helping them through their hard times through their 'all-knowing leadership'.

Through the course material, mentors made important growth in their understandings around Whiteness and connected these understandings to their plans for approaching their upcoming work with young people of color.

Identity, Intersectionality, and Positionality

Much of the learning about systemic racism and whiteness, while building sociopolitical and sociocultural consciousness, prompted student reflections and questioning their own intersecting identities and positionality. Some mentors wrote on the concept of intersectionality, which was brought up in their critical mentoring book. For example, Andrea wrote,

> *There are so many non-race related aspects of identity that are unexplored and misunderstood, ignored and demonized. Incorporating gender identities and sexual preferences that are social taboos, compounded with one's race and socioeconomic identity and age, into the critical mentoring scope makes it so much more complex than I was originally learning it to be...Critical mentoring goes deep into the nitty gritty of what it means to be a human, especially a marginalized one.*

Emily specifically reflected on the Whiteness of her identity and experiences, and what this might mean while working with youth of color. She wrote,

> *I have the potential to be a good mentor for students of other ethnic backgrounds, but there are many things I need to check myself on each day...I think the root of healing comes from acknowledging, not actively ignoring, the plain and simple truth; for me, that will be expressing the obvious fact that I am a very white woman, and I come from a different background than these youth.*

Some mentors reflected more specifically on their developing understandings and wonderings about their own identities and roles given their positionalities. About the course in its entirety, Amara said in an interview, "*It showed me what my role was. Without it I don't think I would've had the right initial mindset. It's provided me with good information, like, not having this savior complex, which to be honest, I totally had.*" Others questioned their role, given the material they had been exposed to. Elise wrote, "*The materials also raised a big question—what is my role, as a privileged, white female, in empowering black communities, especially minority youth, to exercise their power against the injustice that they face?*" Emily spoke further on this concern, particularly on issues of assimilation and success. She wrote,

> *I have been thinking about how one may struggle to offer productive means of mentoring a marginalized youth in an incredibly white-driven system. Past papers acknowledge that trying to uplift marginalized individuals can be counter-productive, because lifting them up, in certain ways, can be trying to make them comply to what it means to be successful in a white, capitalistic society. However, it is difficult to not do this to a certain degree, because complying to such standards is what allows a person to exist in this society.*

From Deficit to Assets-Based Thinking and Approaches

Through the course material, particularly the course articles, undergraduate mentors became aware of their own deficit-oriented mindsets around particular issues and began transitions into asset-oriented mindsets. Emily reflected deeply on the deficit-oriented ways in which society and media portrays and treats Black youth and the need to see Black youth for the wealth of knowledge and experience that they hold. She wrote,

> Black students are not to be treated as a completely different entity, as such movies suggest; they are complex individuals and their experiences, no matter what they have been, earn them unique wisdom that they can share in a cooperative partnership with their mentor. Youth possess incredibly wild amounts of knowledge, creativity, and ingenuity that mentors can frequently lack. They do not deserve to undergo their mentor's 'white savior' complex. I couldn't have said it better myself when the blog post closed with: "Mentoring Black youth is an honor, and it deserves to be treated as such."

After reading an article about deficit thinking, Amara wrote about transitioning away from deficit-oriented thinking when working with young people and communities of color, inspired by an article about working with Black youth. She wrote, "*not looking at black youth as "problem kids" that are "trying to make it out" is super important. We do not know anything about them and we have to keep an open mind, literally.*" Reflecting on that same article, Andrea also wrote about shifting her mentality,

> One thing that popped my bubble was not to have the mentality to help them "make it out" of their situations. That very mentality is horrible because it tells the youth that the context that raised them and gives them identity is something bad to run away from. This was extremely useful advice to me because I had this mentality without knowing it.

Andrea continued to write about her shift toward assets-based thinking, "*I also learned that culture and ethnicity can work to bond strangers who then carry the weight of the struggles by the people they identify with.*" Elise wrote on her intentions moving forward toward assets-based mentoring. She reflected,

> Youth, especially minority and marginalized youth, have so much knowledge and experience that gets suppressed with institutionalized racism and segregation in schooling. Youth are not being seen or heard. As a mentor, it is so important to provide a space for youth to be seen and heard, to be engaged and challenged. I am going to work on my listening skills to truly listen to understand, not just listen to listen. I really want to encourage my mentees to tell and share stories because stories hold so much power.

The mentors' reflections illustrate important growth toward assets-based, youth centric, dispositions. They demonstrated a shift in power dynamics from mentor to mentee as a valuable holder of knowledge, experience, and contribution.

Youth Centrism and the Power of Young People

Building on their developing assets-based mindsets, the mentors grew into mindsets of affirming the power in young people and planning to center the young people in their experiences. They built these indirectly through the powerful clips of youth voices, and directly through the concept of critical mentoring. Some mentors wrote about learning from and being inspired by the young people. Emily wrote,

> The content reminded me how powerful youth are, and that they hold so much potential on their own…Seeing the momentum one young person can have on the world, particularly a young person who has already articulated experiences set-backs due to institutionalized racism, I'm in awe. I also think of the potential that was in so many kids like Marley, but who were suppressed due to the current educational system, instead of lifted up from it. It is an immense loss to society.

Other mentors reflected pointedly on the concept of youth centrism. Camila reflected on the concept and connected it to her own childhood experiences. She wrote,

> I learned about youth centrism which is the concept of putting youth first in an organization…youth are more influential than adults give them credit for. When I was in elementary school I admittedly had so much more motivation and courage than I do now. Perhaps this youthful self power diminishes over time due to adults rejecting rather than fostering creativity and bravery.

The mentors' reflections on youth centrism demonstrate continued growth in their knowledge and dispositions around mentoring that builds from youth assets in a horizontalized way that centers youth as the stakeholders in the work.

Culturally Relevant Mentoring

All of the mentors reflected on their growing understandings of culturally relevant mentoring, a key component of critical mentoring, particularly toward the end of the course. Andrea reflected on the importance of the articles in combination with exposure to youth voices from many identities, "*I learned in the past 6 weeks the importance of making sure that mentors/teachers take into account the identities of every individual youth and use them as a source of knowledge with which to connect the lessons.*" Camila shared her understanding of culturally relevant mentoring, "*I learned about cultural relevance which is three ideas of academic success, cultural competence, and critical consciousness. I thought the cultural competence aspect was interesting because it focuses on using a students' culture as a drive to learning.*" Danielle wrote about her own realization around culture and learning, "*I never thought critically about the way cultural differences may impact students' learning. This is important to think about when creating content and super helpful as someone who is going to mentor folks who have different backgrounds than me.*" While theory to practice is a whole different process, the mentors made significant growth in their knowledge and perspectives around critical mentoring, inspired by articles on the subjects in combination with youth voices from slam poetries and video clips.

Growth During the Summer Program

Wow, I went from Growing North to my last year of college and I learned so much less in college. I would go into classes and I would have focus problems. I would have issues with learning anything genuinely. And this summer, I did the same internship, and I've learned so much more about plants, soil, interacting with people, so much more knowledge than I did in my last year at a big university. My last year of college I was thinking, like there's something wrong with my head. I just can't learn anymore. Then I went to Growing North and was like, oh no, I'm learning fine. (Emily)

Data analyses of interviews, weekly summer reflections, and field notes revealed important themes related to mentor's growth in knowledge, dispositions and skills related to critical mentoring during the summer program. These themes included: sociopolitical and sociocultural consciousness; personal awareness of positionality; community knowledge/cultural wealth; collaborative mentoring, working across differences and intergenerational learning/learning from diverse perspectives.

Sociopolitical and Sociocultural Consciousness

Building on knowledge built from the course materials and experiences, the mentors continued growth in sociopolitical and sociocultural knowledge, particularly in moving their understandings from theory to practice and in challenging negative narratives and stereotypes.

From Theory to Practice: Power, Privilege, Systemic Inequities, Trauma, Diversity

While the mentors grew significantly during the course in their socio-political understandings, many of them spoke about the importance of bringing this knowledge into a reality filled with layers of experience, history, humanity, and emotion. Danielle spoke about learning about systemic inequities and intersectionality through her experience,

I realized how different, like even within North Minneapolis, their inequities are. There's so many intersecting parts of a person's identity that each person's experience is so different than the other...this summer we had conversations about, like, what it meant to be the child of immigrant parents and how that experience of being like a black female is different... I knew that, but when you go to a neighborhood, you experience it.

Amara shared the importance of experiencing the humanity behind the sociopolitical issues she learned about through the course and through her sociology major,

I've grown in that I'm learning that the youth have and want a lot of agency in their lives. And, I forget to think about that...we talk about it in sociology in a very like Black people, Asian people, White people kind of way. And then you forget... there are actual people behind there. It's another thing to go into your community and to people and see what they actually think about the world and how they want to change it.

Andrea shared how working with her group of young people supported her understandings around the sociopolitical realities of their lives. She described a particular learning experience,

David...he's a big talker and he's definitely got a mouth on him. When we were talking about code switching... and we all came up with a list of people that you would need to code switch with... then you introduce the question and they talk in that way. One of them was police, and so it was David's turn to interview his partner. He was like, oh, I'm not even going to say nothing...I'm just going to be quiet. They already won. They already won before I did anything.

While the mentors had learned about inequitable policing practices and police brutality, hearing from the youth brought an entirely different learning experience—with personal connection and emotional charge.

Elise reflected particularly on learning sociopolitical and sociohistorical realities of trauma and the impact of trauma on the working community. She said,

When the group comes to the table, they bring their trauma with them. And that may be why there's arguments and blow ups and all this stuff. And so it just made me realize how much, like how much more complex issues of race and justice and historical trauma...and how much that plays into how people are and how they work.

Elise's experience and reflection speaks to the value, albeit challenge, of working with community mentors of identities, histories, and experiences completely different from her own. Through this, she developed understandings around sociopolitical histories and realities that she would not otherwise have access to, apart from a theoretically oriented distance through courses.

Challenging Negative Stereotypes

In their mid- and end-of-summer interviews, all of the mentors spoke about the negative stereotypes that are placed on the North Minneapolis community and youth. They shared the processes of challenging their own stereotypes and biases, and significant issues of others' stereotyping youth and communities of color. Elise reflected on her own processes of opening her mind to the beauty in the community beyond the stories she had heard previously. She said, "The picture of what North Minneapolis was painted like unfortunately was not the best. And I've been realizing how wrong that is and how you can't make judgments about certain communities without actually being involved in them." She continued to speak to the importance of moving beyond the single-story narrative about the community, and the importance of understanding different and valuable ways of being in spaces that can be subject to external judgment without understanding. She explained,

There's a lot of inclusivity and community and I think the community aspect looks a lot different here than it does other places. Everyone comes out in the street and jokes around and has fun together… not like, I'm gonna say hi to you from across the street or the picket fence. I think, as an outsider, it would be hard to

understand because that's how the media portrays it…. like, you're loitering or up to no good.

Elise's words demonstrate a depth of sociopolitical understandings around stereotyping and media depictions, as well as cultural understanding and appreciation for different ways of being.

Amara spoke more specifically about moving past her own unconscious biases around black men, through working with her group of five young black men. She shared, "*We had conversations in onboarding about how society stereotypes young black men…being around young black men, I've gotten to know how sweet and smart and sensitive they are… it's helping me engage with other black men…*" She moved on to talk about how she wishes others would approach young black men. She said, "*I worked with five young men, so they've been stereotyped as like, you know, violent and hyper masculine and not treating women well. …they all love and adore their moms. And, they all treat us with so much respect.*"

Personal Awareness of Positionality and Being in a Space

Coming into a community space as an outsider, particularly as an outsider from the university into a community of color that has been harmed by the university, is difficult work. This was a difficulty that undergraduate mentors consistently worked through and reached out for help throughout the summer. While it's not an area that any outsider can master, all the mentors grew in their consciousness of their positionalities and the intersecting identities they brought with them. Camila reflected on her developing understanding of how to be in the North Minneapolis community space. She said,

I'm just here to learn from others…like I just appreciate the work that everyone else has done and I'm not trying to take over…I realized that I'm not fully, like, a citizen of North Minneapolis. Mama Athena said it in a way that was much better—like you just have to come in here, like, wanting to understand people. Otherwise no one's going to trust you.

Camila spoke to a sentiment that all the mentors shared—that they were not there to take over, but instead there to help and support a vision and program already doing good work. Aware of their positionalities as university-identifying and aware of the appalling history of harm to the community by the university, they wanted badly for the community to understand that they had no desire for power.

Building on the understanding of self as a supporter, rather than leader, most mentors spoke about building awareness through listening and navigating their own voice in the space. Elise shared,

I learned something every single time we have a group meeting. It's just, to go in with open ears and kind of digest it as it comes. It is challenging to work with, cause I don't know, when is appropriate to insert my voice, you know? I've been really working on listening and now finding the balance of listening but also being able to—voice your perspective. And I don't think I always feel super comfortable

doing that being who I am, you know, and like based on my identity in the space that I'm coming into.

Elise's developing thoughts and actions show important growth in awareness of self and positionality related to community-driven work. Danielle also shared her process of relinquishing the control of always needing to have a voice and to respond to everything said. She explained, "*It's easy to get riled up about things and wanting to talk. It's important to listen to what everybody has to say…this group has taught me to listen without reacting and not come up with my own rebuttals.*"

Community Work: Community Knowledge and Cultural Wealth

All of the mentors—throughout the summer, in reflections, and in interviews—spoke about the beauty, depth and cultural wealth of the North Minneapolis community and community mentors, and about ways in which community work differs from university work. In this, they built an awareness and understanding of the value of knowledge and skills and cultural wealth outside of traditional University understandings of wealth and knowledge. Amara shared her thoughts about the overall value of having community mentors on the team and supporting the mentors, "*Having community folks ground us and tell us how it's important and they're always here to support us. They bring themselves and they bring their stories and that's very impactful because it makes them.*" Danielle reflected on the cultural assets and strengths of the community, community mentors, and how the community engages in work together,

Something that I've seen a lot is how the community works together to help one another. Like, when something happens everyone's out and asking you what you need, which is something that I don't find in other communities…And like the resiliency thing, just being able to like find resources and figure out things when they're not like given resources from outside people. They're able to figure it out…like you ask somebody in our group for something and they're like, well I don't have it but I'll figure out a way to get it.

Danielle's words show a growing understanding and appreciation for the cultural wealth of the community and community mentors—of working together, supporting one another and resourcefulness. This recognition is important, especially when traditionally white spaces, like universities, so often value things like individualism, efficiency, and economic wealth. Similarly, Andrea spoke to the power in the North Minneapolis community—in coming together and supporting and caring for one another and the community as a whole. She said,

It's exposed me to how much the community cares about itself…seeing people recognize the injustice of not having fresh food around, not having really good education systems, not having a safe place for their children to walk outside. The fact that they're trying to come together and unite and create a better tomorrow for their kids is really cool…

The mentors' reflections on the community and community-driven work show a deepened understanding of the North Minneapolis community, built through their hands-on experiences of working in the community and in collaboration with community mentors. Their reflections demonstrated a growing understanding of and appreciation for the cultural wealth of the community and the way the community worked together and advocated for justice.

Collaborative Mentoring

All the undergraduate mentors spoke about the value of their community mentor partners' knowledge, skills and perspectives, and learning from community mentors through collaborative mentoring. They learned about gardening, working with young people, working in the community, and about identity. Danielle reflected on the new experience of working alongside elders rather than people her own age,

> I never worked with community elders anywhere before or even like older people. It's always been like peers, my own age and interests. It's been fun for me to get to know the elders and see how much knowledge all of the elders have to bring. They've taught me so much about North Minneapolis being a person honestly, just like knowing my identity.

Elise also spoke about how the community mentors brought their whole selves, which encouraged her to do the same. She said, "*They're so different. I learned to, like, be yourself, and be cool with that. They are all so much themselves and it's awesome. They don't conform to the space that they're in.*"

Danielle shared how she learned from her community mentor about working with young people, specifically in prioritizing the young people over the garden work. She explained,

> I think Joseph is really good at like seeing—cause I get like too focused on the garden, but he's really good at seeing like when somebody is having an off day and that'll go over my head, because I'm so focused on like the actual like work. He helped me like check-in on the person. It makes me realize like, Oh yeah, I need to step back, slow down and like make sure that everybody's doing okay and understanding.

Amara also reflected on learning from her community mentor about working with youth and encouraging them to build on their strengths. She shared, "*When people are being particularly defiant, she's like—you know you're a leader right? People follow you. She's complimenting and telling them they gotta do stuff in positive ways...She sees the human and really brings out strengths.*" Amara felt that she received similar care and support from her community mentor partner as the youth. She said, "*She's always encouraging me...if I make a mistake, she's not on my case about it. She knows that I'm growing as a person too...*"

A few of the mentors spoke specifically to the sociocultural knowledge, history and experiences community mentors brought, as well as shared lived experiences to the young people, all of which they were able to learn from. Emily shared,

> He would just be blunt about a lot of things about racism, about systemic issues in North Minneapolis. He would bring up tough things about, like, gangs and like violence and stuff that I only slightly read about it, you know, but he would be able to be like, I remember this. I was there. I remember how this felt. I remember how this person felt when this person died.

Danielle spoke more specifically to how sociocultural history and experience her community mentor brought impacted her views and practices around working with her group of young people in important ways. She said,

> We were lenient about some things...and Joseph, this is one thing that Joseph said time and time again—that I don't have the cultural experience of—he's like, a lot of kids who grew up in North Minneapolis, they're not given more than one chance. He told me not to break down our kids, but just to remind them that like we're giving them chances now that they're not going to get again.

As demonstrated through the mentor reflections, the community mentor partnerships were critically valuable. The community mentors brought diverse and complementary knowledge, skills, histories and identities that greatly supported the growth of undergraduate mentors and garden groups as a whole.

Working Across Differences: Community Work, Communication, and Conflict Styles

While the mentors unequivocally learned and grew from working in the community and alongside community mentors, they also experienced significant challenges in working across differences. Through these challenges, they demonstrated immense growth and expressed appreciation. Elise shared about her growth through working across differences, "*I've grown in that I've worked with so many different kinds of people that have many different ways to interact with the world and speak and present themselves, and I've grown in my knowledge of how to navigate that.*" Similarly, Camila spoke more to the value of working with people of cultures and generations different than her own. She reflected, "*Gaining cultural understanding and working with people I hadn't before. I think that's important for anyone in any career. Working with different ages, the community mentors, because for most people, it's 10 years above, and here it's 50 years above.*"

Camila explained more about the differences in her garden group in contrast to more traditional working environments. She said,

> This is a community organization, like it's not gonna have the same structure as very professional corporate internships. So just having an open mind of—everything starts from the seed and just gets better over time. So we're still in that growing rooting process. We're a seedling. Like, you're not going to come here and it's going to be all spic and span...And I took that as a learning experience of being able to work in...something that is more free flowing.

The mentors' words show important growth in understanding how the ways in which things are done in community are

different than in the university. Both spoke about appreciating and thriving in structured environments, and both grew to appreciate and work with, rather than against, the different structures of community work.

Another marked difference that each of the mentors highlighted was the ways in which communication happened in the GNM community, including conflict resolution and different ways of showing respect. Elise spoke to the challenges she navigated in working with different communication and conflict styles than she was accustomed to. Camila reflected on the challenges and value of learning to work alongside and communicate in a diverse group,

I think we had a lot of differences and in a good way. I was able to learn how they've been treated in society and how they wish to be treated and what type of problems they see in the world. Ms. Cassandra does really well on letting us know her thoughts very clearly, which I really appreciate. So, learning to work with that is sometimes tricky, but really valuable to have different opinions and learning how to speak to someone who doesn't have that same opinion.

Danielle shared her experiences of navigating the different communication and conflict resolution styles of community mentors, particularly around learning to better understand the anger that was regularly expressed amongst elders. She explained,

The elders brought a lot of kindness. Sometimes they're kind of volatile to each other, but they always brought help and understanding when we needed it. Even if our two community members aren't getting along, they'll be able to separate issues. It confused me a ton in the beginning, cause I'm like, whoa, I thought you guys hated each other. And it's like, oh, it's just this one issue that we don't agree on. It's not like them as a person.

Emily spoke to another part of learning to communicate across differences—the importance of communicating one's vulnerabilities to develop trust and be heard. She said, "*When I articulated my vulnerabilities, is where they're more willing to hear what I'm saying. They want to take care of you. Showing your vulnerability to people in this community is, like, essential to being a part of it.*" For each of the mentors, learning to communicate across differences varied, yet all grew in their abilities to navigate working with people of different identities, different ways of working together.

Intergenerational Community Learning and Learning From Diverse and Multiple Perspectives

Mentors spoke about community learning, cultural learning, intergenerational learning, and learning from diverse perspectives. An openness to these types of learning is an essential disposition of a critical mentor. Danielle spoke about the power of community-based experiential learning in developing understandings around food insecurity in communities of color and problem-solving around these issues. She said,

A lot of what I've heard about North Minneapolis comes from my food classes at school. It's interesting like the way that they talk about it in classes vs. like the way it is...It's not the problem that there aren't stores. It's what's in the stores...I've realized that you really need to see it and explore it for yourself to see what solutions could actually work.

Andrea reflected on being introduced to cultural learning and community learning, and the power of these types of learning. She shared, "*I was introduced to cultural learning and community learning...It's a completely different dynamic. It's real shallow in the university...here—having a bunch of different people who are passionate about their work and showing me.*"

Amara spoke more on the differences of learning in community, highlighting the value of learning from others in a familial way. She shared, "*Learning from people allows you to learn more about the space that you're in. And, more than what a piece of paper can tell you... in school, you have to listen to the professors...Here it's a family environment.*" Community learning and cultural learning validate experiences and histories, and the reciprocal sharing of these through relationships, all of which constitutes valuable knowledge.

Many mentors spoke to the power of learning through a diversity of perspectives—youth, community, and peers. In Emily's words, "*It's more of a complete knowledge circle...it creates a more holistic view of learning for different life perspectives and the perspective of privilege vs. more trauma and trials and tribulations and acknowledging that both exist in the world.*" Danielle elaborated on the importance of having a diversity of voices and perspectives in a learning environment,

Generally here we're getting a diversity of voices. In the university, it's so many old white people telling you their pitch...and it's super frustrating because I know that there are other opinions...but where am I going to get that information from? Because, none of the papers I'm reading are representative of diverse voices and none of my professors are. But, within Growing North, those voices and representation are already integrated in.

Camila spoke more on the value of learning from the generational diversity in GNM, saying, "*We're all learning from youth and from older people. I think Growing North brings a lot of innovation and creativity because you're working with young people. So they have different ideas than maybe college students would.*" Elise commented on the knowledge that her group of young people brought to the table and the importance of learning from youth lived experience. She explained,

You can gain so much knowledge from experiences. And like some of that comes from age, some of that comes from education, some of that comes from the community that you grow up in. They all had a lot of knowledge about the way things are, about reality, the world that we live in.

The reflections of the mentors learning from multiple and diverse perspectives demonstrates their critically oriented dispositions, open to different types of knowledge and ways of knowing, outside typically regarded institutional knowledge.

DISCUSSION

In this section, we discuss our findings in connection to existing research on critical mentoring and critical food systems education. Specifically, we build on concerns about incongruencies in mentor/mentee identities (Lindwall, 2017) and associated risks of deficit-oriented, assimilation approaches that so often depict the mentor as a savior and the youth in need of saving (e.g., Baldridge, 2017). These concerns raise the critical question of how best to prepare undergraduate mentors to work with communities and youth of marginalized identities such that they develop the necessary knowledge, skills, and dispositions to support marginalized youth. Based on our research findings, we provide suggestions to prepare mentors, particularly those from dominant and privileged backgrounds, for work with youth and communities of marginalized identities.

Our findings show that critical mentoring necessitates a dive into context, the complexities of marginalization and the intersectionalities of oppressions. Critical mentors need to build cultural competencies and sociopolitical consciousness to engage in conversations and work around these issues. Aligned with Weiston-Serdan's (2017) work on critical mentoring, we found our undergraduate mentors benefited greatly from an intensive 7-week preparation course designated to develop important knowledge and dispositions. Extending Weiston-Serdan's work, we found that undergraduate mentors were best supported in engaging in this critical work through a diverse representation of course materials. They most regularly drew on the voices and lived experiences of individuals of various marginalized identities represented in the course, through slam poetry, blogs, and TED Talks. Mentors found audiovisual resources to be the most impactful and lasting, as they were often loaded with personal experience and emotion.

For many mentors, the preparation course was a crash course in issues to which they had little prior exposure. This created a shock factor as they grappled with tough issues, such as institutionalized racism, particularly given their own privileged identities and upbringings. The shock was uncomfortable and scary for most, but with time, they reported that the shock was also instrumental to their growth processes. These understandings and dispositions were further strengthened during the summer program as they moved from theory into practice, learning from community context and the diverse voices of community mentors and youth.

It was important for the mentors to build both local and broader contextual understandings of these issues. Broadly, they reflected regularly on what it means to be marginalized in America, with inequities in the justice system and policing, intergenerational poverty, intersecting marginalities, and negative stereotyping. This broad understanding was supported through local issues such a historical redlining in the North Minneapolis community. They also built local contextual understandings through hours working in the community and through interactions with community mentors. Weiston-Serdan (2017) also speaks to the importance of critical mentors understanding context, particularly because the context in which youth grow up, is toxic—racially, socially and economically. Like her, we found it important to support our mentors in critically exploring these contexts, especially as many were previously unaware having grown up in relatively privileged bubbles. Expanding on Weiston-Serdan's work, we found the exploration of both local and broader contexts to be beneficial to the mentors' understandings and building of critical dispositions. In course reflections, the mentors spoke about their plans to work alongside the youth to transform the toxic contexts surrounding them and to support them in creating new and positive narratives of their identities and communities. No longer able to ignore the toxic systemic issues, the mentors moved away from prevalent deficit-based and assimilationist mentoring (e.g., Baldridge, 2017; Lindwall, 2017) to assets-based thinking that builds on youth power leadership (Weiston-Serdan, 2017).

In our research, we found that beyond the course material, undergraduate mentors found important value in learning with and from others—their peers, community mentors, and youth. During the course, they appreciated having the designated time and space to talk through their developing understandings and to learn from others' identities, perspectives and lived experiences. They found value in building relationships through the sessions with community mentors and from spending time working with community mentors. During their summer program, the mentors reflected continuously on learning from their community mentor partners, the team as a whole, and the young people they worked with. Through this work, they continued to grow as critical mentors. They further developed important skills and dispositions in critical consciousness; recognizing and building from community and youth assets; in working across differences; and in personal awareness of their own intersecting positionalities in the community space. Critical was the ability to learn from a different system of knowledge—from community and cultural knowledge, rather than institutionalized knowledge. In our experience, the interaction from the course preceding the summer program was critical to their openness to embrace discomforts and to their readiness to grow in these ways. The course supported them in developing the foundations of critical consciousness and cultural competencies, as well as an openness to learning from diverse perspectives and different types of knowing and being.

Significance and Recommendations

Our findings have important implications for youth programs and university service-learning programs working to prepare mentors for youth work, particularly when working with youth of marginalized identities. Based on our findings, we offer five key recommendations, all to happen prior to the community-based summer program. *First*, we advise a preparation course or workshop series oriented in critical explorations around the institutionalized nature of racism, whiteness, and white supremacy, intersectionality of oppressions, power and privilege. We suggest explorations that are both broader and local/specific to the youth and communities involved. *Second*, after the shock factor of exploring these issues, we advise for the course to move into what we can do about these issues: to topics like critical and culturally relevant mentoring. *Third*, we recommend diverse representation of types of course materials, particularly

highlighting voices not often included in traditional education spaces—youth and adults of marginalized identities. In this, we also recommend a diversity of course material, as those not represented in traditional academic and schooling spaces are not often represented in traditional materials, like books and articles. For this, we leaned on slam poetries, blogs, YouTube videos, podcasts and TED Talks. *Fourth*, we recommend intentional reflection opportunities throughout the entire experience—for personal reflection and the time and space to reflect in community. *Fifth*, if possible, we propose community and partner involvement in the course. The power of learning from others' lived experiences and from learning in community cannot be underestimated. For us, this was community mentors. For others, it might be family, teachers and school partners, or community partners. We found that the recommendations highlighted prepared our undergraduate mentors to enter the summer program with an openness and eagerness to continue to learn from a diversity of perspectives, and to partner with youth and community to critically mentor.

The GNM program serves as an equity-based model for SFSE programs that are interested in undergraduate service-learning projects and poses an alternative to typical garden-based and farm-to-school curricula. Typical stated goals for many of these food systems programs have focused on encouraging youth to make healthier food choices, rather than investigating historic and systematic inequalities within food systems, which often perpetuate race and class-based assumptions and deficit mindsets (Meek and Tarlau, 2016). Although the undergraduate mentors in our study were enrolled in various programs of study, this cohort identified knowledge, skills, attitudes and practices reflective of equity competencies deemed important for sustainable food systems education, an emerging program of study (Valley et al., 2020). Self-awareness can be exhibited by "awareness of one's own assumptions, values, and beliefs that may contribute to personal biases" (Valley et al., 2020). As a result of participation in the preparation course and the summer program, student mentors showed evidence of increased awareness of white privilege, understanding Whiteness, and how white supremacy manifests when working in marginalized communities. Student mentors were able to identify implicit biases that appeared as deficit-mindedness toward the North Minneapolis community and shift their view to recognize and appreciate assets. Students also showed increased awareness of their social and cultural identities and positionalities in how they may be perceived by others and learned how to present themselves in a more supportive, collaborative role through this experience. Undergraduate mentors deepened their awareness of others and their interactions with them, including the ability to recognize the "extent to which socio-cultural structures and values may oppress, marginalize, alienate, or enhance privilege and power in other's lives" (Valley et al., 2020). This was evidenced by understanding how racism affects many of the youth mentees, such as unequal policing practices, and how intersectionality can influence social inequities. In addition, undergraduate mentors learned to tailor their communication styles to more effectively interact with both community mentors and youth mentees and expressed increased confidence in

working across generational, cultural, and racial differences. These attributes are important to engender trust and build partnerships necessary to do transformative, food-justice work and meaningfully address inequities in the food system.

The preparation course offered the opportunity to expose undergraduate students to systems of oppression, including identification of historic and current, localized systemic inequities that affect individuals in the North Minneapolis community, specifically. This allowed students to identify and dismantle negative stereotypes perpetuated in the media both nationally and locally. The preparation course was instrumental in shifting student mindsets to recognize deficit bias and focus on community and youth assets. Through a critical mentoring approach that we describe here, we show that undergraduate students in SFSE can gain key equity competencies that are needed to work collectively and collaboratively to dismantle food system inequities.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by University of Minnesota Institutional Review Board. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs. 2022.754639/full#supplementary-material

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Mapping Inequity: The Campus Foodscape as Pedagogy and Practice

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Universities and colleges are fertile foodscapes for action-based education. They are physical and socio-cultural sites where pressing food systems problems play out at micro to macro scales. Structural inequities based on race, class, gender and gender identity, sexual orientation, dis/ability, and other forms of marginalization affect both access to food and to agri-food learning opportunities. In this article, we propose that students can learn through their everyday experiences of engaging with their physical and socio-cultural environment, namely the campus food system, by conducting foodscape mapping. Since 2015, the University of California Berkeley Food Institute has supported the Foodscape Mapping Project, in which students, staff, and faculty generate food systems knowledge while developing practical interventions to advance justice, equity, diversity, and inclusion (JEDI). We investigate how campus foodscape mapping might generate substantive learning about JEDI in food systems education; the kinds of learning that take place through foodscape mapping; and the educational practices and institutional structures that can support learning through foodscape mapping. We identify at least eight forms and processes of expansive learning that emerged through mapping work, using students' own insights into what they were learning. Finally, we reflect on our learning experiences in running the project, and develop broader design elements that other campuses can apply.

Keywords: foodscape mapping, campus food systems, food justice, social justice, pedagogy, learning, JEDI

I mean, this isn't even a hyperbole, but it was a life changer. Because I had never thought about food in this way, I could connect my personal interests in food with research in a more academic focused way with these different research tools.
~ *Nathalie Muñoz, undergraduate transfer student*

INTRODUCTION

Universities and colleges are not only institutions which provide sustainable food systems education that students then carry out into the world. Campuses are also fertile places for engaging in action-based education—that is, learning from experience in practicing social change—as they are physical and socio-cultural sites that reproduce larger food system problems. In particular, structural inequities based on race, class, gender and gender identity, sexual orientation, dis/ability, and other forms of marginalization affect access to both food and learning opportunities. Prior to (and further exacerbated by) the COVID 19 pandemic, 41% of students at universities in

the United States reported food insecurity (Nazmi et al., 2019). Yet hunger does not harm all students equally. Minoritized students are far more likely to suffer from food insecurity than other students—specifically Black, Latinx, Native American/Alaska Native, Native Hawaiian, LGBTQ+, foster youth, first-generation college students, student parents, financial aid recipients, and students who were food insecure as children (Martinez et al., 2018, 2020; Nazmi et al., 2019).

In parallel, food and agriculture-related majors and courses, often embedded in environmental science programs, frequently do not interrogate how their curriculum valorizes epistemologies and content that exclude non-dominant students' knowledges and experiences. By primarily focusing on agricultural production and nutrition through a Western scientific standpoint, these programs manifest what Ebel et al. (2020) call "problematic and harmful patterns of hegemony, ethnocentrism, ahistoricism, depoliticization, salvationism, uncomplicated solutions, and paternalism that permeate the food system and society broadly" (p. 7). Martin and Hartmann (2020) reveal how whiteness, racism, and homophobia intersect in agricultural education, creating hostile environments for minoritized students. When food systems equity issues are discussed, they are often treated as external to the university, rather than probed through the lived experiences of students. Moreover, the teaching practices and overall culture in environmental science departments are often hostile to Black, Indigenous, and other students of color (Esquivel et al., 2020; Cronin et al., 2021).

In recent years, researchers working in the food systems higher education space have called for a signature pedagogy for undergraduate curriculum (Valley et al., 2018; Ebel et al., 2020) that is equity-oriented (Valley et al., 2020), values-based (Galt et al., 2012), and student-centered (Galt et al., 2013). We add to this growing body of work by applying the theories of expansive learning (Engeström, 2001; Engeström and Sannino, 2010) and justice-oriented science pedagogy (Morales-Doyle, 2017; Davis and Schaeffer, 2019) to propose that students can learn through their everyday experiences of engaging with their physical and socio-cultural environment, namely the campus food system, by conducting foodscape mapping.

Engeström developed the theory of expansive learning as an extension of Vygotsky (1978) cultural-historical activity theory (CHAT) framework to account for the fact that learning is not simply a vertical process, by which individuals gain new skills and knowledge in their specific cultural environment through interaction with more advanced peers and teachers. While Vygotsky seminal work elucidated the fundamental sociohistorical aspect of learning, Engeström's intervention accounts for learning *in the unknown:* "People and organizations are all the time learning something that is not stable, not even defined or understood ahead of time. In important transformations of our personal lives and organizational practices, we must learn new forms of activity which are not yet there. They are literally learned as they are being created" (Engeström, 2001, p. 137–138). Engeström's theory thus focuses on the possibility of transformation through collective, horizontal learning where the current context is questioned, contradictions are taken as a given, and both articulation

of problems themselves and solutions are co-generated in cycles of inquiry. Engeström's theory of expansive learning emerged from his empirical work with Finnish families, medical personnel, and hospital managers learning together to address problems in health care for children with long-term illnesses. In dialogue with Engeström, Gutiérrez draws on her decades-long literacy work with high school students from migrant-farmworker families to bring attention to the possibilities of expansive learning in minoritized communities (Gutiérrez and Larson, 2007; Gutiérrez, 2008). She calls for learning ecologies that cultivate a "sociocritical literacy…that privileges and is contingent upon students' sociohistorical lives" (2008, p. 149). Likewise, Davis and Schaeffer (2019) state that justice-oriented science pedagogy emphasizes the learning power of students "examin[ing] socio-scientific issues of personal and communal importance" to them (p. 369).

Since 2015, the Berkeley Food Institute at the University of California, Berkeley (UC Berkeley) has supported the Foodscape Mapping Project as a pedagogy to catalyze participatory, justice-oriented food systems learning. The project uses the UC Berkeley campus as a living laboratory for students, staff, and faculty to generate food systems knowledge while simultaneously developing practical interventions to advance justice, equity, diversity, and inclusion (JEDI) in the campus foodscape. Foodscape mapping helps make the campus food system substantially more visible in a context where it normally exists as a largely invisible infrastructure. Campus members eat at dining halls, wander through a production garden, buy soda from vending machines, or take a food-related class, but rarely think about the larger structures and processes that adversely affect the lives of minoritized students and staff, configure the kinds of food and courses available, control whether gardens can be created, or determine the employment conditions of staff at campus eateries. With over 60,000 students, faculty, staff, postdocs and visiting scholars[1], over 45 eateries, a $10 million PepsiCo pouring contract, a web of suppliers for dining halls, restaurants, and catering, and 185 food courses, UC Berkeley has a complex campus food system that contains many injustices and eludes ready comprehension.

Foodscape maps, then, can create the "missing object" of a campus food system. "By constituting missing objects— representations, tools, practices or artifacts that stand in for something that cannot be easily experienced or envisaged— people can speak about things that they previously could not" (Iles, 2005, p. 164). People can visualize the workings of the campus food system, bridge distances, catalyze dialogue, and interact with each other *via* missing objects that extend their cognitive and social capacity. Foodscape maps can also

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[1]In spring 2020 (reflecting pre-Covid numbers) the Berkeley campus consisted of: 30,411 undergraduate students; 11,667 graduate students, 1,511 regular faculty; 1,401 other faculty (i.e., lecturers and visiting faculty); 3,286 other academics (i.e., postdocs, staff researchers, librarians, and cooperative extension titles); 8,369 staff (operational, technical, professional, managerial, and executive); 4,160 affiliates/non-employees (includes visiting scholars and independent contractors); and countless community members and alumni who frequent campus regularly (Office of the Vice Chancellor of Finance, 2021) See: https://calanswers.berkeley.edu (accessed August 15, 2021).

expose the hierarchical and stratified decision-making power relations within a campus food system that lead to problems of equity and inclusion. More specifically, foodscape maps offer a "learning platform" (Röling and Jiggins, 1998) for students, faculty, and staff to come together to achieve both deep and wide learning about their campus by, for example, generating an array of spatial location maps, oral and written stories about minoritized student experiences with food injustices, visualizations of course offerings and "hot spot" tensions, and surveys of fraternity and sorority community food disparities. Maps can be developed according to the particular situations and needs of individual campuses. Mapping enables student learning in ways that are much more difficult in conventional courses and internships.

To better understand whether and how foodscape mapping can contribute to critical food pedagogy, in this two-part article we investigate the following research questions:

- How might campus foodscape mapping generate substantive learning about JEDI in food systems education?
- What kinds of learning takes place through foodscape mapping?
- What educational practices and institutional structures can support learning through foodscape mapping?

In part one, we provide an overview of the Foodscape Mapping Project before describing the pedagogical approach and structure of the learning environment underlying the mapping work. We then use an example of a Greek Life sub-project to illustrate the cycles of research and action that the project nurtured. To analyze the research questions, we draw on our participatory observations between 2015 and 2020 as the project leadership team (Fanshel as project director and Iles as principal investigator); reviews of student notes and feedback throughout the length of the project; and retrospective interviews conducted in mid-2021 with eight core student fellows. Based on this interpretative analysis, in part two we identify at least eight forms and processes of expansive learning (Engeström, 2001; Engeström and Sannino, 2010) that emerged through mapping work, using students' own insights into what they were learning. Finally, we reflect on lessons from our experiences of running the project, and discuss several design elements that other campuses can adapt to meet their needs.

UC BERKELEY FOODSCAPE MAPPING PROJECT OVERVIEW

The UC Berkeley Foodscape Mapping Project is a democratically-produced, interactive digital map that offers extensive data on the structural factors affecting diversity, equity, and inclusion across campus activities and units. Our project's working definition of a campus foodscape is: *Entities that make up food-related learning and practice, encompassing (but is not limited to) teaching, research, student organizations, activism, administrative decisions and initiatives, support services, campus gardens, dining services,* *eateries, catering, and other procurement*[2]. Developed through community workshops, student research, and visual and auditory design projects beginning in 2015, the map both reveals barriers to the full participation of historically marginalized campus members in food-related learning and practice, and highlights opportunities for, and successes in, overcoming such obstacles. To see what the map encompasses, visit the UC Berkeley Foodscape Map website (Berkeley Food Institute, 2021). Between 2015 and 2021, a core of 38 undergraduate and graduate fellows have engaged with the project through in-depth research and coursework, and 132 additional students have participated more peripherally in data collection and visualization. Over 2,500 other members of the UC Berkeley community have also contributed to the project *via* surveys, interviews, crowd-sourced data, and public events.

The project website includes two full-system maps that attempt to show the big picture of our campus foodscape: (1) the Campus Food Players, a power map which displays all foodscape nodes organized by formal reporting structure, allowing map users to see how decisions and funding travel through the system (see **Figure 1**), and (2) the Geographic Asset Map, which shows locations and useful data about important food-related services and facilities at UC Berkeley, from crucial basic needs services like the UC Berkeley Food Pantry, to campus gardens, eateries, and self-service facilities (lactation rooms, microwaves, water refill stations, and zero-waste stations) in and around campus buildings (see **Figure 2**)[3]. Eighteen additional "spotlight maps" explore structural inequities and/or celebrate successes in achieving change for JEDI in specific foodscape nodes within the four broad categories of academic units, campus facilities, service units, and student leadership. The maps are a patchwork quilt of different visual, narrative, and auditory designs that represent the creative choices of student mapmakers. A broad spectrum of social science and physical data collection methods inform the maps, including surveys, content analysis of archival documents, key informant interviews, oral histories, crowdsourcing, and physical surveys (see **Table 1** for details on each spotlight "map within a map," data collection methods, and map type). The maps collectively shed light on how the campus food system operates in everyday practice and how it affects community members' lives.

Beyond the map as a "product," the Foodscape Mapping Project continues to be a learning platform that interweaves community-based participatory research, pedagogy, and advocacy. Through cycles of inquiry and action, the project has evolved across a series of iterations and sub-projects rather than as a single overarching effort: it has followed various "hot spot" topics circulating in the campus community and the interests of individual student team members. In 2018, the project team held a large public town hall and summarized the research findings to date into a synthesized report that offered policy and program recommendations and identified entities throughout UC Berkeley's institutional structure with the influence to

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[2]See Vonthron et al. (2020) for an extended discussion of what a "foodscape" entails.

[3]The Geographic Asset Map is also available in mobile application form, *via* Berkeley Mobile.

Berkeley Food Institute
Campus Food Players

Spring 2018

Academic Units — Campus Facilities — Service Units — Student Leadership

BFI Partner School

# of BFI Affiliates

# of Food Courses

College of Natural Resources (🏠 , 👤 54 , 📖 61)

Academic Programs
International and Executive Programs (👤 1)
Masters in Development Practice (📖 1)
Nutritional Sciences and Toxicology (👤 3 , 📖 16)
Plant and Microbial Biology (👤 4 , 📖 9)

Atkins Center for Weight and Health (with Public Health)

Berkeley Food Institute

California Outdoor Engagement Coalition

Center for Effective Global Action

Gill Tract Field Station — UC Gill Tract Community Farm

Oxford Facility

Berkeley Unified School District Cooking and Gardening Program Student Internship (with Graduate School of Education)

FIGURE 1 | Campus food players, with the animated power map fully expanded. The inset features a detail. In the online map, each tile contains a live link to the unit. See: https://food.berkeley.edu/foodscape/map/. Data collection by Angelina Amezcua, Nadia Barhoum, Rosalie Zdzienicka Fanshel, Melina Packer, Will Payne, Dennis Uyat, and Kara Young. Final visualization by Will Payne.

FIGURE 2 | Geographic asset map. In the online map, each icon opens to a pop-up with information about the resource. See: https://food.berkeley.edu/foodscape/ geographic-map/. Basic needs data collection by Emily Altman and Natalia Semeraro. Campus gardens data collection by Nathalie Muñoz, Meg Prier, and Natalia Semeraro. Campus eateries data collection by Will Payne, Melina Packer, Hortencia Rodríguez, and Kevin Tuok. Lactation room data collection by Kim Guess. Microwave data collection by KC Chung, Margaret Shi, Hannah Tong, and Lucy Yu. Water refill station data collection by Kevin Tuok and students of NST 166: Nutrition in the community with Professor Mary Lesser. Zero waste station data collection by Claudio Valencia. Visualization and development by Will Payne and Kevin Tuok. Map icons by Kevin Tuok and Shalandy Zhang. Project manager: Rosalie Zdzienicka Fanshel.

enact change (see Fanshel et al., 2018). The town hall and report enabled the project team—and campus community members—to have a comprehensive perspective of the UC Berkeley foodscape for the first time[4]. This sparked subsequent cycles of data collection, mapping, and advocacy projects to seek specific changes for JEDI in the UC Berkeley foodscape.

PEDAGOGICAL APPROACH

As a pedagogical approach, the Foodscape Mapping Project is broadly rooted in the critical principles of praxis, or knowledge generation and regeneration through action, reflection, and dialogue (Darder et al., 2017; Freire, 2018). We take seriously Freire's (2018) call for a "problem-posing education" where learners develop consciousness of forms of social domination in their own contexts to work toward liberation, as opposed to simply "problem-based education." The project recognizes students as authoritative producers of knowledge about campus food systems, and draws on their own lived experiences before and during their time at Berkeley to identify and inform

the specific topics to be researched as well as methods of inquiry (hooks, 1994; Gutiérrez, 2008). Our primary pedagogical inspirations for a food systems critical pedagogy derive from justice-centered K−12 science education and U.S.-based agri-food social justice movements.

In the context of formal schooling, scholars in K−12 environmental science education offer interventions in the white supremacist underpinnings of a dominant science curriculum that is veiled as "objective," neutral, and acultural while failing to academically serve low income students and students of color (e.g., Bang and Medin, 2010; Morales-Doyle, 2017; Davis and Schaeffer, 2019). They advocate for a curriculum that recognizes the interconnections between scientific and social worlds and uplifts place-based, community-derived knowledge and lived experience. Morales-Doyle (2017) introduces justice-centered science pedagogy as a framework for addressing dominant scientific education's historic role in (re)producing social inequities. Building on critical pedagogy and culturally relevant pedagogy (Ladson-Billings, 1995), justice-centered science pedagogy aims to develop "transformative intellectuals'" (p. 1,037) who excel academically *and* develop critical consciousness through engagement in epistemologically heterogenous, participatory learning activities that address scientific problems relevant to their communities. As a concrete example of justice-centered science pedagogy, Morales-Doyles

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[4]We recognize that the view was by no means complete—the project had mapped 20 nodes out of over 50 we had identified. Yet synthesizing the Campus Food Players, Geographic Asset Maps, and various spotlight maps into a policy report did indeed reveal the hitherto invisible foodscape.

TABLE 1 | Foodscape mapping project full system maps and spotlight maps.

Map name	Data collection method	Map type
Full System Maps		
Campus food players	Web and archival searches, stakeholder meetings	Animated horizontal organizational chart
Geographic asset map	Physical surveys	Dynamic geographic map
Spotlight Maps		
Academic Units		
Accessibility at research spaces	Site surveys, legal analysis, interviews	Illustrated and animated graphic
Food and agriculture courses	Web scraping and content analysis	Animated timeline and stream graph
Hot Spot: Oxford Tract *(an agricultural field station that was slated for housing development; cross-listed with Campus Facilities)*	Environmental and social cost benefit analysis	Narrative with photos and tables
Campus Facilities		
Campus gardens	Biophysical and social surveys	Animated satellite view map
Campus garden stories	Oral history, interviews, critical reflection	Audio and video portraits; narrative report
Hot Spot: Oxford Tract *(an agricultural field station that was slated for housing development; cross-listed with Academic Units)*	Environmental and social cost benefit analysis	Narrative with photos and tables
Microwaves and water refill stations	Crowdsourcing (Microwaves) and physical survey (water refill stations)	Illustrated and animated graphic
Sustainable and just catering	Policy and best practices analysis	Resource list
UC field stations	Web directory searches	GIS, using Carto
Service Units		
Coalition for healthy campus food and beverages	Stakeholder meetings, physical survey	Narrative
Basic needs: food security	Deidentified pantry usage logs and program enrollment records; physical food weighing	Illustrated and animated graphic
From garden to pantry	Physical food weighing	Illustrated and animated graphic; bar graph and pie charts
University health services stories	Oral history	Audio portraits
Wellness program for high risk jobs	Deidentified health screening and program enrollment records	Narrative with photos, tables, and bar graphs
Student Leadership		
Greek life	Semi-structured questionnaire	Illustrated graphic and pie charts
Learning through our food	Oral History	Watercolor paintings and audio portraits
Student cooperatives	Semi-structured questionnaire	Illustrated graphic and pie charts
Student groups	Semi-structured questionnaire	Illustrated graphic and animated donut charts
Student group stories	Open-ended interview and oral history	Video and audio portraits

provides an extended case study of a year-long unit on soil in an Advanced Placement (AP) chemistry class at a community-founded high school in an economically-marginalized urban Mexican community in the U.S. Midwest. In contrast to the dominant AP science curriculum, the soil unit situated development of hard chemistry skills in the context of a deeper inquiry into environmental racism affecting the students' lives through centering diverse learning activities around the recent closure of two neighborhood coal power plants. One activity saw students testing soil samples for the presence of toxins such as lead and relating the results to their community's exposure to power plant emissions. Students then reported back to the community at a town hall, highlighting how their

education included public outreach. In another example, Davis and Schaeffer's (2019) ethnography of Black 4th-/5th-grader agency in a Michigan school with a justice-centered, place-based unit on water highlights how their pedagogy accounted for the "complex experiential, emotional, spiritual, and cultural associations of people and groups (e.g., Black Americans, Indigenous peoples)" have with water (p. 367). Importantly, justice-centered science pedagogy "encompasses curriculum, teaching practices, and classroom structures" (Morales-Doyle, 2017, p. 1,035): it is a holistic framework that guides us toward a new learning ontology.

Outside formal education, a long tradition of peer-to-peer, non-hierarchical knowledge-making exists in agri-food social

justice movements in the U.S. For example, *teatro campesino,* or field-based educational skits by and for farmworkers, emerged as a powerful sharing tool during the 1965 Delano Grape Strike (Bagby and Valdez, 1967) and continues to be used by predominantly Latinx farmworker organizations today, such as Líderes Campesinas in California and the Coalition of Immokalee Workers in Florida (Blackwell, 2007; Haedicke, 2020). Since the 1930's, the Highlander Research and Education Center (formerly the Highlander Folk School) has served as a hub for adult popular education, participatory research, and cultural work in low-income Black and white communities in Appalachia and the southern states. Most famous as a training ground for organizers in the labor union movement, Civil Rights Movement, and anti-strip mining activism, Highlander also worked with farming cooperatives in the 1940–50's and since the 2000's has organized a land and sustainability initiative (Thayer-Bacon, 2004; Highlander Research and Education Center, 2021). Peer-to-peer learning processes have also long been at the center of agroecological farmer networks [e.g., the *campesino-a-campesino* learning described in Holt-Giménez (2006)], as well as numerous other farmer field school programs worldwide.

Accordingly, the Foodscape Mapping Project has taken a strong community-based, participatory research orientation (Wallerstein et al., 2018) by purposefully engaging in processes aimed at co-learning, capacity building, and empowerment of participants (primarily students, but also university staff and faculty). The Foodscape Mapping Project grew out of an initial project on equity and inclusion in UC Berkeley's food system, which held community workshops to gather diverse perspectives. Participants noted they did not understand how the campus food system worked, or what power relations and decision-makers might affect the system. Subsequently, through brainstorming sessions with post-it notes and diagrams, the original project team (consisting of staff members and graduate and undergraduate student fellows) proposed that a mapping approach might provide this information—in effect, constituting a missing object. Mapping has emerged as a popular tool in food systems scholarship, particularly in studying local foodshed production capacity (Peters et al., 2009; Kremer and DeLiberty, 2011; Taylor and Lovell, 2012) and food access issues (Widener, 2018; De Master and Daniels, 2019). Elsewhere, we have detailed in an extended case study (Fanshel and Iles, 2020)[5] the process by which the map took form, how students were recruited, what existing campus educational and research programs could be leveraged, and the funding that made it possible.

The project's emphasis on research stems from its conception by Rosalie, who is a staff member of the Berkeley Food Institute (BFI), a cross-campus center aimed at cultivating diverse, just, resilient, and healthy food systems[6]. BFI has a strong interdisciplinary research model that encourages collaboration

between faculty, staff, and students. Doing research not only generates information otherwise not accessible but generates credibility and authority within a university context, and matches the campus mission of making knowledge. While undergraduate, masters, and doctoral students have been fellows in the project since the beginning, they initially did not do research. Rather, their involvement during the 1st year centered on programmatic development and advocacy with the aim of making changes for JEDI.

Yet participatory research, activism, and pedagogy are profoundly intertwined (Hale, 2008; Freire, 2018). Rosalie and Alastair (who was BFI's faculty co-director at the time) realized that the Foodscape Mapping Project had the potential to also serve as a learning platform. Röling and Jiggins (1998) explain how the use of platforms comprising stakeholders to support mutual learning for problem-solving enables collaborative learning. Students, staff, and faculty—along with administrators—can use a campus foodscape map as a platform to come together to understand JEDI problems, and make decisions on what to do to remedy those harms[7]. In this way, the Foodscape Mapping Project attempts to create spaces for expansive learning (Engeström, 2001), that is "learning in which the learners are involved in constructing and implementing a radically new, wider and more complex object and concept for their activity" (Engeström and Sannino, 2010, p. 2).

As a result, we soon pivoted to a mapping model founded on modular research projects with an intentional pedagogical design. This was evident in how students approached framing research questions, choosing particular foodscape nodes to examine further, identifying specific research tools, and determining how to present data. To map inequities in the campus foodscape, students (with guidance from Rosalie and Alastair as project leads) asked research questions such as: How do inequities in food access mirror inequities in access in each of these foodscape nodes? Which students can participate in food and agricultural coursework and research opportunities? Who benefits from campus garden activities? How can a climate of inclusivity, equity, and diversity in food and agricultural research, teaching, service delivery, and activism be cultivated at UC Berkeley?

Other university-based food systems projects with similar goals include the University of British Columbia Food Systems Project (Rojas et al., 2007) and the Brown University Providence Foodshed Justice Mapping Project (De Master and Daniels, 2019). However, these projects focus on campus sustainability and the local city, respectively. The UC Berkeley Foodscape Mapping project instead centers *equity* within the campus foodscape, and takes an explicit advocacy stance by seeking to make change in that system. Through iterative cycles of studying

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[5]The paper is openly available at: https://food.berkeley.edu/wp-content/uploads/2021/11/CSE_Fanshel_Iles_1120325.pdf.

[6]Other lead collaborating organizations at the project's inception included UC Berkeley research centers and student service programs: the Othering and Belonging Institute, Centers for Educational Equity and Excellence, and Multicultural Community Center.

[7]For example, Steins and Edwards (1999) note: "A crucial element in collective resource management by Australian Landcare groups is the strengthening of 'land literacy.' Land literacy refers to activities designed to help people appreciate the signs of health and ill-health in a landscape, to understand the conditions of and trends in the environment around them, and to make the invisible become visible (Campbell, 1994)" (p. 247–248). The creation of Landcare groups provides the learning platform.

the foodscape, participants are using the map artifact to become agents with the ability to create alternatives to the status quo.

Power is embedded in how maps are researched, represented, and communicated. It plays out in the underlying ideologies of cartographers, built-in assumptions of cartographic tools, technical approachability of maps for both makers and users, and performance of legitimacy of knowledge that maps generate and omit (Crampton and Krygier, 2006; Crampton, 2009; Kim, 2015; Monmonier, 2018). For example, racially and economically marginalized communities are often problematically represented through a deprivation gaze by the use of the term "food deserts" to describe food availability, when the communities may actually feature urban gardens, food sharing circuits, and corner stores that are largely invisible to usually white scientists who lack connections with the groups they purport to study (De Master and Daniels, 2019). Our project, therefore, asked participants to reflect during their research on how mapping the Berkeley campus foodscape might encode prevailing power inequalities and how they might do research to make maps that portray complex narratives. Reflecting this "multiple stories" ontology, the map comprises many maps at once, is both a cyclical process and provisional product, and uses multiple visual and auditory methodologies to tell the story of UC Berkeley's foodscape from as many perspectives as possible. No single map can capture the full texture of this system.

RESEARCH METHODS

To investigate our research questions, we used a case study approach with mixed qualitative methods, combining participatory observation, notes and materials produced throughout the project, and retrospective interviews with core participants. Rosalie (project manager) and Alastair (principal investigator) both conducted participatory observations as the project developed between 2015 and 2021. This spanned a large range of activities associated with the mapping work, including: initial community workshops to articulate the project objectives; regular research team meetings; map visualization design discussions; presentation of map results at town halls; a semester-long case design course; advocacy meetings with campus leadership; and population-specific interventions related to map findings. We had access to comprehensive materials from all the various sub-projects, such as emails, detailed meeting notes, student fellow reports, collected data, each iteration of sub-project research designs and draft map products, and the publically-available map itself. Through a series of conversations as co-authors in preparing this case study for publication, we reflected on whether and how the mapping work had contributed to student learning about JEDI issues in the campus food system, the kinds of learning that took place in the project, and the educational practices and institutional structures that helped or hindered the mapping work.

To gain insight into what student fellows perceived they learned from participating in the project, Rosalie conducted interviews with eight student fellows during June and July 2021. This sample group accounts for about 21% of core

participants (eight out of 38 student fellows). Summarized in **Table 2**, the students were purposefully selected for interviews because they had had an intensive engagement with the project (spending 5–15 h per week over the course of 4–18 months) and represented a cross-section of core participants in terms of their intersecting personal identities[8], disciplinary background, and level of student (transfer or 4-year undergraduate, masters, or PhD). Furthermore, the eight students worked on the project at different times across 5 years, such that the types of activities they undertook and primary object of inquiry—the full campus foodscape or one to four specific nodes—reflected different life stages of the overall cycles of project inquiry (e.g., early visioning, intensive data collection, mapmaking, development of policy, and advocacy work). Each student had also continued to stay in touch with Rosalie and/or Alastair, even after each had graduated from Berkeley, and all had expressed in prior exchanges that their participation in the Foodscape Mapping Project had a lasting impact on them. All interviewees agreed to have their full names used in this article, along with some personal background details outlined in their own words (see **Table 2**). The interviews do not, therefore, capture learning that did *not* happen, or the experiences of students for whom the project was less meaningful. While the interviewees did express areas for improvement (see Critical Reflections, below), further analysis would be necessary to address instances of non-learning.

Interviews ranged from 50 to 75 min and were conducted by Zoom video calls. They were then transcribed by Rosalie with use of Temi speech to text transcription software. Interview questions covered students' reasons for joining the project, how it compared to their other educational experiences at Berkeley, and what meaning-making they produced from their work on the project around food systems, JEDI, and learning itself. Interviewees spoke extensively about how the Foodscape Mapping Project fit into the broader ecology of their learning and careers. Rosalie also asked students about ways the project could have better fostered learning. Subsequently, we carried out content analysis of interview transcriptions and coded for forms and processes of expansive learning grounded in the pedagogical theories discussed just above. We used a combination of descriptive and process coding strategies (Saldaña, 2013) to categorize interview material for patterns regarding the kinds of learning manifested, the impacts of mapping work on student growth, and evidence of learning about JEDI and campus food systems specifically. We then triangulated these student insights with our own observations (as captured in historical artifacts of email exchanges and meeting notes) to produce an interpretative analysis of learning *via* foodscape mapping.

THE PEDAGOGICAL ENVIRONMENT

A key component of developing the Foodscape Mapping Project was leveraging campus learning structures outside

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[8]The eight interviewees are a sample, and not comprehensive of the full diversity of core student participants: for example, for this article Rosalie did not interview Black, Indigenous, or Southeast Asian project participants who were also deeply engaged with the project.

TABLE 2 | Author and interviewee positions and identities.

Name	Position	Structure of engagement	Time on project	Academic program (major; minor)	Gender identity	Racial and/ or ethnic Identity	Domestic or international	Other salient identities
Rosalie Zdzienicka Fanshel	Professional staff; Doctoral student from 2019	Staff project director	2015–21 (6 years)	Berkeley Food Institute; Society and Environment	Non-binary female	White/Jewish	Domestic, in-state	Gay; Lower/working class
Alastair Iles	Professor	Faculty principal investigator	2016–20 (4 years)	Society and Environment	Male	White/Scottish	International from Australia	"Disabled:" deaf from birth
Joyce Lee	Masters and Didactic Program in Dietetics	Paid fellowship and coursework credit	2018–20 (18 months)	Public Health Nutrition; Dietetics	Cisgender woman	Chinese-Taiwanese-American	Domestic, in-state	First generation student; Low-income immigrant household who experienced upward social mobility
Alejandra Marquez	Undergraduate 4-year	Coursework credit	2019 (4 months)	Society and Environment; Data Science	Female	Latinx/Mexican	International from Mexico	
Selena Melgoza	Undergraduate 4-year	Coursework credit; student government position	Formally 2018–19 (10 months), followed by additional work in 2019–21 (20 months)	Society and Environment; Public Policy	Female	Latina/Mexican	Domestic, in-state	First generation student
Nathalie Muñoz	Undergraduate transfer	Paid fellowship and coursework credit	2017–18 (17 months)	Environmental Sciences	Woman identifying	White/ Mexican-American	Domestic, in-state	Bisexual; First generation student (siblings also went to college)
Will Payne	Doctoral	Paid fellowship	2017–18 (10 months) and 2020 (5 months)	Geography	Cisgender man	Non-Hispanic white	Domestic, out-of-state	Straight
Hortencia Rodríguez	Masters dual degree	Paid fellowship	2016–2017 (10 months)	Public Policy and International and Area Studies	Female	Latine	"Domestic" from Puerto Rico	Bisexual
Natalia Semeraro	Undergraduate 4-year	Paid fellowship and coursework credit	2017–2018 (17 months)	Nutritional Science; Food Systems	Cisgender woman	White/ European American	Domestic, in-state	
Dennis Uyat	Undergraduate transfer	Coursework credit	2017 (4 months)	Geography; Geographic Information Science and Technology	Non-binary male	Turkish Colombian	Domestic, in-state	Bisexual; Disabled

All interviewees agreed to have their full names used in this article, along with the details of their backgrounds they have chosen to share here. All identities in this table are in individuals' own words.

of conventional coursework to provide hands-on educational opportunities for students. These included paid undergraduate and graduate student fellowships through the Berkeley Food Institute, and undergraduate course credit through Berkeley's research apprenticeship programs, the Food Systems Minor community engagement capstone course (which BFI helped launch at the same time as the Foodscape Mapping Project), independent study research units, and honors theses. Students were recruited through BFI's weekly Food Systems Opportunities Newsletter and its network of 150 faculty affiliates, food-related student groups, social media, student affairs officers, and research program project calls. Sometimes project teams consisted of a hybrid of paid and course credit students, or students moved between paid and credit opportunities to meet their academic and financial needs. Providing paid fellowships was crucial to the project goal of increasing equity in access to food system learning. Berkeley's course credit-based research apprenticeship programs have historically marginalized students who are dependent on holding jobs while pursuing their education, as they are often not able to afford the luxury of taking credits beyond the minimum needed for their majors[9].

Undergraduate, masters, and PhD students joined the project from fields as diverse as sociology, geography, society and environment, environmental economics and policy, public policy, development practice, public health, nutritional sciences, environmental sciences, molecular and cellular biology, urban studies, city and regional planning, and American studies. 38 students engaged in the project through what we call "core opportunities." They delved into 1–3 foodscape nodes, worked in teams of 2–4 students, and committed 5–15 hours per week over the course of 1–4 semesters. Between 2015 and 2020 during any given semester and summer, 2–4 teams were working simultaneously on Foodscape Map sub-projects. Building the map was thus modular in nature, with each team unearthing the intricacies of how issues of equity and inclusion radiated through particular aspects of the campus food system.

At the beginning of each semester, Rosalie made a basic scaffolding of a project plan for each team that outlined initial goals and learning objectives for the team to further develop together, and a tentative timeline of benchmarks. The project plans served as living documents: all members of each team edited the plans in weekly meetings to maintain a running set of notes throughout a project. Each session ended with identifying what the students wanted to accomplish by the following week,

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[9]The Foodscape Mapping Project engaged students from 2016 to 2019 through the College of Natural Resources Sponsored Projects for Undergraduate Research (SPUR) and College of Letters and Science Undergraduate Research Apprenticeship Program (URAP). Both programs are designed for undergraduate students to gain research experience through close collaboration in a small team with graduate students, faculty, and (less typically) professional staff. Participation is through competitive application and students receive upper division independent research course credit. A small stipend is provided to the faculty lead to support project expenses, but students themselves are unpaid. Undergraduate and graduate students in the College of Natural Resources have been demanding reforms to the SPUR program to provide living wages for students so as to make the programs more accessible to minoritized students. See for example: Environmental Science, Policy, and Management Graduate Diversity Council (2020).

pivoting goals and deadlines as needed to follow the threads of learning—often in dramatically different directions from where we had started. In this way, the learning structure embodied what Nabudere (2008) describes as the Freirean "sequence of action, reflection, questioning, researching hunches, drawing conclusions, evaluating options, and planning further action based on the learning that has been generated" (p. 70).

Throughout the semester the project teams paused for more substantial critical reflection. Through verbal discussions and end-of-semester written reflections Rosalie asked the students to consider both the content and process of their work, with starting questions such as: What has surprised you about the journey we've taken so far? What have you learned about the campus foodscape and issues of equity? What have you learned about yourself? Are there new skills you have exercised, and which skills would you like to develop further? Where would you like to see the project go next? What can I be doing differently as a mentor to better support your learning? The student-directed, flexible project plans and reflection activities aimed to enable what Gutiérrez and Larson (2007) call "expansive learning that transforms spaces" where learning is understood to be "the construction and resolution of the continually emerging contradictions in the practices in which people participate…[where we] not only make sense of contradictions, but also turn to authentic practices that initiate meaningful change" (p. 73).

Each semester's project foci were iterative expansions of work created in the previous semester. Often students decided to continue beyond their initial commitment, and new students were also recruited to build on projects that previous students had started, or to branch into directions that the previous teams had identified as important new threads. We have found that a minimum of two semesters (7–10 months of concentrated effort) makes for the most meaningful learning experiences—after 2–3 months students begin to deeply identify with the project, after which they are eager to follow through with longer cycles of iterative inquiry, described in detail under "Findings and Discussion," below. Another 132 students participated in "additional opportunities," which were shorter term commitments focused on either a data collection "blitz" performed through a large undergraduate course or extracurricular student group, or paid positions to visualize data collected by the primary students. The data visualizers worked closely with Rosalie and the primary students to translate the research into compelling graphics for the map website.

CYCLES OF RESEARCH AND ACTION: GREEK LIFE

Before we analyze the forms and processes of learning that the Foodscape Mapping Project enabled as a platform, we present here an example sub-project that provides insight into the cycles of inquiry and iterative project development that took place, as well as the structures of learning environments, research, and advocacy the project built. We also provide details on a second case, on grappling with UC Berkeley's exclusive beverage

contract with PepsiCo, in the **Supplementary Materials**. Greek Life emerged as a priority area for advocacy and program development during strategy sessions in September 2018, at which five student fellows and three staff and faculty team members reviewed recommendations in the policy report released earlier that year. The work on Greek Life is exemplary of the processes we undertook for other foodscape nodes explored through the project.

Approximately 3,400 undergraduates are members of CalGreeks, the UC Berkeley community of 50 fraternities and sororities (ASUC and LEAD Center, 2021)[10]. Almost 12% of undergraduates participate in Greek Life, yet fraternities and sororities were largely ignored as part of the campus food system. Inequities based on race, class, gender, sexual orientation, and religion have been structurally built into national Greek organizations since the first fraternity was founded over 250 years ago, and are the topic of much academic literature on JEDI and student experience in higher education (e.g., Hughey, 2010; Jozkowski and Wiersma-Mosley, 2017; Gillon et al., 2019). Exclusion of non-whites and non-Protestants was legally sanctioned in Greek Life until the 1960's, and students of color still face formidable barriers to belonging in historically white organizations. Anti-Black, anti-Mexican, and anti-Asian racism, sexual assault against women, condonment of rape culture, anti-LGBTQ+ hate, and hazing deaths at fraternities and sororities have repeatedly made national headlines in the last decade.

At UC Berkeley, recent cases of misogyny, racism, and homophobia in CalGreeks have engendered multiple op-eds in the student newspaper, *The Daily Californian,* calling for reform and boycotts of Greek organizations (Muir, 2015; Editorial Board, 2018; Estacio, 2018). In 2016, Berkeley's Panhellenic Council, which represents historically white sororities, introduced a "community development" role to address diversity and inclusion. Yet the 2017 inaugural training required by all chapters prior to fall recruitment was heavily edited at the last minute, without the creator's permission, to make language on implicit bias, racism, and the LGBTQ+ community less "strong" (Kim, 2017).

Against this backdrop, in the 2017–18 academic year, the Foodscape Mapping Project sought to understand how students' experience of equity and inclusion in Greek Life intersected with their food experiences. UC Berkeley has four Greek councils: the Intrafraternity Council (IFC: 30 fraternities, mostly historically white), the Panhellenic Council (PHC: 14 sororities, mostly historically white), the Multi-Cultural Greek Council (MCGC: 14 culturally-based fraternities and sororities), and the National Pan-Hellenic Council (NPHC; 6 historically African-American fraternities and sororities). Rosalie created calls for interested students to join a new research project through Berkeley's undergraduate research apprenticeship programs, in return for course credit that Alastair provided. After selection interviews, one student participated in the fall semester and four in the spring semester: three PHC members, one IFC member, and one MCGC member. Later, two advocacy fellows were recruited to build

upon these research efforts. Collectively, the students represented both diversity within the Greek system and its dominant white culture: four white women, one Latina woman, one Latino man, and one Asian non-binary transgender woman.

After lengthy discussion, the research fellows chose to conduct comprehensive surveys targeted at both members and chapter presidents. Those surveys were the first systematic attempt to collect demographic and identity data among CalGreek participants, let alone their food experiences[11]. Thus the project was a novel research venture aimed at generating data to illuminate a neglected part of the campus foodscape. Drawing on their own knowledge, the fellows recognized that chapter presidents might know much more about how fraternity and sorority houses managed their own food infrastructures, while members might know much more about their everyday experiences of food (e.g., diets, the ability to cook, or fears around food-related behavior). Moreover, it was important to distinguish between different groups of Greek members, rather than treating them homogeneously. Surveys also offered the opportunity to answer anonymously and confidentially in a context where responses might be very sensitive. Nonetheless, the fellows did not have previous experiences or skills in designing, disseminating, and interpreting surveys. With our mentoring (Rosalie provided the majority of everyday input, while Alastair helped with feedback on question design and distribution plans), the students learned how to draft, pilot, and refine the surveys. In the first semester we tested the surveys, followed by scaled up data collection in the second semester, allowing plenty of time to understand the challenges, devise strategies, and generate data for use in the map.

The member surveys asked up to 67 multiple choice and open-ended questions about student demographics and identities; reasons for participation in Greek Life and their particular fraternity or sorority; the structure of the housing and food options for their organization; and their thoughts about their food experiences. The chapter president surveys added 20 multiple choice and open-ended questions about number of members; cost of membership and financial aid options; use of membership fees; chapter efforts related to diversity and equity (including acceptance of transgender and non-binary members), and more detailed questions about the structure of house kitchens and meal plans.

Critically, the fellows had to develop a workable process for distributing the surveys in a situation where fraternity and sorority houses were not necessarily friendly to the idea, or cooperative with each other. In their weekly meetings and frequent email and text communications (alongside our advising), they dealt with numerous obstacles, from how to reach members and chapter presidents, to how to increase lagging response rates, to how to respond to push-back from skeptical marginalized houses. Sometimes they could not find a solution. Outreach efforts eventually included emails to every member of CalGreeks from the Berkeley CalGreeks staff advisor, fliers posted in fraternities and sororities with physical houses, presentations

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[10]In 2017–18 when the Foodscape Mapping Project was initially conducting research at CalGreeks there were 3,600 members and over 60 recognized chapters.

[11]Per personal communication with Jeff Woods, Director of Fraternity & Sorority Life and LEAD Center Associate Director, UC Berkeley, March 6, 2018.

at weekly chapter meetings, social media, personal networking by project fellows, and a competitive incentive of a free pizza party by the organization who had the highest percentage of survey participation. Ultimately, 387 students responded (or 11% of CalGreek members), but major differences in response rates revealed inequalities (274 for PHC, 107 for IFC, but only 6 for MCGC, and 0 for NPHC).

The fellows explained this pattern as follows: As majority white organizations, virtually all PHC and IFC chapters have houses on UC Berkeley's "Fraternity Row." The MCGC and NPHC chapters, which specifically serve students of color and LGBTQ+ students, mostly lack chapter houses, undermining their "legitimacy" in Greek Life through physical marginalization from Fraternity Row and also limiting members' ability to access and share meals as a community. A fundamental housed/unhoused divide among campus chapters reflected the racialized, gendered, and economic inequities between Greek organizations at both the national and local level.

The fellows also generated data from the historically white chapters that suggested vast discrepancies between the food experiences of female and male students[12]. One hundred percent of sorority respondents had a house meal plan with professional "house moms" and chefs that oversee operations; however, 93% were not allowed to access their kitchen even though they wanted access. In contrast, 93% of fraternity respondents did have kitchen access but only 43% had meal plans. Of the 57% without meal plans, 74% wanted them. Areas of top concern for sorority participants were the health of their diet, eating disorders, and lack of autonomy over their food. In contrast, fraternity participants worried about poor kitchen quality (lack of hygiene and functioning equipment) and ability to interact with each other over meals. The gender-based divergence in the food experience of CalGreek members reflected a self-perpetuating cycle of historic conditions that structured both their material food options and expectations of their social behavior. Another significant finding was that while 32% of sorority and 43% of fraternity respondents skipped meals because they did not have enough food and/or money, only 4% of sorority and 21% of fraternity respondents used UC Berkeley's extensive food assistance programs.

After analyzing these data, the fellows created recommendations for the Foodscape Map and policy report. We proposed requiring chapters to collect demographic information about their members so as to create a baseline for evaluating diversity, equity, and inclusion, and forming a Greek Food Policy Council. The students envisioned several functions for the Food Policy Council, including providing opportunities for members to connect over shared meals in students of color-friendly, gender-inclusive communal spaces. Cooking workshops should be held for members of all Greek chapters.

A taskforce of MCGC and NPHC members could learn about, and act on, how Greek system structures affect their access to food, including barriers to obtaining chapter houses. The council should also raise awareness about, and destigmatize the use of, campus food assistance programs in Greek chapters (see the full recommendations at: https://food.berkeley.edu/foodscape/student-leadership/greek-life/).

In 2018–19, Rosalie and two new project fellows, both in PHC sororities, worked to turn the recommendations into action. We presented the recommendations to the staff director of CalGreeks, the staff liaison to CalGreeks at the campus health services, and presidents of each council. The fellows created fliers about campus basic needs resources that were hung in every chapter house and presented by health workers appointed at each chapter. We also piloted two community meals at which we presented research findings and created space for participants to discuss food issues within the CalGreek communities. Many attendees reported that it was the first time they could openly discuss financial pressures to eat out, eating disorders among fraternity brothers, and the cultural agreement to spend their membership dues on alcohol instead of food. Ultimately, national level policy and financial inequities, such as which organizations can afford properties, appeared an insurmountable challenge for creating structural change at the local level. Yet the Foodscape Mapping Project's work to improve equity within the CalGreeks food system has had durable outcomes. Greening the Greeks, a pan-council organization focused on sustainability and environmental justice, has absorbed many tasks of the envisioned Food Policy Council. Attendance at Greening the Greek workshops are now mandatory for PHC and IFC members, and students report that the events are genuinely reflective and engaged spaces[13].

FINDINGS AND DISCUSSION: EMERGENT LEARNING FORMS AND PROCESSES

We next investigate how the Foodscape Mapping Project functions as a multidimensional learning platform, drawing on the principles of critical pedagogy, expansive learning, sociocritical literacy, and justice-centered science pedagogy that we reviewed earlier. Based on our coding of student reflections and follow up interviews conducted in mid-2021, we identify at least eight learning forms and processes that the project manifested (see **Figure 3** and **Table 3**). Our analysis combines both results and discussion. Together, these forms and processes of learning comprise an interpretative framework that can be applied to build or study other campus mapping efforts and to campus food pedagogy more generally. By paying attention to these forms and processes of learning, scholars and practitioners can configure campus food pedagogical experiments to better design for meaningful student learning. We purposefully articulate the learning in students' own words.

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[12]Only one IFC respondent identified as gender non-conforming. This compares with 4% of Berkeley undergraduates overall who identify as transgender or gender non-conforming (Office of the Chancellor, 2019), speaking to the hegemonic gender binary of Greek Life. By contrast, three out of six MCGC respondents were gender non-conforming—all were members of Berkeley's two LGBTQ+ chapters.

[13]Per personal communication with Selena Melgoza, 2018–19 Foodscape Map fellow and PHC member, June 22, 2021.

FIGURE 3 | Emergent learning forms and processes. Illustration by Rosalie Zdzienicka Fanshel. This diagram demonstrates the forms and processes of learning we identified as emerging in foodscape mapping work. See **Table 3** for details of corresponding themes.
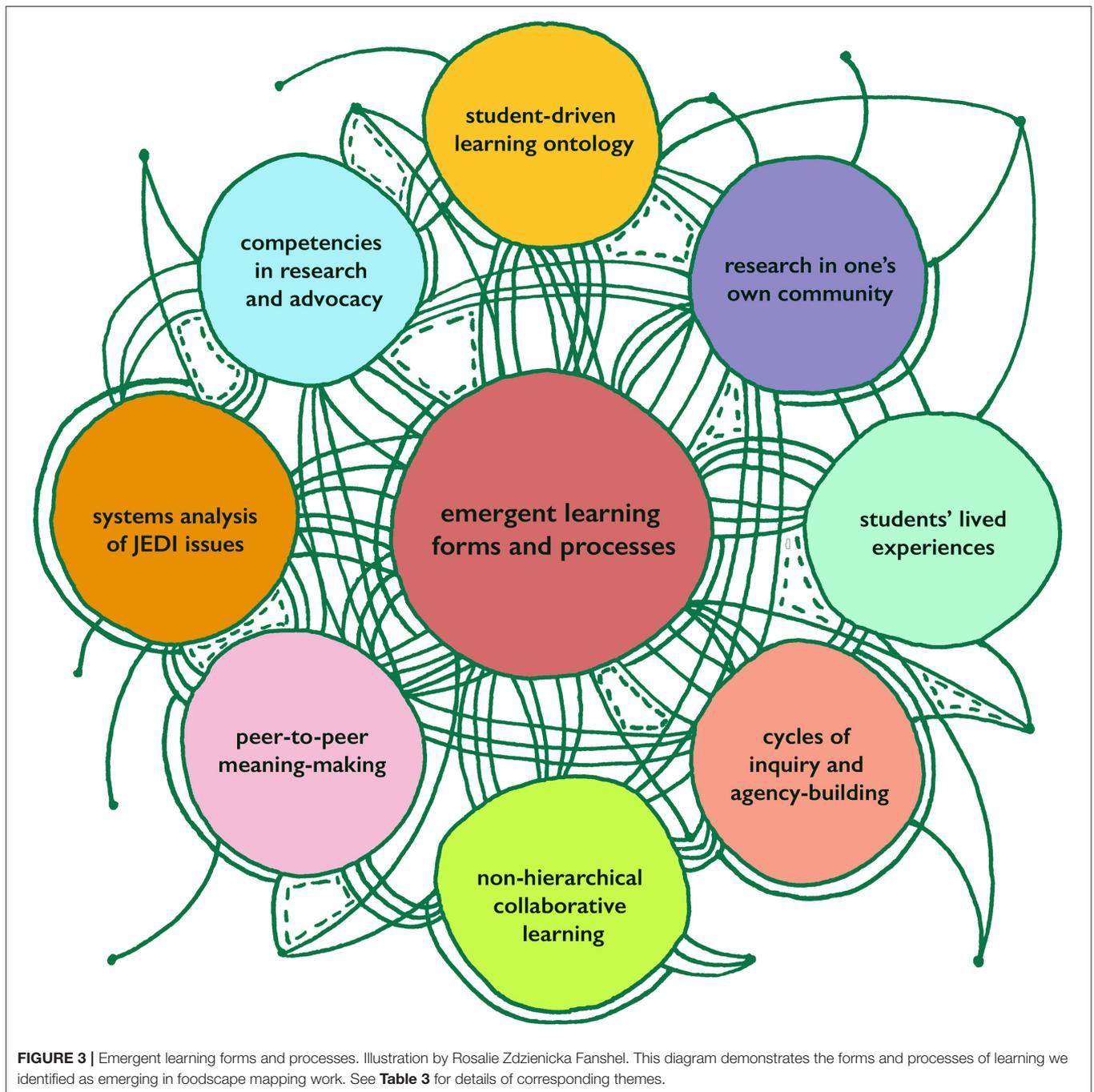
Importantly, the project also resulted in substantial learning by staff, administrators, and faculty, as well as by map users. However, for this article, we focus on the experience of students.

Cultivating a Student-Driven Learning Ontology

Student fellows repeatedly noted that the project cultivated a vastly different learning ontology from their academic programs. At UC Berkeley, undergraduate students typically participate in courses with large enrollments (60–300), rarely interact directly

with graduate students except as instructors in course sections, and seldom engage with faculty outside the classroom. Students also encounter learning environments modeled on the traditional lecture format, even if this may be occasionally tweaked to be more interactive or "flipped around" (i.e., students doing some teaching through class exercises). They may never join a faculty-led research project during their time on campus; if they do, their work is usually dictated by the professor's agenda. Learning through experience, where both topics of inquiry and research design are student-driven, is not a widely valued pedagogical

TABLE 3 | Emergent learning forms and processes.

Emergent learning forms and processes	Description
Cultivating a student-driven learning ontology	Whereas most university education emphasizes top-down, professor-designed, large-scale learning environments, the project favored small teams with shared leadership between undergraduates, graduate students, staff, and faculty
Enabling students to do research in one's own community for their learning	The ability of students to do research in and for their communities on campus was empowering and motivating
Legitimizing students' lived experiences through data collection	Students often felt immediate, visceral connections between the data they were collecting and their own journeys in navigating JEDI issues on campus
Catalyzing cycles of inquiry and agency-building	Through interrogating discoveries and roadblocks during research team meetings and identifying next steps together, students developed an investigative lens through cycles of inquiry, and built new agency as a result
Designing for non-hierarchical, collaborative learning	The project worked to build learning environments that fostered students-driven collaborative decision-making, the growth of student expertise, and peer-to-peer exchange
Nourishing extended peer-to-peer meaning-making	Students pulled in their peers through informal conversations about their research and the project, which helped to test findings-in-the-making
Enabling students to do system analysis of JEDI issues at both campus and societal scales	The project encouraged students to situate their learning about the JEDI issues in the campus foodscape into much larger food systems that universities are nestled within
Developing competencies in research and advocacy	Students acquired practical skills they later applied to other critical food systems work on campus and their unfolding careers

approach. For professional degree students, their studies include smaller classes and some research, such as master theses or capstone projects. Yet, they are also largely confined to content that is delivered in an one-directional, top-down way.

In contrast, fellows underlined the benefits they gained from being part of a project based on small teams with shared leadership between undergraduates, graduate students, staff, and faculty. Undergraduate Society and Environment student Alejandra Marquez commented: "It'll be a small group and it'll be graduates with undergrads together. I never had that type of experience before." She continued, "Developing an implementation plan…and just carrying out the entire strategy of how are we going to do it? What do the costs and benefits look like? How are you going to present it? Just carrying out that story and looking at all the parts of it. I think I learned more than if I had just taken a course like economics or financial modeling or whatever."

Hortencia Rodríguez, a dual masters student in Public Policy and International and Area Studies, reflected: "But there's also not a lot of opportunity in the coursework, at least that I experienced, for dialogue. Cause you were in sort of small seminar classes, or not even that small…which are structured based on lectures. You just listen to someone provide information to you, be

it a historical analysis or things like that." In common with some other professional programs, Masters of Public Policy students are required to complete a policy analysis project, ostensibly to acquire practical knowledge of developing policy ideas. Hortencia added: "[In the master's program] essentially you have a client, they have a really clear idea of what they want and you just need to provide the data and answer this really specific question. I felt that the Foodscape Project was so much more creative and there were so many more possibilities, because we were in such an early stage that we could explore what we wanted it to become."

Masters of Public Health student Joyce Lee describes how the projects research-advocacy nexus sparked a different kind of learning than she experienced in her other coursework: "I think what is true for both the [Staff] Basic Needs project that I was working on as well as the PepsiCo project was the fact that I was able to create research and really look at something, and then from there go into activism as well." Joyce synthesized data on Berkeley employment by job title, pay grades, local cost of living, and CalFresh eligibility, and then with the cross-campus Staff Basic Needs Working Group developed and delivered customized outreach programs to food insecure staff. Actually interacting with Berkeley staff in need was crucial to Joyce's learning. She said, "Even as a graduate student, you might just be on the side of research more, and you don't really have either the time or even the context or the resources to be able to bring that over to the people that you do want to serve." Alejandra, Hortencia, and Joyce are each describing a problem-posing learning ontology.

Enabling Students to Do Research in One's Own Community for Their Learning

Student fellows consistently mentioned the ability to do research in and for their communities on campus empowering and motivating. Even if students have the opportunity to do research as part of their assignments, this activity is to meet course specifications and may have very little relevance to the students' everyday lives. Students are routinely alienated from their communities through being encouraged to follow academic practices of impartial and "removed" knowledge-making. They can be disincentivized from pursuing a more meaningful educational pathway and may only seek to complete their degrees to gain credentials. By contrast, if students can derive practically and politically meaningful results from their research, they are much more likely to engage deeply with their educational experiences (Freire, 2018). Learning is more likely to happen during participation in activities that students value (Gutiérrez and Larson, 2007).

At the time Selena Melgoza first joined the project, she was an undergraduate Society and Environment major participating in Greek Life. She initially did not know anything about her house's food procurement but the project awakened her awareness of the inequalities of food access and decision-making that her community faced. Working on the CalGreeks survey project made her feel like she "had a huge stake in the results and the outcomes of what we were studying and what we wanted to do.

Being in Greek Life and learning how the food works, and who gets food and who doesn't get food and…how do we talk about it?" She took this insight into her work on healthy beverages, as she connected how student food choices could be limited by campus policies lacking transparency and accountability. The potential to make positive changes through the project motivated her to deepen her learning and to discover that the map could be profoundly relevant to her community's well-being. "And then the same with the PepsiCo: like, I don't really have a say in this, and also the rest of the campus doesn't even know that this is the contract. I feel like this is my chance to make something happen, and it's something that really needs to happen. As a student, I could obviously benefit from these changes and every other student could also benefit."

Undergraduate Nutritional Science major Natalia Semeraro, who studied the accessibility of campus gardens to a diverse range of students, felt a much stronger connection to her learning because it was about spaces she already participated in. She said: "[The map] was really cool and something that was really needed. Cause everyone was like, 'I don't understand, there's all these gardens?' It was really directly related to what I was doing in my job for CalDining, because I was managing a garden. So to me that felt super relevant and it all made sense. It visually makes sense. But we also had to figure out: How did we want it to be visualized in a map? What information did we really need? And how could we get it from all those different gardens?" Natalia's deep investment in the campus gardens community guided her in developing the research design.

Students were excited about learning something they could immediately put into practice in their communities. Selena found: "I went into this and I was like, 'Oh my God, you can learn something and then actually apply it right then and there!' So I think that really changed my whole perspective on what kind of research I would even want to do. Community participant research is super fun and exciting. There's so much value in that. Working with communities that you're actually trying to make the change in, I think is super important and something I still want to continue doing."

Legitimizing Students' Lived Experiences Through Data Collection

Reflecting a justice-centered pedagogical framework, the Foodscape Mapping Project prompted students to examine socio-scientific problems of importance to their own lives and those of their close communities (Morales-Doyle, 2017; Davis and Schaeffer, 2019). Students often felt immediate, visceral connections between the data they were collecting and their own journeys in navigating JEDI issues on campus. The findings helped them better articulate their personal experiences and offered legitimacy to student knowledge production and activism. For two project fellows who were also active in the Students of Color Environmental Collective[14], data collection for

[14]Founded in 2016, the UC Berkeley Students of Color Environmental Collective "is a space for students of color to seek refuge from white-dominated environmental and social justice spaces, to learn more about the intersections between environmental and social justice, and to foster conversation about

two different foodscape nodes resonated with current concerns of the Collective. Undergraduate Environmental Sciences major Nathalie Muñoz conducted semi-structured surveys with participants in food-related extracurricular groups that revealed that their members were wealthier and with a higher percentage of female, white, and Asian students than the Berkeley student population at-large. The surveys also showed a low level of critical self-reflection in the groups about their lack of diversity. Nathalie commented: "I mean, at that very same time that we were working on that project, students from the Students of Color Environmental Collective were getting the cops called on them for going into Mulford [a campus building] because they put up a sign that said 'Where are the professors of color?' on top of the very white wall of [photos of] professors. So it gave more weight to the numbers that we were seeing, and it helped create more of a story behind the information that we were collecting."

Undergraduate Geography major Dennis Uyat reflected that learning how previous student activism helped shape campus structures gave them hope: "It was the first time that I actually did in-depth research. Going to the library, fishing for really old texts about the University, and trying to piece together this timeline really helped to inform how the [Campus Food Players] power map came to be. Learning about the history of UC Berkeley…and just reading about how the forestry department came to be as a result of student efforts was really encouraging, personally. What I wished after learning that is the Students of Color Environmental Collective, if we had been more strategic in demanding maybe even a department of environmental justice, because if that's how forestry came to be—like relevant issues, like environmental justice or food justice."

The students were not just learning about the campus foodscape through their research—they were transforming their food-related experiences into something that *could* be talked about. Selena Melgoza articulated this realization: "But recognizing at the same time, these institutions weren't designed for people like us in the first place. And like, that's a whole radical, revolutionary kind of idea. How do you tackle that?" The direct connection students made between foodscape research and their own experiences of marginalization demonstrates a sociocritical literacy (Gutiérrez, 2008). As they develop critical consciousness (Freire, 2018) of their role as historic actors in the campus foodscape, students can arrive at an emergent agency that inspires them to take action.

Catalyzing Cycles of Inquiry and Agency-Building

The responsive structure of project meetings, which were designed to interrogate discoveries and roadblocks during the previous week and identify next steps together, was conducive to students developing an investigative lens through cycles of inquiry, and building new agency as a result. Selena Melgoza described the weekly cycle as follows: "Because once we look at something, we were like, 'What's going on?' And then a bunch more questions keep coming. Then we just keep answering them

environmental racism and justice" (Students of Color Environmental Collective, 2021).

and then more questions arise and then we keep answering them." Selena is relating her experience to what Gutiérrez (2008) calls learning in which "the individual and her sociocultural environment actively seek to change the other to their own ends" (p. 153). Inquiry was never separate from the overarching question of, "What are we going to do about it?" which Rosalie frequently posed to students. Throughout the project, Rosalie was struck by how students would respond: "Okay, we say we want to do that. Let's make it happen! What are we going to do to make this happen?"

During cycles of inquiry, students both felt this voracious fearlessness and were overloaded, as they toggled between a focus on micro level issues and connecting with larger structures of power and historical and sociopolitical formations of the U.S. food system. Hortencia Rodríguez, who worked on the project at an early stage when we were deciding which spotlight maps to pursue, reflected: "I have to say, the more that you learn it's a little overwhelming. Cause you're like, 'Whoa, there's so much going on. There's so much that's connected.' And then you have all of these intersecting issues where it's labor rights, how you select vendors, what are the campus boundaries?" It was in these daunting moments that expansive learning occurred— that is, when the students collectively figured out their goals and object of inquiry (their activity) at the same time that they were implementing it (Engeström, 2001; Engeström and Sannino, 2010). Joyce Lee described the process of developing proposals in the beverages case design course as such: "We came up with an idea and I was like, 'Wait, I don't think we can move forward with this. So let's come up with another idea too.' So it's just being able to come up with many brainstorms and move pretty far along with them, and then being like, 'Oh, wait, let's see what else we can do. Cause this might not work out as well as we thought'." Here, the students are learning they *can* ask their own questions, and that these questions need to come from many angles. They are learning how to frame, answer, and evaluate questions within a vertiginous, open-ended problem space.

Both Selena and Joyce also used the term "snowball effect" to describe their learning experiences. They were part of a four-person mixed undergraduate and graduate team that joined the project after release of the policy report in 2018. Their first task was to decide which foodscape nodes to pursue for further research and advocacy. Joyce explains: "So Selena, Alex, Isa, and I were just trying to figure out what we wanted our priorities to be. Then as a group, we found the PepsiCo contract to be very interesting, we decided to go forward with that... Then from that, I feel like we just snowballed into a bunch of other really great programs too." Similarly, Selena described the process of developing the community meals and peer-to-peer workshops in CalGreeks as follows: "It's like a snowball effect. I feel like we just started with this one idea. We had those brainstorming sessions and then we made it happen. I think at the time, we didn't really know how exactly these things were going to pan out. But while working together, [my team mate]... knew everyone at Hillel. She had that connection and we used that to our advantage, then we met more people at these community events, and they're like, 'Oh yeah, we could have this at our fraternity next time'." The snowball metaphor

reveals the students' experience of learning as a collective, active, improvisational, and sometimes unwieldy undertaking. They adapted to their rapidly changing understanding, and decided what pathways they would try following.

Designing for Non-hierarchical, Collaborative Learning

Peer-to-peer, non-hierarchical knowledge-making is rare in formal higher education, especially at an institution like Berkeley, where incoming 1st year undergraduates have a 18% acceptance rate and an unweighted/weighted grade point average of 3.86–4.0/4.27–4.62 (on a scale of 4.0; Office of Undergraduate Admissions, 2020). While the Berkeley Center for Teaching and Learning emphasizes the importance of teamwork (Ciston, 2015), Berkeley students are trained to compete with each other and focus on individual achievement from before their arrival and throughout their Berkeley education. Simultaneously, they are seldom treated as knowledgeable experts in their own right, except when it comes to matters of "student life." Faculty are seen as the primary experts and makers of knowledge on campus.

The Foodscape Mapping Project's guiding principle was democratic knowledge production: we strived to build learning environments that fostered students-driven collaborative decision-making, the growth of student expertise, and peer-to-peer exchange. Whether students were participating *via* course credit or paid work, we deliberately designed spaces where each had equal power in steering the project. We emphasized strengthening of competencies through practice (see further below) and greater confidence in being active knowledge-makers, not just passive recipients. Project fellows commented that the level of collaboration was unique in their Berkeley education. Natalia Semeraro observed: "I was like, 'This is so cool because this work was a complete collaboration.' We did this part, they helped create the visualization of it. None of it could have happened without all the people that we talked to make it happen. I think I learned a lot about how—it seems so simple, it should be obvious. But when you're in school, these projects, you just start it and you do it and it's your project. But projects really are... you actually need a whole team and a web of many people."

This collaboration included pairing data collectors with data visualizers who, often working in shorter stints, turned in-depth social science research into actual maps. Many of the visualizers were in computer science and related fields and were excited to practice their coding skills to create animated graphics; in the process, they were exposed to thinking about food systems for the first time. Likewise, the social science students working on data collection were introduced to programming. Dennis Uyat, himself a skilled cartographer who created the draft Campus Food Players visualization, reflected: "One thing that was really cool about the [project] was there were different relationships that happened there in the campus community. Like every space on campus is everybody's and it's fun to see all the connections. I remember [Rosalie] paired us with the computer science student who programmed the Foodscape Map from the visual sketch to this other generative thing. I remember that experience just being so cool, because not only were we paired with the computer

science student, but also a PhD student who had both a CS and theoretical and visual arts background."

The mixing of first-year admits and transfer undergraduates, masters, and doctoral students was deliberate, and meaningful for students at all stages of their education. Alejandra Marquez commented about being on a team with masters students: "In the time that we were working, feeling that I had very unique perspectives and that I could also bring my own expertise, even though they were higher up in their education. That was very cool to just build my confidence, and where the team was with people that had other levels of knowledge, but also feeling like I'm bringing something that is valuable." This learning was multi-directional. Will Payne, then an advanced doctoral candidate in Geography (now Assistant Professor of Planning and Public Policy at Rutgers University), remarked: "I've supervised for my own research now a number of undergrad and graduate student researchers. I think some of the way that I work with them is informed by the Foodscape Mapping Project. Seeing how we do things that are relatively bounded tasks that build into something bigger and working with [students] to figure out what they're going to be most excited about or most align with what they want to do that also moves the project forward."

Teams were also consciously formed to bring together diverse students in terms of personal identities, life experiences, and disciplinary knowledge. During interviews to join the project, students were asked about their prior background in anti-oppression work: that is, in recognizing and understanding the intersecting ways people can experience oppression and marginalization, critically analyzing the social structures of power and privilege, and then attempting to mitigate their effects and equalize power imbalances. With JEDI issues as the core of the project, at times racial dynamics between students—and between students and Rosalie and Alastair as white project director and PI—needed to be explicitly discussed and negotiated so as to keep an honest focus on recognizing and upending embedded power. Simultaneously, we had to acknowledge that our official staff and faculty positions on campus could never be disentangled from student perceptions of our power. Eighty percent of project participants were students of color, many of whom were additionally minoritized as LGBTQ+, first generation, and/or having a disability. As an example of one such dialogue, during the 1st year of the project, two Latinx and one Southeast Asian undergraduate fellows requested that a workshop be held for students of color only, which they would organize under the mentorship of a Black doctoral student fellow. Rosalie and a white doctoral student fellow provided logistical support but did not participate in workshop design or attend the event.

hooks (1994) encourages mentors to bring their full selves into the learning environment: "When professors bring narratives of their experiences into classroom discussions it eliminates the possibility that we can function as all-knowing, silent interrogators. It is often productive if professors take the first risk, linking confessional narratives to academic discussions so as to show how experience can illuminate and enhance our understanding of academic material" (p. 21). Rosalie was frank with students about her positionality: openly acknowledging her cognitive biases as a white person while sharing that she is Jewish, queer, and from a working class family with a homeless parent—that her own interest in the Foodscape Mapping Project stemmed from parental experience with food and housing insecurity and feeling that she did not belong in higher education. In addition, Alastair is the only born-deaf professor at UC Berkeley (out of over 1,500 faculty) and has wrestled with access to higher education, both as student and as faculty, for decades. Dennis and Nathalie Muñoz both said that when Rosalie shared her queer identity it created a vulnerable space where they too felt comfortable to publicly identify themselves as queer.

In our (Alastair and Rosalie's) own reflection, we recognize that Rosalie's role as project director from her positionality as a staff member—rather than a faculty or graduate student instructor—helped foster the non-hierarchical learning environment. Few students have worked closely with university staff members in a research or curricular setting. Rosalie purposely framed herself as a "non-expert": while she had worked for the university since 2008 after a decade in nonprofit food systems work, she did not have an advanced degree[15]. This disruption of typical instructor-student roles helped frame the learning environment as equally exploratory for everyone.

Nourishing Extended Peer-to-Peer Meaning-Making

Beyond the project teams, fellows expanded their meaning-making by discussing the Foodscape Mapping Project with peers in other settings. As discussed above in regards to *teatro campesino* in farmworker activism and the Highlander Research and Education Center, peer-to-peer learning has long been at the center of agri-food systems social justice movements in the U.S., as well as worldwide. Hortencia Rodríguez explains how the Foodscape Map served as a nexus for her and her peers to integrate learnings from myriad food-related encounters on campus: "The way that I think of learning, when you're in a classroom, yes, you're learning, but you're also learning when you're just hanging out with people and participating in events and going to student organizing meetings. But perhaps you don't realize that until you come together and debrief it…and you're like, 'How about that meeting? That was interesting.' And then you're like, 'I hadn't thought about it that way.' You internalize different perspectives and new perspectives through that kind of conversation. I feel like the Foodscape Mapping Project was an opportunity to do that with an explicit objective. It was thinking about it as a system."

Through community workshops and public town halls, students gained skills in formally presenting their research findings to peers (as well as faculty and administrators), at times to audiences who were unfamiliar with academic language around food systems such as in the Greek Life workshops described above. Students also took the opportunity to extend

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[15]In 2019 Rosalie enrolled as a doctoral student—with Alastair as her advisor—while concurrently continuing her staff position at the Berkeley Food Institute. Therefore some Foodscape Map students worked with Rosalie in her dual role. Rosalie's doctoral work grew out of the Foodscape Mapping Project; the project thus provided an educational opportunity even for its staff director.

their learnings by discussing the project with their friends in informal settings. Alejandra Marquez recalled of the PepsiCo work: "Not only were we having this great learning environment and doing all this strategy and learning so much, but it was for something that was happening around us and other students really cared about, that I could talk to my friends about. It impacted all of us." Nathalie Muñoz added that through discussing the project with her friends outside of food systems studies, she gained new insights: "It pulled my head up to think about all of these other bigger things. The way that I would talk about what I was doing with my time in this project with other people, that was also another place of meaning-making for me. Talking about it with my peers and really putting all of it into perspective for me in terms of what you can do with the research and how big it really can be."

These dialogues in turn became an extended community peer review of sorts that informed the evolving directions of the Foodscape Map. In exploring how contemporary scientific practice addresses technological and ecological risks by producing "post-normal science," researchers in Science and Technology Studies have proposed the concept of extended peer review (Funtowicz and Ravetz, 1993). Because post-normal science tackles uncertain topics with significant policy and material impacts, peer review should include *all* the stakeholders found in a given issue, to assure high quality results. For example, in researching chemical risks, researchers should include community members, corporate managers, and policy-makers. In terms of foodscape mapping, fellows pulled in their peers as they did their research, to test findings-in-the making.

Selena Melgoza described this extended peer review as a crucial part of developing the strategy for the Pour Out Pepsi campaign, an activism project she initiated *via* student government inspired by her time on the Foodscape Mapping Project: "Then I was like, 'Do you guys have any ideas? Like what is your experience?' I think learning from [my peers] as well because I felt like sometimes even with PepsiCo stuff, I'm like, 'Oh, I have all this information and this is what we should do.' Then someone from an outside perspective is like, 'Oh, well what is this?' And then you're like, 'Oh wait, I didn't think about that because I've just been clouded by all the information that's already in my head'."

Enabling Students to Do System Analysis of JEDI Issues at Both Campus and Societal Scales

Using systems analysis of the campus foodscape, the project enabled fellows to enrich their knowledge about food systems and JEDI more broadly. They were frequently highly motivated to join the project out of a strong desire to contribute to campus change, but diverged greatly in how much they knew about food systems as a concept prior to their involvement. Through their mapping endeavors, fellows came to greater understanding that in fact a campus food *system* exists, and thereby became better able to dissect how it works, who are the key participants, and what power relations exist. In tandem, students became substantially more cognizant of manifold JEDI issues, from

exploitation of largely minoritized food workers, to how race, gender, sexual orientation, and disability are determinants of access to education, gardens, and basic food security.

Importantly, the project was designed to encourage fellows to situate this learning in the much larger food systems that universities are nestled within. It attempted to introduce students to what Weis and Fine (2012) call critical bifocality, or "mak[ing] visible the sinewy linkages or circuits through which structural conditions are enacted in policy and reform institutions as well as the ways in which such conditions come to be woven into community relationships and metabolized by individuals" (p. 174). For example, in assessing how campus decision-makers frequently view urban agricultural research/production and housing as competing for "scarce" land, and thus can affect the environmental and economic well-being of neighboring communities (see the spotlight map on the Oxford Tract), students could relate campus topics to global land use issues they might learn about in coursework. Through the spotlight map that analyzed 100 years of UC Berkeley course offerings (see the spotlight map on Food and Agriculture Courses), students learned about Berkeley's history of teaching eugenics and practices for overseas colonial resource extraction, for example, and were able to reflect on the University's evolving visions of what the study of agriculture and food should include— and offer their own JEDI-based visions. In other words, the project helped pull back the veil on not just food systems, but higher education systems, and how the two intersect.

In the beverages case we discuss in the **Supplementary Materials,** fellows learned about the substantive features of the soda industry; its social, health, and ecological effects; and how soda companies manipulate agreements to control access to beverages on campuses and thereby harm student well-being, while simultaneously harming distant communities in the production chain. Fellows also learned about innovative policies that could put pressure on companies to abandon unhealthy products, along with viable business models for alternatives. Joyce Lee reflected: "As a public health nutrition student, a lot of the research that we read, a lot of things we focused on were things like the soda taxes that came from the research at Berkeley…But really just demonstrating how the beverage landscape itself had such a big impact on overall health and really being one of the leading contributors to obesity and obesity-related diseases like diabetes too, and be able to see what it was like at our specific campus as well." She explained why the team decided to pursue the PepsiCo contract as an advocacy project: "Because as a student, you don't really know what partnerships the school might have been with…After understanding the contract some more and really seeing who benefited from the contract, it made me think that as a student who is part of this community, why are we the targets of these advertisements or an exclusive beverage marketplace that only has certain products. Like why are we a part of this type of food system? Do we like the fact that we're being privately sponsored by a conglomerate big soda company? Is this the norm, really?"

In terms of the campus foodscape, fellows were repeatedly astonished at how complex and ill-structured it actually is. Will Payne remembered, "I think I learned that through this project

at Berkeley is the overlapping constituencies and fiefdoms for different things….With the [Campus] Food Players map, I think that really kind of came into full vision of like, 'Oh, wow, these things just kind of sediment themselves and grow in weird ways.' It's not logical, if somebody just told you ahead of time, 'What office is this function in?' I don't think most people would guess right about Berkeley…about any university, because it's all path dependent." Without actually mapping power relations and flows of decision-making coursing through the university, people could not fathom who and what shapes the campus food system. For instance, Berkeley's 24 campus gardens are overseen by 14 different administrative structures, causing frequent confusion for students seeking employment and learning activities in these spaces, let alone advocating for expansion of garden-based opportunities. Faculty and staff nutrition and wellness programs—such as programs for campus employees with the highest risk jobs, which include food service—are embedded in University Health Services, which reports to Student Affairs, affecting funding priorities for services aimed at low-wage staff populations. Because of its historical status as the University's land grant base, the College of Natural Resources controls much of the food course offerings and agri-food research. This knowledge ultimately became incorporated into the Campus Food Players, an interactive power map that allowed users to reveal who were responsible for what facilities, academic units, service units, and student groups.

Importantly, fellows began to develop a sense of how a complex reality behaves as a "system" by trying to connect between all the parts of the campus foodscape they were learning about. Simultaneously, they built the foodscape map as a learning platform (Röling and Jiggins, 1998), by adding their various contributions and seeing what became visible. Hortencia Rodríguez mused: "So there were just a lot of things that I felt were sort of isolated but related initiatives, but there was nothing kind of like bringing them together in a cohesive framework. I felt like this was a really wonderful opportunity for me to think about it as a system…There are initiatives that are responding to different things, but we do need to think about it as a whole. I remember that meeting that we had with the catering and dining people and getting a perspective of sort of thinking about what are the vendors and how do they select vendors? That was just an area that I was like, 'Whoa, I hadn't even thought about this. Labor rights and what do we do with our restaurant workers?' That was just a whole other level that I wouldn't have really thought about unless I had participated in a project like this." For her, the campus foodscape was a microcosm of larger food systems.

Fellows also began integrating JEDI into their coalescing systems perspective. Instead of simply viewing specific cases of injustice in isolation, they understood these as examples of structural oppression working across history and time throughout the campus foodscape. Some (not all) students used critical race and feminist theory to articulate what they were observing. Dennis Uyat explained: "I feel like [the project] really put certain frameworks of white supremacy, all the isms, and patriarchy, et cetera. Like I had this framework and then put it all together in a praxis, putting that theory to practice. So I feel

like that was cool to see and execute and have the opportunity to do that."

Discussing access to gardens, Natalia Semeraro said, "With the gardens, there's always been in the project, but outside of the project too, a lot of discussion around power. I think this is related to student groups too. Like the University of California Botanical Garden is this institution, right. And how no one could harvest the food there. That was a super interesting conversation I remember that Nathalie and I had. Like, 'This is so dumb, this is the biggest garden when you look at it and nothing there is really going to feed anybody!' Super interesting. Then we have these little tiny gardens that are producing a good amount, but also are not allowed, really supposed to be on campus. There's the dynamics there. Then there's the oldest student garden, SOGA [the Student Organic Garden Association], which a lot of students felt not welcome there. Like they couldn't really be involved just the space and the people involved already were not really welcoming to everybody. It was like a very white space. So we talked a lot about that." Natalia is identifying what Bang et al. (2012) called "settled expectations" in STEM education, where white ontological and epistemological constructs have greater currency. Precarious students of color-led food gardens are juxtaposed with long-standing white-led spaces and powerful "scientific" gardens on the same campus. Access to these spaces is not only racialized but based on hierarchies of knowledge and practice. Scientific research on botany and ecology is valued much more by the campus administration and most faculty than experiential learning for urban agriculture, let alone achieving food security.

Developing Competencies in Research and Advocacy

By participating in the project, students acquired practical skills they later applied to other critical food systems work on campus and their unfolding careers. Because the project depended on primary research to inform the map, student teams developed new expertise in research design and methods. Students learned to discern which methods might support their research questions, often garnering skills in methods they had not used previously. Varying between specific sub-projects, these methods included: semi-structured interviews, oral histories, participant observation, semi-structured questionnaires, physical surveys of gardens and buildings, ecological cost-benefit analysis, legal and policy analysis, crowdsourcing observations, web and library searches, analysis of deidentified food pantry and health records, and content analysis of historical documents (see **Table 1**). Students also devoted many hours to appraising this data and figuring out how to visualize and share their findings in ways that would resonate with map users.

As a result, many fellows grew into experienced researchers adept at combining multiple methods. For Nathalie Muñoz, who did not have prior experience with social science research, the project broadened her whole idea of what research could be. "I enjoyed how much this project just completely blew open another door for what could be considered research for me. The idea of interviewing people as a form of research,

that wasn't really something that I had envisioned because I was coming from a hard STEM background of engineering." Nathalie worked on four spotlight maps across 17 months on the project, during which she learned skills in conducting oral histories, content analysis of big data sets, and survey design and execution. Students in the beverage case design course (see **Supplementary Material**) learned hard skills in systems mapping, stakeholder interviews, cost-benefit analysis, financial modeling, value proposition development, writing implementation plans, and crafting a pitch. For Alejandra Marquez, the systems mapping stood out: "I just fell in love with this type of systems thinking and just looking at all the components. Complex systems really are very interesting to me. And so I really loved the activity of systems mapping. That was I think one of the first things that we did that I was like, 'This is so cool. I want to learn more about it'."

Logically, map design was a fundamental area of skill development. As a PhD student, Will Payne joined the Foodscape Mapping Project for the opportunity to work on collaborative cartography. He commented that unlike typical doctoral work, he was motivated to "do something that was project-based that was going to not necessarily just result in a paper that one person would read. This was a chance to test out some of the mapping and visualization on something that was a group effort." Will highlighted that through the trial process he learned about the technical limitations of free versions of private software, which led him to redesign the Geographic Asset Map with all open source software. He commented that he will continue to use open source software moving forward, both as a philosophical choice and to manage public projects with small budgets. A few of the primary fellows, such as Will and Dennis Uyat, worked on both data collection and the visual (or auditory) map-making. For the 10 students who worked only on shorter-term cartographic projects, they gained skills in collaborating with data collectors on translating the research into meaningful visualizations, and building animated graphics that often stretched their previous technical know-how. Each map went through multiple iterations between the researchers and cartographers as the students worked out together a shared vision.

The students demonstrated that learning "hard" methods-based research skills happens alongside other key competencies in the critical nexus of food systems research-activism-pedagogy (Valley et al., 2020). Project management was among these competencies. What should the maps include? Which priorities should be pursued at a given time, leaving other topics for later? What constraints bound what we can realistically accomplish, and what can we creatively overcome? Asked about how she approached the initial design of the map, Hortencia Rodríguez said, "Okay, info gathering, getting myself up to speed. Then there was a phase of being like, 'Oh my god, this is a lot of information. How do we structure in a cohesive and logical way that you can convey in an interesting way without being overwhelming?' Then having to have a conversation about scope and being like, 'Is this within the scope of this project or is this something that we just name for others to investigate further?'...And I think that's how all of the derivative maps [spotlight maps]—also where we had to identify, this is the big map, but then even within these different topics and layers, there's

a whole other map....Those are universal skills, right. To think about systems in that way. And also just how to be in a project, basic project management skills and working in a team... that I felt were really valuable for me as well."

In our interviews, many students remarked that networking and stakeholder engagement was one of their biggest areas of learning: interacting with new peers, a wide variety of campus staff, and people in high authority positions on campus; facilitating meetings; and building confidence in speaking up. Reflecting on program development and coalition building, Joyce Lee said: "So essentially I feel like the whole experience was a learning experience for me because I had not been part of stakeholder engagement or coalition building in such a large way before. Through the [Staff] Basic Needs Working Group...I learned what a working group was and I learned how to make one successful. And I learned that when something became too big, when we had too many ideas, I learned how it was a good idea to effectively separate it into two focuses, such as the Policy and Advocacy Group or the Programming and Outreach group." In other words, students learned how to organize their work to have an impact.

Student leaders also shared their work in public forums: graduate students attended two off-campus conferences, and both graduate and undergraduate students presented at Berkeley town halls and workshops. Many students generated written products stemming from the map, such as a blog post about the healthy beverages course (Pfeiffer, 2020), op-eds about the PepsiCo contract (Solis and Melgoza, 2019) in the campus newspaper, and a report on beverage logo advertising and product mix availability on campus (Lee et al., 2020). Gaining competencies in project management, networking, and communication alongside research methods enabled students to turn the map into an effective advocacy tool in campus administrative politics that has garnered broad attention thus far.

Fellows reflected that the interwoven competencies they gained during their time on the Foodscape Mapping Project gave them hope and confidence for their future careers. Natalia Semeraro reflected: "One thing that was really helpful in figuring out or understanding what kind of work might be possible in food systems, because you don't know that necessarily just from some of the food systems classes, because they tend to get pretty specific on a topic like insect ecology or the nutrition classes... [They] don't really show you like what's actually possible. How else could you think about these things and make connections between the different topics? I think it helped me figure out, 'Okay, what are my skills relating to food systems? Where could I fit in potentially?'" Joyce added: "The way that this had been structured gave me a lot of optimism about my own future and in my own career that there is flexibility out there in order to do some of the things that I am passionate about."

CRITICAL REFLECTIONS: WHAT TO DO BETTER

The mapping led to not only the constitution of a new missing object (the campus foodscape) but also to diverse strands of expansive learning about food systems and JEDI. For the first

time, campus community members could actually grasp what its foodscape looked like, and begin identifying intervention points within the complex administrative structure to make change for racial and other social justices. While the cycles of advocacy and policy that the map project has initiated are continuing to build, it has already led to some concrete effects, such as the creation of new basic needs programming on campus specifically for campus staff[16]. Elsewhere, we have detailed the process by which the map took form, how students were recruited, what existing campus educational and research programs could be leveraged, and the funding that made it possible (Fanshel and Iles, 2020). Here, we briefly review important practical lessons—drawn from both our successes and shortcomings—to help guide campus foodscape mapping at other universities, according to their particular situations and needs.

Mentorship

Without intensive mentoring of students and a carefully structured process for managing teams, the project would not have succeeded. As students wrestled with navigating their amorphous problem space, they needed mentorship to develop doable cycles of inquiry and action, and to grow more confident in grappling with seemingly overwhelming data. Yet learning how to mentor proficiently and patiently took much time and effort—as did doing the actual mentoring work. Partly as a result, Rosalie carried a far too hefty workload as the project director, meeting regularly with multiple student teams each semester, constantly giving feedback on plans and work-in-progress, and overseeing the map's technical design. This was atop her existing responsibilities managing other BFI programs.

Mentorship scholarship emphasizes the importance of promoting a sense of social belonging in an academic community, especially for students of color (Griffin et al., 2020). This includes developing a circle of mentors who vary in their expertise, perspectives, positionality, and life experience (Montgomery, 2017). With majority students of color as project participants, yet a white person in the primary mentorship role, students did not benefit from a network that included mentors with overlapping racial identities. While a project's content may explicitly focus on equity and inclusion, creating a community of belonging is a distinct task. In addition to more effort on expanding a mentorship circle, we could have also been more intentional in specifically recruiting a greater number of Black and Native American students—two populations who are egregiously underrepresented at Berkeley.

We also discovered that mentorship was most supportive after at least two semesters, yet half the primary fellows only participated for one semester due to the structure of educational opportunities available on campus. Most of the shorter-term students indicated that they had significant learning experiences while participating in the project, but a few students did not, for a number of reasons. Data collectors had more meaningful

semester-long learning experiences than students whose roles were focused on policy and advocacy. Developing a depth of understanding of the complex foodscape and project ownership was hard to achieve in a compressed time frame. A few projects had only an individual student working on them, and those students often felt isolated from students working in teams on other foodscape nodes. Regularly scheduled cross-team meetings between concurrent projects, as well as a shared training program at the start of their involvement, would have supported those students more.

In hindsight, facilitated training in mentorship for staff and faculty participants and a formal process of tracking mentoring performance would also be helpful. We have since learned about the value of making mentorship agreements with students, and defining the respective responsibilities of mentors and mentees in these documents. The growing trend in some science faculty research groups toward articulating an explicit anti-racist laboratory policy and community guidelines (Berkeley Agroecology Lab, 2020; CLEAR Lab, 2021) can also offer examples of how mapping projects may develop their own policies. All this speaks to the importance of having sufficient funding to support a network of mentors to be able to dedicate substantial time to both working with students and developing their own competencies in mentorship.

Faculty Support, Institutional Home, and Funding

Only four other faculty members apart from Alastair participated consistently in the Foodcape Mapping Project subsequent to the initial 2015 equity and inclusion workshops that had inspired the map concept (11 faculty participated then). Increased faculty participation would widen the circle of mentorship for specific sub-projects (drawing on faculty-student interest convergence) and increase project legitimacy on campus. As consulting advisors, faculty can offer valuable expert research methods and content knowledge to inform student teams. We also counter-argue for the importance of legitimizing projects with shared, non-hierarchical leadership. The relative absence of faculty in our project probably helped create its collaborative, democratic culture. By contrast, over a dozen professional staff members were very active in data collection, student mentorship, and advocacy and their contributions created fewer power differentials with students. Staff used their program development skills to implement change in response to map findings. Overall, we feel that for campus foodscape mapping to thrive, more faculty involvement is needed, as long as this does not undermine non-hierarchical mapping practice or emphasis on JEDI. Faculty would need to sign on to the learning ontology we describe above, and be receptive to regular appraisals of whether they are acting to help cultivate a student-driven, collaborative learning environment.

If the project had its institutional home in a teaching department rather than a research center, more faculty might be involved and it could be better integrated into Berkeley's undergraduate Food Systems Minor and graduate Certificate in Food Systems, including as a series of consecutive classes.

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[16]Basic needs security programming for students has been very robust on the Berkeley campus since 2014. The Foodscape Mapping Project identified low-wage staff, postdocs, and visiting scholars as additional communities facing high levels of food and housing insecurity. We worked to transform the Basic Need Center into a resource inclusive to these communities through several staff-specific programs.

Course structures such as Berkeley's American Cultures Engaged Scholarship Program (American Cultures Center, 2021) and sophomore seminars, for example, could also be conducive to a foodscape mapping project. The University of British Columbia Food Systems Project serves as an effective model of collaboration between teaching departments, research centers, and student service programs, with extensive coursework integration (Rojas et al., 2007). On the other hand, there were unique benefits to being outside the course structure, such as the potential for longer term engagement by some students, paid opportunities, smaller sized project teams, and not being constrained by course requirements. Moreover, with its mission to nourish interdisciplinary research and experiential learning across campus, the Berkeley Food Institute provided an unconventional home with a dedicated staff member that a discipline-based department may be less able to provide.

The project also had an unstable, small funding base that limited its full growth and created ongoing precarity. It relied on cobbling together small grants, held a crowdfunding campaign, and used a University of California systemwide fellowship program to fund paid student positions (see Funding, below). Taking advantage of the various institutional and educational resources available on a campus can help mapping progress. For instance, Alastair mobilized small grants ($300–$500 per student) associated with Berkeley's undergraduate research apprenticeship programs to help pay for technical development of the map's web platform, public workshops, and survey incentives. Yet, many projects and aspects of the Foodscape Mapping Project were unfunded, drawing instead on the voluntary labor of students and staff from across campus who were dedicated to the project goals. Graduate students also could not have their tuition fees covered because the project lacked large grants, thus making their participation depend on whether they could find other ways to pay the fees—a clear conflict for a project intended to increase JEDI in the campus foodscape. Rosalie also volunteered an average of 5 h per week beyond her paid staff position to support the project, which contributed to chronic burnout.

Alternative funding options would be to apply for larger internal or external grants, such as through a campus's research office or the U.S. Department of Agriculture, or to a foundation that supports food systems education, but these all pose significant costs and barriers to weigh. For example, applying to a foundation might mean that the project must meet reporting requirements and align with the donor's expressed priorities that might inhibit an expansive, flexible learning environment. Potentially, universities could be persuaded to make large, multi-year grants to enable their campus foodscapes to be mapped in the public service. The U.S. nationwide call for a so-called "racial reckoning" following the murder of George Floyd in 2020 speaks to a new heightened awareness and urgency for universities to take meaningful action on JEDI.

Critical Food Systems Pedagogy

Some of our most important lessons are to do with pedagogical design and practice. We should have taken on racial justice more explicitly by having each new project team begin with discussion of a set of core readings from critical race and decolonial scholarship that are particularly relevant to university campuses, such as "Whiteness as Property" (Harris, 1993), excerpts from *Racism without Racists: Color-Blind Racism and the Persistence of Racial Inequality in America* (Bonilla-Silva, 2017), and the recently published "Land Grab Universities" (Lee and Ahtone, 2020). From there, readings could be added that are specific to each foodscape node. We (Rosalie and Alastair) could have consistently integrated discussion of our positionality as part of this dialogue, instead of treating this in an *ad hoc* manner. Each sub-project could have had more structured analysis of intersectional equity issues built into team dynamics and project management.

In our interviews students shared that they would have benefited greatly from readings and exercises related to hard research skills development (for example, designing surveys, conducting interviews, or reviewing historical documents). We paid for several students to participate in a workshop run by the Oral History Center at Berkeley, to aid them in collecting stories from underrepresented members of the campus about their food system and activism experiences. This skill-building could have been promoted more systematically, according to the needs of particular projects that students joined. This adds all the more to the mentoring responsibilities that project staff and faculty may face, which is why serious attention must be given to their training and support.

Finally, the project could have developed ways for students in separate sub-projects to learn from each other more consistently. Some fellows told us they only fully realized what the foodscape map looked like and what insights it offered as a whole during an April 2018 event at which student teams presented their work and we introduced the policy report of key findings. At different stages of the project, student teams were either focused on thinking about the foodscape as a whole (such as the early years and immediately after release of the report) whereas at other stages students deep dove into specific foodscape map nodes. These latter students worked on simultaneous semi-discrete projects. These in-depth projects were crucial to the "thick" materialization of the full campus system, but much further learning could have happened through making connections across sub-projects. Pedagogical ways to support this meta-learning include holding informal share out sessions between project teams at least twice per semester, more frequent public town halls, and assigning previous project work as essential readings for new teams.

CONCLUSION

Foodscape mapping is a powerful pedagogical and participatory research approach to food systems education that centers justice, equity, diversity, and inclusion. Mapping can help make a complex campus food system more legible and tractable by serving as a learning platform for students, staff, faculty, and administrators to collaborate on mutual learning and problem solving—that is, by providing a structure for inquiry-based, participatory, and action-focused knowledge production. We have attempted here to demonstrate how the UC Berkeley

Foodscape Mapping Project created an environment for expansive learning, where students became engaged actors in their education through achieving a level of sociocritical literacy. This learning-as-changemaking approach led to advocacy efforts aimed at improving the experiences of marginalized members of the campus community.

We have shared insights from our experiences at Berkeley to encourage other universities and colleges to consider embarking on their own mapping endeavors as part of developing their innovative food systems educational programs. Such mapping projects also need not be limited to the foodscape—the approach could be applied to, for example, climate equity or transportation equity. In closing, Alejandra Marquez offers these words on the power of mapping as a learning platform: "I think a lot of students, especially in Berkeley, we go to protest or we sign petitions and are part of campaigns or really want to change things at the university. Being part of the entire project and talking to the stakeholders really showed me what can be done beyond just organizing a campaign. More of an in-depth analysis of the need for change. What can happen if we change? Where can we go? What pathways are possible?"

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by UC Berkeley Committee for Protection of Human Subjects (CPHS). The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

RF conceived of, wrote, edited this article, conducted, transcribed, coded the eight interviews with project fellows, served as project lead on conceptualization, methodology, investigation, supervision, mentorship of student researchers, analysis, data curation, visualization, project administration, and funding acquisition. AI conceived of, wrote, edited this article, coded the interviews, served as project champion, contributed to conceptualization, methodology, supervision, mentorship of student researchers, and funding acquisition. Both authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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Ontological Awareness in Food Systems Education

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We observe efforts in Sustainable Food Systems Education and Critical Food Systems Education literature to employ education in ways that seek social and environmental transformation of food systems. Here, we argue that forms of food systems education that are disconnected from awareness of their ontological roots are destined to reproduce the same food systems with the same consequences for life on Earth. This theoretical paper invites discussions that unpack "habits of being" underpinning modern/colonial conceptualizations of food system issues, transformation efforts, and pedagogies. We note the risk of reinscribing, within food systems education, specific onto-epistemological norms and values that are the root of multiple crises facing food systems (separability, global capital, nation-states, humanism). Using the metaphor of the "house that modernity built," we invite scholars, teachers, learners, and other practitioners to bring explicit attention to how the ontology of Western modernity arises in discourses on food systems and is reproduced through food systems education. We begin by describing this ontological position and its dominance, situating how contemporary transformations in food systems education neglect ontological foundations, and enumerating a set of harms arising from this disavowal. As a beginning, we suggest that fields related to food systems are a compelling place to interrupt a habit of being that denies and disavows even the presence of ontological positions. Food systems educators within postsecondary institutions are entreated to develop their analyses and pedagogical approaches toward a more just and sustainable future that denaturalizes harmful and falsely universalized ontological foundations.

Keywords: food systems education, western modernity, food systems transformation, ontology, epistemology–education

Through the imagery of a tree, Ahenakew (2016) illustrates how ontology can be viewed as the root of an intellectual and cultural tradition, while epistemologies, or ways of knowing, form the upper trunk and branches, and methodologies are represented by fruits. There are many different types of trees, and thus many different roots. Many knowledge traditions include considerations of the different ways of being and different natures of reality at their roots, and, in so doing, keep ontological foundations explicit. Others fail to consider the impact of assuming that their ontological foundations are universal. There are a diverse variety of roots both within Indigenous intellectual traditions and within traditions of non-Indigenous peoples. In this paper we focus on the common ontological foundation in modern/colonial practices, institutions, and narratives that

are dominant in Western academies[1]. Normative prescriptions for transforming food systems education (Valley et al., 2018, 2020; Anderson et al., 2019) do not explicitly identify the modern/colonial ontological positions that underpin globalized, capitalist, and industrial food systems. Without identifying, interrogating, and denaturalizing the ontological roots of our currently dominant food system, pedagogical interventions will often presume a "free-floating," "rational" learner potentially resulting in methodological or even epistemological shifts (Rosiek et al., 2020), but ultimately leaving unexamined the underpinnings of the dominant global food system[2] and its modern/colonial habits of being. Montenegro de Wit (2021a), for example, examines the fallacy of the apparent dichotomy of gene editing and agroecology that leads to superficial analysis.

We foresee a set of significant issues arising when proponents of the transformative role of food systems education (FSE) ignore the ontological "root" of Western modernity/coloniality. We are particularly concerned about transformative efforts that engage the branches and fruits of other knowledge traditions. For example, FSE instructors might employ a talking circle approach (i.e., a methodological or epistemological change) while ignoring the Indigenous worldviews and traditions that comprise the talking circle's ontological "root." Similarly, this ignoring may happen with the teaching method of asking racialized students to describe their presumed cultural food systems to illustrate alternatives to dominant food systems without taking the time to discern the ontological differences between cases or preparing students for this level of analysis. When these different roots are ignored, there is a risk of reproducing harmful and extractive patterns of engagement with non-Western knowledges—including universalizing, appropriation, instrumentalization, and romanticization—thereby leaving untouched the modern/colonial habits of being that underlie mainstream food systems education (Ahenakew, 2016). For example, Indigenous ontological rootstocks that recognize animate landscapes and agential ecosystems can be reduced to "cultural beliefs" by Western sciences rather than equally valid and valued ways of knowing, being, and relating in the world (Blackstock, 2001; Marker, 2006; Blaser, 2009; Bang et al., 2012; Watson, 2013).

For these reasons, food systems education programs in agroecology, food studies, nutritional sciences, agronomy, economics, public policy, etc., should interrogate individual, disciplinary, and program-level ontological assumptions to recognize how these ontologies manifest, or are hidden, within postsecondary pedagogical projects.

WHAT IS WESTERN MODERNIST ONTOLOGY?

Mignolo (2011) describes Western modernity as a parochial European narrative, coupled with sets of practices, institutions, and sensibilities, that builds Western civilization by celebrating its achievements while ignoring the invisible costs of those achievements for other humans and other-than-human beings. Coloniality, he argues, is constitutive of modernity, hence the expression "modernity/coloniality." Building on the scholar Quijano's insights, Mignolo (2011) posits a colonial matrix of power comprising four entangled domains, "control of the economy, of authority, of gender and sexuality, and of knowledge and subjectivity" (p. 8), which are supported by racial and patriarchal foundations of knowledge.

Stein et al. (2017) use the metaphor of the "house that modernity built" (p. 73) to illustrate modernity's primary dimensions. The house has a "foundation of separability" (p. 73) that "separates humans from one another, ranking them into racial and civilizational hierarchies" (p. 73), and rationalizes the use of the world "as a source of raw materials and labor for its own upkeep" (p. 73). It has a supporting wall of European Enlightenment humanism that "presumes a linear and universal path of human progress that positions European/White people (particularly men) at its head, while all others are deemed to have a lower 'degree of mental' (moral and intellectual) 'development' (Silva, 2007, p. 123)" (p. 74). Another supporting wall is a fictional social contract that rationalizes the modern nation-state's "law-instituting violence (the appropriation of resources, land, and labor to build the house), as well its law-preserving violence through the police and the military" (p. 73). The house also sits under a failing roof of capitalism that "appears as a betrayal of the promise that the market will reward hard work" (p. 75) and casts blame especially on "those outside the house, when in fact it is they who are likely to suffer most" (p. 75). The house is inherently harmful and unsustainable, given that it requires unlimited growth and consumption on a finite planet. They frame the elements that make up the house as the root causes of contemporary social and ecological crises.

Coulthard (2010) argues that Indigenous ontologies are at odds with this modernist worldview and mode of being and relating, illustrating this difference with the example of his own Dene ontology:

> In the Yellowknives Dene (Weledeh) dialect of Dogrib, "land" (dè) is translated . . . as that which encompasses . . . people and animals, rocks and trees, lakes and rivers, and so on . . . we are as much a part of the land as any other element . . . human beings are not the only constituent believed to embody spirit or agency. Ethically, this meant that humans held certain obligations to the land, animals, plants, and lakes in much the same way that we hold obligations to other people (p. 80).

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[1]We acknowledge that the foundationalism of ontology as more primary than epistemology is debated within Western and non-Western sources (Burton, 2018), and also that sometimes Indigenous and Western use of the word epistemology includes metaphysics, ontology, and ethics (Fellner et al., 2020).

[2]While a review of the global food system literature is beyond this perspective paper, we encourage readers to explore this literature as there are some resonances with the analysis of food systems (see Clapp and Fuchs, 2009; Clapp, 2012; McMichael, 2021). We note that global food systems share a common Western modernity/coloniality foundation, and that assumptions and analyses based on neoliberalism, liberalism, or critical perspectives can share this commonality (Pashby et al., 2020). In this piece, we highlight that the ontological foundations are often missing as the Western modern/colonial ontology presumes universality. When food systems education and global food systems analysis enter conversation due to their common goal of achieving social change, we encourage them not to reproduce the same hegemony of ontologically singular visions of the future.

This orientation "serves as the ethical foundation from which many Indigenous people and communities continue to resist and critique the dual imperatives of state sovereignty and capitalist accumulation that constitute our colonial present" (p. 82). This relational and reciprocal orientation to land as a living entity contrasts starkly with Western ideas of land as property to be owned and exploited for profit by humans.

REPRODUCTION OF WESTERN MODERNIST ONTOLOGY IN FSE

In response to the increasing socio-ecological complexity of contemporary food systems (Jordan et al., 2014; iPES-FOOD, 2015), Canadian and US higher education institutions are developing new degrees, specializations, and certificates that center systems thinking, multi/inter/trans-disciplinarity, community-based experiential learning, and equity (Jacobsen et al., 2012; Self et al., 2012; Jordan et al., 2014; Hartle et al., 2017; Valley et al., 2020; Sterling et al., 2021). However, universities are steeped in and contribute to the reproduction of a political-economic system that privileges neoliberal and market logics, the elite status of Eurocentric knowledge systems, and the production of research that fails to address the root causes of systemic oppression, marginalization, dispossession, and ecological destruction (People's Knowledge Editorial Collective., 2017; Grande, 2018).

A key and shaky assumption in analyses of contemporary food systems is that solutions generated from within the current modern/colonial paradigm can address today's complex socio-ecological problems. However, drawing on the metaphor of the house modernity built, solutions sourced from within the house are unlikely to be sufficient for addressing the problems that the house itself has created. While adjustments or reforms may enable institutions to weather the immediate storm and reduce some harms, taking the long view of structural transformation may require the "non-negotiable termination of the many discrete, yet 'locked in' elements of the industrial agrifood regime" (Montenegro de Wit, 2021b, p. 121), or compassionately hospicing their transformation as we envision multiple possible futures (Machado de Oliveira, 2021).

Two main alternative fields of food systems education are Sustainable Food Systems Education (SFSE; Jordan et al., 2014; Valley et al., 2018; Ebel et al., 2020) and Critical Food Systems Education (CFSE; Meek and Tarlau, 2015, 2016; Anderson et al., 2019). Both SFSE and CFSE advance, at varying levels, community-engaged scholarship, elements of decolonizing education, an appeal to incorporate equity and social justice, recognition and application of different epistemologies and methodologies (e.g., Indigenous, Black, Queer, Feminist), and some recognition of ontological diversity. An example of an acknowledgment can be found in a CFSE publication that states that its purpose is

> to [lever] the broader educational system and innovative pedagogical techniques so that students and educators can utilize food system knowledge and agroecological practices to systematically *dismantle the structural and ideological elements of*

the corporate food regime and develop transgressive subjectivities. [emphasis added] (Sawyer, 2004, as cited in Meek et al., 2019, p. 612; see also Meek and Tarlau, 2015, 2016).

Here, the emphasis is on epistemological and methodological transformation, although there is the potential for this to be extended to an ontological dimension if the approaches to transgression, or dismantling, recognizes the limits and harms of a singular, universal modern/colonial way-of-being/nature-of-reality.

Food systems decolonization scholars such as Matties (2016), Kepkiewicz (2015) criticize settler discourses about place in food systems education for failing to acknowledge a plurality of worldviews. Similarly, Williams and Brant (2019) note the implicit colonial underpinnings employed in claims to equity and social justice within "neutral" educational approaches. Those engaged in decolonizing food systems point to modern/colonial worldviews and subjectivities as important sites of scholarship and subsequent intervention (Morrison, 2011; Martens et al., 2016; Rotz, 2017). As an example, Rotz (2017) shows how settler farmers in the province of Ontario, Canada construct settler identities by "occupying socio-symbolic spaces of perseverance, resilience, resourcefulness, and self-reliance, while on the other hand constructing Indigenous peoples in uncomplicated spaces of dependence, irresponsibility, irrationality and violence" (p. 163).

A key challenge that remains for transformative food systems education is how SFSE and CFSE are engaging with a growing and shared critique of modernity (e.g., Stein et al., 2017). This might require unlearning harmful patterns which can then enable educators and learners to explore and co-create alternative ways of being, interrupting the sanctioned ignorance that forecloses recognition of other ontologies, and leading efforts to address our mutual entanglement, complicity in violence, and acceptance of planetary limits. However, it remains difficult for us as SFSE and CFSE scholars to raise awareness of, and interrogate, our own ontological positions that underpin our pedagogies. We acknowledge the contradiction and tension of this central challenge—to critique our modern/colonial ontology as practitioners in the formality of a traditional academic article without reproducing this worldview.

Another approach arises within Indigenous-led post-secondary institutions and land-based pedagogies[3]. Writing from the First Nations Technical Institute in Tyendinaga Mohawk Territory Ontario, Canada, Williams and Brant (2019) state that in the development of Indigenous food systems education,

> the primary goal [is] the revitalization of Indigenous identity in relation to the individual, family, community, nation, and natural

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[3]It is often the case in Western framings of the food system that they are all one and the same. Indigenous food systems and onto-epistemologies are not "alternative" and are often othered or romanticized. As settlers living on unceded and stolen lands we have a responsibility to question how we teach students to understand their responsibility to settler colonialism. We also note the contradictions that may arise in the reading of this section as it suggests comparisons that we note are not hierarchically positioned nor placed into competition.

and spiritual World. Indigenous food systems degree program will support learners to first restore or strengthen their own cultural fluency and then to learn about the various dimensions of Indigenous food system revitalization, all of which are grounded in both Haudenosaunee worldviews and traditional ecological knowledge (p. 134).

The central educational task is one of building relationality and reciprocity with ways of being. For non-Indigenous peoples, we draw attention to the difficulty of engaging with Indigenous food systems approaches without appropriating, instrumentalizing, extracting, or romanticizing them, and the inseparability of worldviews from epistemological and pedagogical dimensions. Yet if enacted with trust, respect, reciprocity, consent, and accountability (Whyte, 2020), these engagements with Indigenous food systems, without making pan-Indigenous overgeneralizations, can serve as an important reminder to non-Indigenous peoples that modern/colonial food systems are not the only possible approach, and in fact they have come at great cost to Indigenous peoples, marginalized communities, and ecological wellbeing.

HOW A DENIAL OF ONTOLOGICAL POSITION IS HARMFUL

We argue for denaturalizing dominant pedagogical models of food systems education while also problematizing efforts to incorporate different ways of knowing, teaching, and learning that do not acknowledge the harms that arise from a falsely universalized way of being. This is the propensity of the modern/colonial way of being that sees knowledge as a "commodity to be exported to those whose knowledge was deviant or non-modern" (Mignolo, 2011, p. 13). Educational interventions at the level of methodology/epistemology tend to presume the problems with the current dominant food systems are problems of ignorance, instead of deeper problems of ontology and investment in the continuity of the promises offered by the house of modernity, including denials of the hidden harms, and processes, that are required to sustain the house itself. As an example, we provide questions that map onto different layers of

analysis of and intervention in food system education and social systems (**Table 1**).

In describing and applying the "house that modernity built" (Stein et al., 2017, p. 73) metaphor, four denials emerge in relation to Western modernist ontology:

- The denial of systemic violence and complicity in harm,
- The denial of the limits of the planet,
- The denial of being entangled with and responsible to other beings,
- The denial of the depth and magnitude of the problems that we face (Gesturing Towards Decolonial Futures, 2018, para. 2; https://decolonialfutures.net/4denials/).

These denials have ramifications for the analysis of global food system problems. For example, the problem of food security for those living within the house is due to scarcity of agricultural products, lack of education, and inefficient resource use. Montenegro de Wit (2021a) notes that the 2021 UN Food Systems Summit's Scientific Group maintains that "genetic engineering and biotechnology should be applied to increase the productivity, quality and resistance of crops to pests and drought … To widen access to bioscience technologies, intellectual-property rights, skills and data sharing should be addressed" von Braun et al., 2021, cited in Montenegro de Wit, 2021a, n.p. Within the framework of coloniality-modernity, this statement is normative and logical. There is no mention, thus a denial, of unsustainable growth and violence to people, planet, and more-than-human entities (Montenegro de Wit, 2021a).

We add a fifth denial, that is, the denial of embodying an ontology at all—a claim of ignorance, and a subsequent disavowal, that our perspectives and knowledges are shaped by our social positionalities and experiences, and thus, denial of the fact that it is impossible for us to claim the position of objectivity and a "view from nowhere" that is able to see and know everything. This disavowal perpetuates and reinforces a violent, unsustainable, and exclusionary vision of existence in which one particular way of being is framed as universal and superior, and all other ways of being are invisibilized and/or pathologized as less advanced and "developed." This disavowal has been mobilized not only to denigrate but also to justify the destruction of other

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TABLE 1 | Example questions for different educational interventions in food systems education.

Methodological	Epistemological	Ontological
How can we educate students to become better "food citizens"? What kinds of tools/practices are foundational for future professionals to develop solutions to food system challenges? How can we teach students about different peoples' foods and food practices to build understanding and intercultural harmony?	Whose understanding of food system issues/challenges is privileged? Whose is marginalized? How might different ways of knowing about food and food practices influence our understanding of the human right to food? What kind of analytical lenses are necessary for students to understand their role in global food system problems (both in solving them and benefitting from them)?	How does a dominant worldview foreclose the range of what is possible, normal, "good" for the future of food systems? What would it look like, and feel like, if students were responsible to all the beings (both human and other-than human) that enable a food system to exist? How can we open ourselves up to multiple worldviews with multiple understandings of how food figures in different peoples' existence?

ways of being, and in turn, to enact a further disavowal of one's complicity in that violence. Without acknowledging the hegemony and harm that have been enacted by the attempted universalization of western ways of being, it will not be possible to confront and accept accountability for the first denial: that one is complicit in the harm that this attempted universalization has caused to those who embody other ways of being.

It is important to note that even within critical approaches to social and global challenges, including those of food systems, these denials can be present to varying degrees. The desire to "be good" or to construct learners as "transformative agents," "global citizens," or "systems thinkers," may hide how the above four denials reproduce harm. For example, the FAO calls for transformative efforts to achieve the UN Sustainable Development Goals by emphasizing "technology, innovation, data, and complements [(governance, human capital, and institutions)]" (United Nations Food Agriculture Organization, 2021, p. 13), that are tightly coupled to agri-corporations and opening markets in Asia, Africa, and Latin America. It is imperative that ontologies and epistemologies that gesture to different ways of being and thinking are not reductively laid on top of a falsely universalized Western modernist ontology (Ahenakew, n.d., p. 3). For instance, when we situate the desire to "fix problems" as common sense and categorize problems hierarchically and separately, as we often do in the "broken food system" discourse of global development (Easterly, 2002; Moyo, 2010), this likely rests on a worldview that glorifies linear technological progress and apolitical scientific analysis: "the need for universal measurement and easily replicable indicators is limited to the project of constituting poverty as an object of management … in ways that render it subject to regulation and which can contain and limit its potential as a radically disruptive political problematic" (du Toit, 2009, p. 240).

If we draw on the critique of the supposed benevolence and universalism of a modernist ontology, this will likely shift how we approach food systems education in post-secondary institutions. This critique suggests that "we cannot expect capitalism, the state, or Enlightenment humanism, to fix the problems that capitalism, the state, and Enlightenment humanism have created" (Andreotti et al., 2018, p. 28). The denial of an ontological position reinforces a homogenizing, essentializing vision of existence, casting science practitioners who examine alternatives to positivism as committing a moral wrong by engaging with subject matter deemed outside the field of science (Leahey, 1980). Thus, it is difficult to address the intentional disavowal of acknowledging an ontological position when there is a taboo about discussing being, existence, and identity in scientific theory and in natural science education itself. It is difficult to move beyond this circularity, especially given that many of us lack the language or pedagogical frameworks with which to address it.

Extending this argument further, the pursuit of Western modernist ways of being also limits, prevents, and suppresses Indigenous ways of existing and relating (Little Bear, 2000; Marker, 2006; Blaser, 2009; Bang et al., 2012). Rather than only trying to school for deeper and more nuanced thinkers, food systems educators need to question the presumption of our ability to plan and achieve an imagined future on behalf

of all people and the planet (Amsler and Facer, 2017; Osberg, 2018). Current challenges arise from a "modern-colonial habit of being" (https://decolonialfutures.net/4denials/, para. 1), rather than merely from gaps in our knowledge and skills (Mika, 2012; Stein et al., 2017).

Western modernity reduces being to a mechanistic and commodified materiality of individual bodies and neurological functioning (Ahenakew, n.d.). The belief that the world can be reduced to our knowledge of it, and to naturalized cognitive and declarative forms of knowledge, presents the status quo of food systems education as permanent and immutable and forecloses alternatives (Bhaskar, 2016). This failure to comprehend an ontological position, coupled with intentional maintenance of ignorance, denial, or "colonial unknowing" (Vimalassery et al., 2016, para. 1), serves to reinforce a singular, immutable reality for those who benefit most from Western modernity. Thus, patterns of epistemological *and* ontological dominance remain in place, and cognitive injustice continues to be a central object of critique in Indigenous studies and other fields (Battiste, 1998; Kuokkanen, 2008). Kuokkanen (2008) notes,

> sanctioned ignorance—the way in which "know-nothingism" is justified and even rewarded in the academy—is "of heterogeneous provenance," manifesting itself in various ways (Spivak 1999, x). It refers to academic practices that enable the continued foreclosure of the "native informant" by not acknowledging her role in producing knowledge and theories. Sanctioned ignorance also relates to ways in which intellectual practices obscure contemporary concerns such as global capitalism and neocolonial processes. Sanctioned ignorance is, therefore, inseparable from colonial domination (Spivak 1987, p. 199). (Kuokkanen, 2008, p. 62).

IMPLICATIONS AND SYNTHESIS

As many academic fields, including food systems education, move to confront their colonial foundations and western-centric curricula, we suggest the need to be mindful of the risk that emergent and alternative ways of being and thinking are carelessly subsumed, grafted, or absorbed into a falsely universalized Western modernist ontology (Ahenakew, n.d., 2016). When this happens, these changes serve more as window-dressing than as a substantive transformation of existing paradigms, and they fail to attend to the accountability of our fields and institutions to redress the harmful impacts of centuries of colonial oppression. While practitioners and educators might already be familiar with the importance of recognizing various ways of knowing and ways of doing research (Moon and Blackman, 2014), transformations only at the level of research epistemologies may leave ontological foundations undisturbed (Rosiek et al., 2020). Thus, during the present ecological crises, food systems educators and learners may continue to unknowingly dwell in the crumbling house of modernity even as routine epistemological crises continue to unfold with little effect.

In SFSE, CFSE, and Indigenous food systems education, we observe efforts being made to employ education in ways that seek

transformation. We argue that forms of food systems education that are disconnected from their ontological roots are destined to reproduce the same food systems with the same consequences for life on Earth. We argue that ways of being based on the house of modernity—colonialism, capitalism, the nation-state, universal Enlightenment rationality, anthropocentrism, binary gender, and separability—are positioned and internalized so that solutions and reforms serve to reproduce these same systems of oppression. Instead, we echo calls to gesture toward onto-epistemological possibilities beyond the limits of current educational efforts conditioned by global capitalism and modernist understandings of the learner (de Oliveira Andreotti, 2014). We are not offering up these possibilities in this paper because it would reproduce the modern promise of self-fulfilling outcomes and certainties. Rather, we are arguing for an awareness of a dominant onto-epistemology and a role for higher education to play in bringing critical awareness. This entails holding space for those of us who work and study within higher education so that we can grapple with the limits of modern/colonial onto-epistemological possibilities, engaging in ethical ways with other existing possibilities, and experimenting with new possibilities that have yet to be imagined.

Recalibration is required to shift our relationships with ways of knowing and being, with traumas and fears, and with ourselves as entangled parts of a broader metabolism. Contemplate the magnitude of the educational task before us: the task of decentering and disarming the modern subject and her/his/their strong desires for progress, futurity (conservation of privilege and perceived entitlements), innocent anthropocentric agency, and totalizing forms of knowledge

(Tuck and Gaztambide-Fernández, 2013; de Oliveira Andreotti, 2014). These desires normalize and naturalize the hegemony of modern subjects in defining the terms of engagement with different ways of being and prevent the emergence of other possibilities of co-existence.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

CD, DC, WV, TC, and WM contributed to conception and design of the perspective piece, including contributing to discussions, literature reviews, and description of lived and professional experiences. CD wrote the first draft of the manuscript. All authors wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Critical community-engaged scholarship in an undergraduate food systems capstone: A case study from Public Health

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In this perspective paper, we present a case study of food systems pedagogy and critical community-university engagement within a school of public health at a large and public research university. We start by providing a contextual foundation for the importance of intentionally centering equity-oriented curriculum and community partnerships in academic settings. After highlighting institutional mandates and curricular innovations from a food systems capstone course, we utilize key questions of critical community-engaged scholarship to analyze the case and critically reflect on gaps and opportunities for ongoing growth.

KEYWORDS

food systems pedagogy, critical community-engaged scholarship, public health, case study, anti-racism, undergraduate capstone

Introduction

Food systems degrees in the US and Canada often include opportunities for community-university engagement and yet rarely center equity and anti-racism as core values and learning outcomes for students (Meek and Tarlau, 2015; Valley et al., 2020). This critical perspective is missing from most food systems programs (Valley et al., 2020). While some programs do incorporate or prioritize anti-racist approaches, they are often marginalized, underfunded, and largely undocumented (Telles, 2019). Community-university engagement that is not explicitly oriented toward equity and anti-racism can serve to reinforce racially exclusionary spaces and power imbalances (Gordon da Cruz, 2017; Telles, 2019).

Academic institutions can often be exploitative forces in and of themselves by way of excluding participation along lines of race, gender, culture, and socioeconomic class, and via a long and fraught history of abuses and betrayals carried out by academics and universities against oppressed communities. Extraordinary cost, prohibitive secondary education performance requirements, and a general air of academic exclusivity have systematically and intergenerationally deprived many communities of the resources and opportunities that universities have to offer. At the same time, these factors have barred many who are unequivocal experts on the realities and needs of their communities from

having a voice in the development of methods, knowledge bases, and curricula that both claim to adequately explain the plights of and largely define the scope and scale of potential solutions for oppressed communities. This deficit is especially glaring as food systems academic programs proliferate. With these considerations acknowledged, anything less than intentionally collaborative and critically reparative partnerships with communities that continue to suffer injustices linked to academic institutions, is effectively complacent and implicitly supportive of ongoing inequity. In this way, the balance of power remains oriented to a status quo that prioritizes Whiteness and white supremacy. Communities of Black, Indigenous, and People of Color, who are so often excluded from institutional leadership roles and academic positions, must be affirmed in their expertise and ceded a high level of directive sovereignty in order to combat these persistent problems.

Food systems degrees traditionally emerge from a variety of disciplines, including agricultural sciences, environmental studies, sociology, anthropology, and more recently, public health. Food and food systems embody many key public health concerns, including diet-related diseases, climate change, and environmental and occupational health. In return, public health increasingly brings forward a commitment to health equity, which can be considered "social justice in health" (Weiler et al., 2015). Health equity is achieved when everyone, regardless of race and identity, has the opportunity to attain their highest level of health (Weiler et al., 2015). Since racism structurally limits the social determinants of health, including food security, housing, education, and employment, anti-racism is a necessary and key component of health equity. The American Public Health Association (APHA) recognizes structural racism and specifically anti-Black racism as a public health crisis and as a fundamental cause of racial health inequities (APHA, 2020). These inequities and their rootedness in persistent social structures that enforce racist and exploitative systems are evidenced by disparate rates of food insecurity across communities and through labor injustice throughout the food supply chain.

We therefore present a practice-based and reflective case study to document a pedagogical focus on equity and anti-racism in a large, community-engaged food systems course at a school of public health within a public research university. Since such documentation is infrequent, this outlier case provides utility through rich and atypical insights (Stake, 1995). In particular, we present the case of the Food Systems Capstone (NUTR 493) of the Food Systems, Nutrition, and Health (FSNH) Bachelor of Arts major within the School of Public Health (SPH) at the University of Washington (UW). In 2016, the UW SPH adopted a school-wide learning competency related to equity and anti-racism: "Recognize the means by which social inequities and racism, generated by power and privilege, undermine health" (Hagopian et al., 2018). While

this competency acknowledged the School's orientation toward racial equity, it is notable that "recognize" aligns only with the first order of in Bloom's Taxonomy, which progresses from knowledge and comprehension to application, analysis, evaluation, and creation (Adams, 2015; Harvard Medical School, 2018). As such, it is only an initial step of an anti-racist learning journey. Since the introduction of this competency, significant work has been initiated within the School to support both knowledge and action. By 2019, the UW SPH Equity, Diversity, and Inclusion (EDI) Action Plan was released (UW SPH, 2019) with related action steps to move the SPH, and its departments, programs, and workgroups, toward its EDI goals. In 2020, during the height of Black Lives Matter protests, over 300 SPH students, staff, and faculty signed a petition calling for universal anti-racism training (UW SPH, 2020). That fall, the School launched its anti-racism training, which is ongoing. An article from the Spring of 2021 in the UW SPH magazine quoted the Assistant Dean EDI, Dr. Victoria Gardener, "Anti-racism work is a journey and we're at the very beginning" (Chandler, 2021).

The FSNH major, which launched in 2019, adapted the School's competency into the following learning objective: "Articulate how social inequities and racism, generated by power and privilege, are embedded within food systems and undermine health." "Articulate" is a second order verb in Bloom's taxonomy, aligned with comprehension. This learning objective for the FSNH program is achieved primarily through the Food Systems Capstone and thus remains somewhat marginalized within the degree. Based on the community-identified projects and the general outlook of the capstone teaching team, the course has been moving into Bloom's third order of action and specifically the field of reparative action, inspired by justice framework elements of participation, horizontalism, and equity outcomes. In this way, we posit that the capstone is meeting and exceeding the scope of both the School's resolution and the FSNH major's learning objective.

The *food systems capstone* at the university of washington school of public health

After the FSNH major launched in 2019, the first capstone was offered in the Spring quarter of 2020 with 45 students; the first full academic period under the COVID-19 pandemic. By the second remote offering in the Spring quarter of 2021, there were 105 students, and the numbers continued to grow to over 130 students in 2022. The capstone learning objectives include supporting students to:

- Apply food systems concepts to real-world circumstances and challenges.
- Practice the methods used to conduct food systems research.

- Analyze the impacts of food systems on population health.
- Develop recommendations and articulate them using clear and effective oral and written communication.
- Appreciate the breadth and depth of professional opportunities in food systems, nutrition, and health.
- Articulate how social inequities and racism, generated by power and privilege, are embedded within food systems and undermine health.

As described in course materials and online, the capstone provides a culminating academic endeavor for FSNH students to apply knowledge and skills acquired in their courses to specific food systems problems or opportunities. Course content focuses on systems thinking, community engaged scholarship, anti-racism and equity, and opportunities for students to grapple with real world, complex issues across food systems. Students work in teams of four to five students, with direction from the teaching team (instructor, project coordinator, teaching assistants) and in partnership with community leaders, who identify project opportunities for the students. We connected with community partners primarily through the professional networks of the instructor (YS) and other FSNH faculty members and invited them to share their "wish list" projects, especially those that would benefit from undergraduate creativity and energy. Community partners include leaders and representatives from community-based organizations, local and county government, social enterprise, and other key stakeholders. Partners represent farm and food systems organizations and initiatives, public agencies, food banks, food hubs, and more. Community partnerships are invited for one or multiple years.

For the 2020 and 2021 capstone offerings, we invited all projects to relate broadly to the theme of growing a resilient and equitable food system within Seattle-King County and Washington state. While resilience and equity are both connected within sustainable food systems, it is essential to acknowledge the breadth of meaning that is attributed to these terms. Some of our partners outwardly embrace decolonial and anti-capitalist values, perspectives, and missions, while others work more firmly within the confines of neo-colonial structures and capitalism. The projects that this range of partners brought forward ranged from mainstream food security work to alternative food systems that explicitly work for food justice and sovereignty. The 2020 and 2021 community partner organizations, project titles, and other relevant details are listed in Table 1 and can also be found on our *Student Projects* webpage. While each project is different, all student teams are guided through collaborative learning processes to support co-creation of a team charter, project proposal, and final outcomes that have included literature reviews, comparisons of existing programs, educational resources, infographics, website mockups, social media content, and other materials requested by their community partner. In addition to skills

in meeting facilitation, project management, written and oral communication, and critical reflection, specific learning activities are tied to the projects' goals and outcomes. Over the quarter, students consult with and report back to their community partner multiple times to solicit feedback and ensure that they are on track. This teamwork, along with individual writing assignments, is also assessed by the capstone instructional team.

Curricular and community partner strategies related to equity

Curricular strategies for racial equity

In both 2020 and 2021, our learning environment was necessarily informed by the COVID-19 pandemic and Black Lives Matter protests. These phenomena impacted our students personally and in their studies of food systems. As was planned prior to the pandemic or social unrest, we drew on the 21 Day Racial Equity Habit Building Challenge from Food Solutions New England as a guide for learning, reflecting, and acting on issues related to identity and racial equity within food systems. Food Solutions New England is a regional food systems initiative consisting of six states in the Northeast United States. This network began publicly centering racial equity in 2013 and began to organize and host the Challenge in 2015. By 2021 they had over 7000 participants. The Challenge provides curated resources and daily reflection questions and activities to support understanding and dismantling white supremacy in individuals and organizations actively working to become anti-racist and promote justice and liberation. Since the capstone runs over a 10-week quarter, we use a modified version of the 21 Day Challenge to engage with the readings, presentations, and opportunities for reflection.

We found that our students generally appreciated the opportunity to participate in the Racial Equity Habit Building Challenge. The relatively digestible, multimedia nature of the resources likely supported student learning and motivation to keep engaged with the material and assignments. The iterative approach of "Learn, Reflect, Act" provided a framework for students to connect the Challenge with their community-based project. For their final presentations and submissions, each team was asked to reflect on their project's implications for resilience and equity.

Community partner strategies

The first two capstone offerings were held remotely due to the COVID-19 pandemic. Classes, meetings, and presentations all occurred over Zoom. Students and partners generally managed the online environment, and in fact, may have met more often due to the accessibility of video calls. While the remote environment provided some ease and efficiency, it was

TABLE 1 An overview of the community partners and community-engaged food system projects from the University of Washington Food Systems Capstone (NUTR 495) in 2020 and 2021.

		Projects	# of Students	# of Student teams	Partner organizations	Returning partner(s)?
2020 (Y1)	**Y1 Overview**	**10 distinct project topics**	**45**	**10**	**10 distinct partner organizations**	–
	Local Projects	*Creating Accessible Food Systems through Education and Community*	5	1	Black Farmers Collective	–
		Food and Farm Business Support Center	4	1	Business Impact Northwest; King County Department of Natural Resources and Parks	–
		Capturing the Benefits of Regional Food Systems	5	1	City of Seattle Farm to Table Program; Nourishan for Life	–
		Food Web or Food Trap	4	1	City of Seattle Farm to Table Program; Nourishan for Life	–
		Washington State Farmer Resources Map	5	1	PCC Farmland Trust	–
		Immigrant Senior Meal Site Resource Guide to Local Foods	5	1	Tilth Alliance	
		Growing Rooftop Roots Across the Community	5	1	University District Food Bank	
		Protecting Native Pollinators at Viva Farms and Beyond	5	1	Viva Farms	–
		Grassroots WA State Sustainable Agriculture Resiliency Survey	5	1	Washington Young Farmers Coalition	
	Un-partnered Project	*Natural Disaster Subsidy For Farmers in Taiwan*	2	1	–	–
2021 (Y2)	**Y2 Overview**	**15 distinct project topics**	**105**	**21**	**11 distinct partner organizations**	**5 returning partners**
	Local Projects	*Building Food Systems toward Food Sovereignty*	10	2	Black Farmers Collective	yes
		An Exploration of Local vs. Industrial Meat Production	10	2	City of Seattle Farm to Table Program	yes
		Building a More Resilient and Equitable Food System in Seattle	10	2	City of Seattle Office of Sustainability and Environment	no
		Creative Land Tenure Options for Farmers in King County	5	1	SnoValley Tilth	no
		Policy, Systems and Environmental (PSE) Strategies at Food Banks	10	2	Solid Ground	no
		Expanding Culturally Relevant Food Choice	10	2	University District Food Bank	yes
		Building a Digestate Distribution Pathway in our Community	6	1	University District Food Bank	yes

(Continued)

TABLE 1   Continued

	Projects	# of Students	# of Student teams	Partner Organizations	Returning Partner(s)?
	A Growing Need for Accessible Agriculture at Viva Farms	10	2	Viva Farms	yes
	Incorporating Food Justice as a Value within Homeless Youth Shelters	10	2	Youthcare's Orion Project	no
	Where's Our Food?	11	2	Plant Based Food Share; Farestart; King County Local Food Initiative	Yes (1 of 3 partners)
Un-partnered Projects	*An Exploration of the Food Delivery Industry in Shanghai*	3	1	–	–
	Analysis of Decreasing Arable Lands in China and Korea	4	1	–	–
	The Organic Food Industry in China	4	1	–	–
	The Making of Composting withCollege Roommates	1	–	–	–
	Building a More Resilient and Equitable Food System in Seattle	1	–	Project was carried out individually, but modeled off of the identically titled projects facilitated by the CIty of Seattle.	–

Community partnerships were situated in Seattle-King County, Washington, and the international projects were created to accommodate students unable to participate in local projects due to disruptions from the COVID-19 pandemic. In the first offering (2020), 45 students engaged in 10 project teams and partnered with 10 distinct community partner organizations; in the second offering (2021), 105 students engaged in 21 project teams and partnered with 11 distinct community partner organizations, as most projects had two assigned student teams. Conducting critical community-engaged projects in large classes is supported through team-based learning, multi-year partnerships where possible, and a curriculum that centers community partners as experts, supports asset-based community engagement, facilitates anti-racism learning and habit-building, and embraces complexity as fundamental to food system pedagogy and critical community-engaged scholarship.

deficient by other measures, including limiting the amount of networking that was possible and also that was planned as we chose not to host additional online meetings for the community partners. As we transition from remote offerings to in-person, we will reconsider opportunities to support community partner networking.

As of 2021 (the second offering) we started paying a nominal sum for each community-based project as a way of honoring partners' time and expertise, as well as their important contributions to the students' education. While it was encouraging to be able to offer some form of financial compensation, greater support is needed. This may include additional funding to better support community partnerships, along with a greater consideration of the ethical responsibilities of public institutions to share and redistribute resources to the communities in which they are located.

Critical community-engaged scholarship questions, strategies, and outcomes

Establishing pathways of reflexivity and action based on lessons learned in the first years of a course is an ongoing process. Contending with a new program, a pandemic, and a time of significant social change while attempting to embrace values and goals that do not always fit effortlessly within surrounding institutional structures, it has been somewhat difficult to apply tangible frameworks to evaluate the course's successes and short-comings. In an effort to contextualize and clarify both our progress and areas most in need of improvement, we have used the four critical questions presented by Gordon da Cruz (2017) to reflect on community-engaged scholarship within the UW Food Systems Capstone. Table 2 lists the questions, with specific strategies and outcomes from the first two offerings.

Discussion

We utilized Gordon da Cruz (2017) framework to reflect on whether the food systems capstone is advancing anti-racism and racial equity (see Table 2). These four critical questions interrogate how knowledge is constructed, how expertise is defined and located, whether research and scholarship are race conscious, and the power of asset-based understandings of community. Stronger strategies lead to more beneficial outcomes for both students and community partners. The capstone is orienting toward critical community-engaged scholarship, yet as noted in the strategies and outcomes column, there is room to grow in how the instructor and program are able to support truly equitable community partnerships, as well as student engagement with race conscious research and scholarship.

All participants - students, teaching team, and community partners - engage as part of an iterating and evolving community of learners. Such learning environments often hold the best intentions to contribute positively, and yet still have potential to cause hurt and harm in various ways. Critical reflection is therefore essential to the process of learning and includes highlighting and considering what does not work well, why, and how it can be improved over time. The capstone continues to develop with each offering. Student and community partner feedback from previous quarters is considered carefully and incorporated as possible. The instructor participates in ongoing skill-building to center anti-oppressive principles within instructional strategies; ideally these opportunities will be better supported for the full teaching team. As we transition back to in-person engagement, we are planning for more hands-on learning opportunities for the students, as well as for networking and celebration that includes community partners. We anticipate these strategies will help to deepen relationships that are fundamental to this learning experience.

While there was generally positive student feedback regarding the racial equity resources and opportunities for engagement, there exists a broader struggle with anti-racist curriculum in an academic context that emerged from and is still ruled by inequity. Structural racism still informs institutions, curricular norms and requirements, and the students who are accepted to college and end up in classrooms. As we strive to embed racial equity content that is digestible and engaging for all students, we also attempt to reconcile the context of an educational system that in many ways still embraces and perpetuates white supremacy. At worst, tailoring materials to be accessible for all students lowers the level of comprehensive anti-racist curriculum that is viable and may compromise the experience of BIPOC students who are already well-versed with these concepts. Regardless of good intentions, catering racial equity curriculum to the lowest strata of student understanding can effectively be experienced as yet another manifestation of structural racism. On the other hand, and at best, embracing a racial equity curriculum for all can facilitate BIPOC and white students collaborating in critical community-engaged scholarship through development of an equity-oriented community of learners. Over time, these cohorts will ideally comprise allied colleagues committed to racial equity.

We received student feedback articulating versions of these perspectives. We tried to be as mindful of these dynamics as possible, but results were imperfect. The process of improvement will be iterative and perhaps ultimately restrained until oppressive institutional and social structures shift, white students enter the course with more thorough conceptions of inequity, and our program's instructor base diversifies.

How does academia address the challenge of simultaneously introducing, instructing, and training a diverse but largely white student body regarding anti-racism, while at the same

TABLE 2 Questions, strategies, and outcomes of critical community-engaged scholarship within the first 2 years of the UW Food Systems Capstone, 2020 and 2021.

Critical Community-Engaged Scholarship Questions (Gordon da Cruz, 2017)	Strategies and Outcomes from the UW Food Systems Capstone, 2020 and 2021
1. Are we collaboratively developing critically conscious knowledge?	Strategy: The Capstone teaching team facilitated explicit and critical examination of how race and racism, along with other intersections of identity and oppression, impact food systems historically, currently, and structurally. Many community partners reinforced these themes and shared examples from their own work to support student development of critical consciousness. Capstone students were invited to be actively involved in their own learning.
	Outcome: Capstone students experienced some significant shifts in awareness and development of critically conscious knowledge. For example, through their projects, several teams transformed their awareness of "food deserts" into a deeper understanding of "food apartheid," acknowledging that lacking affordable, fresh, nutrient densefoods that are culturally acceptable is *not* simply a geographic problem, but rather the direct result of an explicit system of inequity.
2. Are we authentically locating expertise?	Strategy: Capstone projects were developed by community partners, with support from the instructor and coordinator. Community partners were recognized as the experts, and maintained creative control and course-setting capacities.
	Outcome: While the expertise of community partners was certainly centered, partners were a mix of *representatives for* and *members of* communities they serve. In some cases, partners did not have lived experience of marginalization and oppression. The risk is that without that specific expertise, there are potential limits on the development of knowledge that supports justice (Gordon da Cruz, 2017).
3. Are we conducting race-conscious (instead of color-blind) research and scholarship?	Strategy: We drew on resources and tools provided by the 21 Day Racial Equity Habit Building Challenge, as well as the recent UW Health Sciences Common Books,
	So You Want to Talk About Race (Oluo, 2019) and How to be an Anti-Racist (Kendi, 2019) to lay a theoretical foundation of race-consciousness. We then encouraged and supported students to integrate this consciousness into their project work.
	Outcome: While each student team was asked to reflect on their project's connection to resilience and equity, there is room to extend the critical reflections to focus on racial equity in particular.
4. Is our work grounded in asset-based understandings of community?	Strategy: We have drawn on Asset-Based Community Development (McKnight et al.) to ground the capstone projects in asset-based understandings of community, pointedly incorporating asset-based framings into course content.
	Outcome: There have been dramatic shifts in understanding and framing, with some students profoundly changing their views and approaches of community-partnered work, but more progress is needed. The extent to which some students are conditioned to embrace sentiments of saviorism and false, problematized narratives of charitable "helping" in these contexts is difficult to overcome; particularly while attempting to create course content that is valuable and safe for all students, not just those struggling to understand how self-serving and self-righteous community engagement can be damaging.

The four critical questions are framed by Gordon da Cruz (2017) as a strategy to reflect on community-engaged scholarship and whether the work is advancing goals of advancing anti-racism and racial equity. For each question, the authors reflected on strategies and outcomes of the capstone.

time creating a valuable, safe, non-traumatic experience for marginalized students who may be more knowledgeable and better qualified to speak on these topics of equity and oppression than their white instructor(s)? We acknowledge the limitations of academia, as well as our own particular context. In our program, we operate within a primarily white faculty base and instructional team. Facilitating learning on these topics for students of color requires acknowledging and valuing their lived experiences and acute awareness of how interlain sociostructural oppressions disproportionally exclude people of color from academia. White supremacist ideology is evidenced in academic institutions through institutional policy, funding structures, long-established disciplinary norms, and even disciplines themselves. Instructors and facilitators have identities, life experiences, and positions of privilege that can be vastly different from students; reflexively and critically situating ourselves may increase opportunities to deliver curriculum that is valuable and safe to students who know and experience oppression actively.

Positionality statements

This case study is situated in a critical epistemological foundation including self-reflexivity around "how, why, and in what ways research is conducted and an understanding of the role of power, privilege, and visibility in the research process" (Jacobson and Mustafa, 2019). The authors therefore share our positionality statements here.

The authors are employed by UW, which sits on traditional and unceded Coast Salish territory, specifically of the Suquamish, Tulalip, and Muckleshoot nations and the Duwamish Tribe. The authors collaborated on the first two offerings of the Food Systems Capstone (2020, 2021), YS as instructor and AI as project coordinator, and participated in the co-constructed community of learners encompassing students, teaching team, and community partners. YS identifies as white, Jewish Ashkenazi, granddaughter of Holocaust survivors, cis-woman (she/her pronous), parent; her background in plant biology, soil ecology, food system networks, and community ownership informs her work on food justice and sustainability. AI identifies as a white, nonbinary person and uses either he/him or they/them pronouns; AI's food systems research and educational work is informed by a background in anthropology and consistent, critical consideration of power structures and systemic violence.

Conclusion

Actionable strategies to advance equity and positive social change remain largely missing and undocumented from most contemporary food systems programs in the US and Canada. There is a need and opportunity to center racial equity and critical community-university engagement to advance justice in and out of the classroom. Equity work cannot be successful while the voices, views, and protocols of those individuals and institutions benefiting from inequity are still the loudest. We recognize there are inherent limitations when white people lead anti-racist curricula; we also embrace the opportunity to use our positions of privilege to actively break down exclusive academic spaces and center the wisdom and expertise of community representatives to help grow equitable, mutual, and critical collaborations.

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Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Critical pedagogy for food systems transformation: Identifying and addressing social-justice problems in food systems and society

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Current crises in the food system have amplified and illuminated the need for urgent social change to increase equity and survivability. Global crises such as climate change, environmental degradation, and pandemics increasingly disrupt everyday lives and limit possibilities in the food system. However, the prevalence of these crises has not yet engendered commensurate rethinking on how to address these increasingly evident and desperate social problems. Food and food systems are at the core of survival and food systems issues are deeply intertwined with and inextricable from the structures and operating principles of society itself. Effective and equitable change requires new ways of thinking, ways that are different than those that led to the problems in the first place. This requires identifying, conceptualizing, and addressing social problems through critical inquiry that places social justice at the center in order to render visible and explicit the social injustices in problem causes and consequences, as well as transformative pathways toward social justice. One of the most important domains for this work is that of higher education, an arena in which crucial conceptual thinking can be supported. In this brief article we review why critical pedagogy should be a priority in higher education; discuss critical pedagogy for food systems equity; and illustrate how we apply critical pedagogy in the Food Systems and Society online Master of Science program at Oregon Health & Science University.

KEYWORDS

critical inquiry, food systems, inequity, pedagogy, praxis, social justice

Introduction

A crucial and appropriate location for conceptual thinking about social problems and their social-justice-based solutions is higher education, where intellectual work can take place free of daily exigencies of survival. Non-profits can struggle to create the necessary time and space for critical inquiry, given their funding pressures and foci of

advocacy and direct action. Private enterprise focuses on profit generation rather than equity. While higher education is the appropriate institution for pedagogical approaches grounded in critical inquiry, it is time-consuming and often not prioritized in the interest of expedience and more instrumental values. Particularly in their neoliberal incarnations and given reductions of public funding, many universities face the same sorts of pressures as do non-profits and private enterprises. Institutions and programs of all sizes may struggle for financial support and often focus on research and education that generates specific pecuniary value for the institutions themselves and for their graduates. Accordingly, universities increasingly tend to push toward instrumental career-focused skill building; valorize research that can be commercialized; increase reliance on contingent faculty; and redefine students as customers purchasing private goods. While these trends are not new, the priorities they represent have been reinforced under neoliberalism and increasingly take precedence over critically-oriented education (see, for example, Saunders, 2010; Giroux, 2014). This is put quite starkly by Giroux (2010, p. 186), who opines that higher education has abandoned the common good and "has become an institution that in its drive to become a primary accomplice to corporate values and power makes social problems both irrelevant and invisible." Consequently, there is little room for addressing social justice, conceptual thinking, critical inquiry, or reflection.

Nonetheless, it is the role and, indeed, responsibility of public education and research institutions to articulate problems and solutions that are in the public interest, that is, to address systemic inequity. This is closely connected to developing capacity for critical thinking, high-level literacy, and discernment—foundations of "real" democracy. For Giroux (2010, p. 188) "higher education may be one of the few public spheres left where knowledge, value, and learning offer a glimpse of the promise education for nurturing critical hope and a substantive democracy." Realizing this promise requires pedagogical approaches that are congruent with it. Drawing on Freire (2005), Giroux explains that these approaches must provide "the knowledge, skills, and social relations that enable students to expand the possibilities of what it means to be critical citizens" so they can effectively participate in a "substantive democracy" (Giroux, 2010, p. 192). In the context of food systems education, Classens and Sytsma (2020) argue that post-secondary institutions have a responsibility to increase food literacy in order to address food insecurity and unsustainable social and ecological outcomes in the food system. We suggest that this responsibility extends beyond food-system-focused literacy and practices and to critical conceptual thinking and inquiry about social structures and systems that enable and constrain social justice. This involves a critical pedagogy that is based on clear problem definition, appropriate epistemologies, and relevant conceptual frameworks that center social justice.

Foundations of critical pedagogy for social justice in food systems and society

Our first point is an ontological one that has to do with the category of, "food system." While problems may be evident in the food system, their causes and solutions transcend the boundaries of the food system per se. They are inextricably connected to the social world through which they were created, persist, and can be solved. Problems such as poverty and resource exploitation are not merely outcomes or contextual factors of food systems, but are integral to dominant food systems and society's operating principles. That is, to address problems in the food system, the unit of analysis must shift from the food system to the historical and contemporary social relations that constitute, structure, and condition the society in which food systems are embedded. Critical ontologies of food systems must include the social relations and systems that construct and condition them. For example, Yamashita and Robinson (2016, p. 270) emphasize the importance of student understanding of "the larger sociopolitical contexts that shape food systems" in developing critical food literacy. This can be applied to the framework of food-system localization and local food systems initiatives.

There is no atomistic "local." We can only comprehend local experiences and social relations when they are contextualized within global systems. As O'Connor (1998) points out, localities are always constructed in relation to other localities and the global economy. While people experience inequity individually and locally, it is rarely produced locally. In relation to food-systems pedagogy, Meek and Tarlau (2016) suggest the role of food systems education "should be a dialectical process of analyzing the reality of the local food system, linking this local reality to national and international structures that have coproduced this local reality, and helping students come up with creative solutions to transform these realities" (134). For working toward social justice, this involves pedagogical approaches that make visible and clearly conceptualize social structures, contexts, and problems relevant to food system equity. Pedagogy thus becomes critical pedagogy as it seeks to cultivate student capacities as "critical agents who actively question and negotiate the relationships between theory and practice, critical analysis and common sense, and learning and social change" (Giroux, 2010; p. 193). Critical pedagogy is based in praxis and critical inquiry.

Praxis structures critical pedagogy by specifying the correspondence among learning, action, and reflection. Praxis, according to Freire (2005, p. 51) is "reflection and action upon the world in order to transform it." Reflection includes developing understanding and knowledge that leads to individual and collective action; that action makes the world we live in and its history. By focusing on praxis-informed

("problem-posing") education, "people develop their power to perceive critically the way they exist in the world with which and in which they find themselves; they come to see the world not as a static reality, but as a reality in process, in transformation" (Freire, 2005, p. 83, italics in original). Praxis is the postulate that people can understand the world and transform it through cycles of learning, action, and reflection; a corollary is that that in order to transform the world, people first need to understand it. While for Freire, thinking is a form of action, in social-justice work there is often a perceived distinction between thinking and action. Mitchell reminds us that this is a false divide, highlighting the intellectual work essential to social-justice activism (Mitchell, 2008). As Musolf (2017, p. 12) points out, we first have to think our way out of oppression before we can fight a way out of it. Consequently, pedagogy focused on understanding and addressing social injustice through the epistemological approach of critical inquiry is foundational to food-system transformation.

Critical inquiry is crucial for enhancing our ability to perceive problems, causes, and remedies relevant to social justice in food systems and society. This requires a departure from or addition to the more familiar and often-used positivist, post-positivist, and constructivist epistemologies employed in food-systems research and education. Critical inquiry directly addresses oppression and privilege in the struggle for social justice, using knowledge to liberate and improve the human condition (Lincoln et al., 2018). While methodological approaches of critical inquiry vary, it has consistent purposes and applications, including developing alternative problem definitions, uncovering assumptions and ideologies, and revealing areas for strategic intervention for socially-just change (Denzin, 2015). Understanding and addressing oppression through critical inquiry begins with specifying and identifying the concepts of social problems and social justice.

Social problems and social justice

A second ontological point is that we cannot address problems unless we first articulate, specify, and valorize their existence. For working toward social justice, the concept of social problem is crucial. A social problem is one that has social consequences and social causes, and consequently, social remedies (Alessio, 2011). Most people concerned about social justice in the food system identify social problems such as food insecurity, environmental degradation, and poverty. We can and do produce horrifying lists of the negative and unjust consequences in the food system. To understand why a social problem exists, though, these harmful consequences must be contextualized alongside their associated beneficial consequences. Often, the food system is framed as "failing" or "broken" (see, for example, Béné et al., 2019 review of narratives

defining food system problems and solutions). But clearly, the food system is not failing for everyone. Oppression and privilege are inverse correlates.

The social systems and social relations in which the food system is embedded impoverish some while enriching others and threatening the resources upon which we all depend. Identifying and understanding who is being harmed and who is benefiting in current configurations of social relations in the food system is therefore essential for transforming the food system toward social justice. The food system has been built on the violences of dispossession, enslavement, exploitation, racism and patriarchy and the ideologies that legitimize these practices. Some frame these conditions in terms of maldistribution of risk and responsibility. Bowness et al. (2020) describe this as organized irresponsibility. They point out that powerful players in our food system create, benefit from, and escape responsibility for systemic risks that show up throughout the globe in the form of pesticide poisoning, food insecurity, land destruction and dispossession, income inequality, and dangerous working conditions, among others. Understanding these kinds of food system issues as socially-produced consequences of social problems requires us to ask about winners and losers in food systems and society, the causes of these imbalances, and what can be done to address them. This approach requires conceptualizing and defining what we mean by social justice.

While the concept social problem structures thinking about the harms and benefits of social problems evident in the food system, the concept of social justice provides a normative basis from which to articulate the forms of injustice present in a problem, who is affected by them, and frameworks for socially-just solutions. In critical scholarship, "conceptions of the good" need to be explicitly identified, distinguishing conditions and norms that enable or, conversely, repress flourishing and the common good (Sayer, 2009). Otherwise, even when social justice is identified as an objective of a framework or intervention, unless it is clearly defined, it may be too vague to animate effective action. For example, in their review of social justice definitions in urban food initiatives in the European Union, Smaal et al. (2021) found that social justice definitions employed tended to be implicit and partial, with unspecified criteria to indicate progress. The consequence, they say, is that inadequate engagement with social justice limits public consciousness and stifles action on social justice issues in the food system such as malnutrition and poverty. The vocabularies and frameworks we employ in food systems can be ineffectual or even inadvertently reinscribe inequity if they do not clearly define social justice or address causes of injustice.

Causes, remedies, and frameworks

Problems, causes, and remedies are a set and are implied in food-system frameworks for transformation. Causes are

what constrain social justice and remedies are what enable social justice. Social problems always have social causes. As discussed, the food system is socially produced and organized. A corollary is that social inequity is also produced, both historically and contemporarily. People, through ideologies, policies, and practices, create positive and negative consequences in food systems and society. Remedies for social-justice problems therefore require investigation of the causes of these problems. Often, however, food system frameworks can exclude or obscure social causes of social problems.

Silence on causation can lead to food-system frameworks for solutions that are meant to include social justice, but do not sufficiently address it. These frameworks include sustainability, resilience, agroecology, and food sovereignty. For example, sustainability is a static term that means keeping things the same, no matter how much many of us have tried to contort and infuse social justice into the term (see, for example, Allen, 2004, 2008). Resilience is equally limiting. While resilience can mean to rebound, rebounding from what is left an open question and it can equally mean to avoid. According to Leary (2019, p. 149) the term was coined by an environmental scientist to measure the persistence of systems in conditions of disturbance to still "maintain the same relationships between populations." It is misplaced and often dangerous to impute biophysical observations to social systems because what we are trying to explain and achieve are different. Applications of resilience frameworks have often failed to address the question "resilient for whom?" or the social dynamics internal to its location of focus (Brown, 2014; p. 109). Moreover, resilience's goal is a stable state, but advocates of resilience addressing social systems are often agnostic on what the "state" should look like, avoiding complex social and normative factors such as power, politics, and patriarchy (see Cote and Nightingale, 2012). In a review of resilience research on food systems, Hedberg (2021, p. 5) finds, "Rights and social justice are central to food system resilience, yet meaningful engagement with rights is not a common feature of existing scholarship." Yet it is those very factors that have created inequality and must be addressed to reduce it. Social relations and collective goals for them, including barriers to and pathways toward social justice, must be visible and central in food system frameworks if they are to be adequately addressed.

Similarly, conceptual frameworks such as agroecology, food sovereignty, local food systems, community, and, ironically, food justice, are often under-theorized or under-specified in their relationship to social justice in food systems and society. For example, Meek and Tarlau (2016) and Meek et al. (2019) emphasize food sovereignty as a guiding conceptual framework for critical food systems education. In a review of food-sovereignty-focused educational programs, Meek et al. (2019, p. 612) note that food sovereignty "means very different things in disparate geographic contexts, making it difficult to provide a universal definition of the concept. Despite this ambiguity,

scholars agree that food sovereignty is a rights-based approach in which farmers, other producers, and communities are in control of their food system." When particular communities wrest control of the food system from extra-local institutions and actors, it could lead to more socially just outcomes, but this cannot be assumed. We must be cognizant of which problems a framework is likely to address and which it is likely to exclude. For example, does the framework address power imbalances and divergent priorities related to class, race-ethnicity, or gender? Anderson et al. (2019, p. 527) point out, for example, that while food sovereignty is theoretically an emancipatory approach, "quiet food sovereignty" may do nothing to "reveal and address the underlying systems of oppression that are left intact and unquestioned." Our perspective is that these issues must be identified and addressed *before*, not after, we adopt and promote frameworks for food-system transformation. That is, let us not put the cart before the horse. Before we identify solutions-oriented frameworks we need to understand the problems we are trying to solve, their causes, their context, and their scope.

To summarize, critical pedagogy for food-system transformation requires relevant ontological, epistemological, and conceptual foundations. Praxis articulates the interrelated roles of learning, understanding, and reflection in achieving transformation toward social justice. Critical inquiry specifies an epistemological approach for learning and understanding that focuses its purposes on confronting oppression and increasing social justice. Applying the concept of social problem through critical inquiry leads to clear identification of social problem causes, harms, benefits, and potential solutions. A clear definition of social justice orients the critical inquirer to the specific injustices present in the problem and provides a pathway for transformation. The next section briefly reviews how these concepts are operationalized in the Food Systems and Society (FSS) graduate program at Oregon Health & Sciences University (OHSU).

Operationalizing critical pedagogy in the food systems and society program

The purpose of the FSS program is to explore and expand critical intellectual capacity for addressing social justice within food systems and society. A foundational ontological position of the FSS program is that food systems are not separate from and cannot be separated from society as a whole. Hence, the name of the program and degree is Food Systems and *Society*. Students who enroll in the program are often initially focused on food-specific frameworks gleaned from food-systems literature discussed above, such as localization, community participation, resilience, sustainability, or food sovereignty.

TABLE 1 Ontological, epistemological, and pedagogical foundations of the food systems and society graduate program.

	Praxis	Critical inquiry	Social problem	Social justice
Ontological What the concept makes visible	The necessity and roles of understanding, action, and reflection in creating socially-just change.	Contrasting research approaches' capacities to address oppression and social justice.	Social problem consequences include harms and benefits; socially-caused problems are socially-solvable.	Injustice and oppression in society; the possibility of a socially-just world.
Epistemological What the concept makes knowable	The ways in which people transform the world through understanding, action, and reflection.	Problems and systems that create barriers for or contribute to improving the human condition; ways to identify, understand, and address social injustices.	Specific and aligned explanations of social problem causes, harms, benefits, and potential remedies that make clear injustices and pathways to justice.	Criteria and processes for identifying injustices; corresponding criteria and processes for realizing social justice.
Pedagogical Applications in FSS program	Students increase understanding of food systems and society through engagement with relevant scholarship, conceptual frameworks, and their applications. Students regularly and systematically reflect on evolving understanding of concepts and their potential applications in future learning and action.	Students explore contrasting ontological, epistemological, and conceptual approaches to inquiry in the food system. Students ask and answer their own questions about social problems in food systems and society, explicitly considering how their research contributes to socially-just change	Course content and assignments explore food system problems as reflective of social problems. Students define and explore social problems evident in the food system, applying conceptual frameworks that illuminate their causes, consequences, and cures.	Students explore conceptual frameworks related to social justice. Students articulate a definition of social justice, applying it in their research on food system social problem causes, consequences, and cures.

Through the FSS curriculum students move beyond food-system-specific frameworks, increasing their capacity to identify and articulate social problems related to social justice, critically inquire about the root causes of those problems, and explore possible solutions.

An important element of seeing the food system through society, and central to developing critical intellectual agency, is recognizing the possibility for social change for social justice. Students learn that the issues we face in the food system have been created by people and hence can be transformed by people. This grounding animates students and encourages active participation in both inquiry and transformative action for social justice. While students can sometimes become overwhelmed by the prevalence and scope of social-justice problems in society, we focus on Harvey's (2000) concepts of insurgent architects, theaters of action, collectivities, and the inevitability of living in the world as it exists while simultaneously working to change it. These notions are infused throughout the FSS curriculum so that students understand that they have power, but that they are not individually responsible for all social-justice work. Many others stand beside them.

To operationalize this approach, students engage collaboratively throughout the curriculum with the concepts of praxis, critical inquiry, social problem, and social justice and their applications in food systems. Table 1 provides an overview of the ontological, epistemological, and pedagogical contributions of key concepts in the FSS program. Each concept suggests the next: praxis compels critical inquiry to systematically increase understanding; critical inquiry requires a conceptual framework like social problem to structure its focus on addressing problems to improve the human condition; and social problem requires a normative conceptual framework such as social justice to guide analysis and evaluation of its causes, consequences, and cures. Conceptual frameworks for praxis and critical inquiry are established early in the FSS program to make visible and elaborate the overall pedagogical approach taken.

The concept of praxis orients students to the idea that intellectual understanding and reflection are as fundamental to socially just change as participatory action. The concept affirms and valorizes their intellectual labor and makes clear that they are an active participant and transformative agent in their education and in the world. In line with critical pedagogy, the concept illustrates the intent and operation of the FSS program to develop critical agents, capable of asking and answering their own questions in order to identify and address pressing social-justice problems. Enacting praxis, reflective assignments

TABLE 2 Foundation and Capstone courses in the food systems and society graduate program.

Course title	Course role in FSS critical pedagogy
Food systems inquiry	Elaborates the foundations of FSS critical pedagogy in praxis, critical inquiry, and social problems.
Concepts and contexts in food systems and society	Critically introduces and explores foundational keywords and concepts in food systems, society, and social justice.
Food policy and politics	Explores causes, consequences, and cures for social-justice problems evident in the food system related to social decisions in food policy and politics.
Food in culture	Examines privilege and oppression and inequality and social justice in food and culture through the lenses of class, gender, race/ethnicity, and intersectionality.
Economic justice in the food system	Critically applies concepts in political economy to develop conceptualizations of economic justice relevant to food systems and society.
Food system theory	Engages key concepts in the philosophy of science and conceptual frameworks relevant to critical inquiry about social-justice problems in the food system.
Social movements in the food system	Explores social movement theory and practice in the food system and beyond, considering implications and insights for creating socially-just change.
Capstone 1	Students begin Capstone projects by identifying and elaborating a social problem of interest, contextualizing it with definitions of food systems, society, and social justice.
Capstone 2	Students are guided in refining and answering research questions that address a specified aspect of a social-justice problem of interest to them.
Capstone 3	Students complete a written document that introduces and elaborates the social-justice significance of their research problem; explains their research approach in terms of critical inquiry; presents findings and analysis; and reviews their contributions to and insights on social justice in food systems and society.
Scholarship and social change	Considers the roles of scholarship in social change; students systematically reflect on potential applications of their learning to socially-just transformation.

included in all FSS courses encourage students to systematically reflect on their evolving understanding of food systems and society and to specifically consider their learning's relevance to socially-just change. This practice, accomplished through end-of-course assignments delivered through persistent and interactive documentation methods, enhances students' critical intellectual capacity and confidence in their ability to create meaningful change.

While elaboration of the concept praxis demonstrates to students the importance of new understanding in socially-just change, critical inquiry helps them better understand the kinds of problems and questions they can address to realize this goal. Students are acquainted with contrasting research paradigms early in the program. These are not positioned as "right" or "wrong," but are explored in terms of variation in their ontologies, epistemologies, methodologies, and their intent or capacity for identifying and addressing different kinds of research problems. Critical inquiry is explained as relevant to understand, illuminate, or transform social processes, institutions, and relationships toward greater equity in power, knowledge, and resource distribution. Engaging with academic scholarship, students explore different theoretical, conceptual, and analytical approaches to research relevant to social justice in food systems and society.

Clear problem-definition is a precondition for effective social-justice-related social-problem solving, as is applying clear analytical criteria for social justice, and identifying points of intervention. Early in the program, students explore conceptual frameworks related to social justice and consider contrasting definitions, framings, and foci. In conceptualizing social justice in the FSS program we consider oppression and privilege starting with the categories and axes of gender, class, race, and their intersections. These inter-related categories construct and reflect ideologies and practices of inequalities that structure people's lives and life chances throughout the world (see, for example, Collins, 2013). Based on these initial categories, students then articulate their own definitions and criteria for social justice, ensuring that they "know it when they see it" and can apply it to defining problems and solutions in their own work. In this way, they avoid relying on vague or surrogate conceptualizations of social justice or underspecified food-system frameworks and can focus not only on inequitable "outcomes," but also on their causes. With a definition of social justice in hand, students are able to identify and explain the aspects of social problems in the food system that need to be addressed in order to create meaningful transformation toward social justice. Without a definition of social justice, it is impossible to develop goals for food system equity, illustrating the fundamental importance of conceptual thinking in critical pedagogies.

Critical, conceptual engagement with the social justice aspects of social problems in the food system continues

TABLE 3 Selected Capstone Research Synthesis (CRS) titles from food systems and society program graduates.

A seat at the table: An inquiry into the treatment of restaurant workers and the "High Road" restaurant movement

An exploration of health and nutrition programs: Are underlying social issues recognized?

An exploratory analysis of culinary educators' constructs of gender equality

Bean in hand, nickel in pocket: the social experience and political economy of senior food insecurity

Commodity racism, cultural appropriation, and the perpetuation of oppressive food discourse

Empathy for justice: A social transformation of the US food system

Fighting the good fight: Food banks as social justice advocates?

Financialization in the food system: Issues of policy and discourse

How alternative are the alternatives? A conceptual framework for analysis of control and value distribution in alternative food networks

Social justice in sustainable food systems: An exploratory analysis of definitions, projects, and funding frameworks

The role labor unions and worker centers play in restaurant industry equality

Through the garden gate: Examining "the edible and the equitable" in garden-based learning programs

Toward dismantling racial inequity in the food system: Exploring inclusivity antiracist practice and radical food justice principles in the sustainable agriculture movement

Understanding democracy: Concepts, practices, and the power of decision-making in the food system

Unsettling settler food movements: An exploration of colonialism, food movements, and decolonization

Veganism and social justice: Applying a conceptual framework of violence

Want amid plenty: The capitalist paradox of hunger and food waste

White supremacy and food media: Identifying and challenging racism in popular food discourse

Student CRS reports are available through the OHSU library: https://scholararchive. ohsu.edu/collections/ff365595x?locale=en.

throughout the program, and culminates in student research that emphasizes clear conceptual thinking over and above data collection or internships. The FSS curriculum contains 50 credits of coursework, including Foundation, Capstone, and Practicum course types. Foundation courses explore key concepts in food systems and society; Capstone courses guide students through research on social-justice problems; and Practicum courses support collaboration and scholarly capacities. Table 2 lists Foundation and Capstone courses and illustrates some of the course content.

In their FSS Capstone research, students synthesize and apply concepts to ask and answer their own questions about social-justice problems in food systems and society. Students focus on social justice problems that are of particular interest to them, based on their experiences and positionality. In

their research, students evidence a social problem, examining its causes, consequences in terms of harms and benefits, and potential remedies. Students engage in basic definitional work of all key concepts in their research, building their own conceptual frameworks and corresponding definitions and analytical criteria for use in critical inquiry. The concepts of praxis, critical inquiry, social problems, and social justice move students toward specific appraisals of problems, their causes, and proposals for solutions to inequities in food systems and society. Clarity in problem identification and conceptualization is essential for developing fundamental critical intellectual capacity that can support social change. Students explicitly consider and reflect upon how their research and new understanding contributes to socially-just change. Each student's research is summarized in a written Capstone Research Synthesis (CRS) report, which is a requirement for graduation. The diversity of social problems, conceptual frameworks, and approaches in student research is illustrated in the sample of CRS titles in Table 3.

While participatory action research and community engagement is sometimes proposed as essential for social-justice work, these activities are understood as possible but not essential pathways in the FSS program. Students develop a sense of efficacy in doing their part to transform the world in the ways that are most relevant to them, always with praxis, social justice, and critical inquiry at the heart of their work. For transformative scholarship, Farias et al. (2017) explain why participatory practices must be combined with critical understanding of large-scale social conditions; without this understanding, interventions can ignore or reproduce injustice. In articulating specific social causes and consequences, social systems that reproduce inequities become visible and changeable. This is because it is first important to understand the principles of social problems, causes, and remedies and because communities and groups may and often do contain axes of oppression themselves. By first developing critical intellectual capacity, students will be better able to participate in these forms of transformative work. Thus, critical inquiry is essential for advancing social justice independent of participatory action or community engagement and it is essential for engaging in these practices as well. Through their work in the FSS program, students develop understandings of oppressive and liberatory social systems and their roles in them; they are changed and, in turn, can and do change the world.

Conclusion

The question posed in this special issue is: What pedagogies and principles are best suited to help students connect critical reflection on food systems with transformative action? Our answer is that we need vocabularies and frameworks that foreground and directly address social-justice problems, their

causes, and potential remedies. There are clear winners and losers in the food system, and "outcomes" in food system analyses must focus not only on harms but also beneficiaries. Engagement with food systems must disrupt the inequitable social systems foundational to the organized irresponsibility in the food system and the risks to which it exposes us. This means resisting, reforming, and transforming social systems so they do not subsist on oppression and exploitation. The conceptual framework of food systems, absent a focus on society and its attendant inequities and their causes does not take us very far toward transformation either of the food system nor the social systems in which it is embedded.

We tend to use vocabularies and frameworks that are in academic and popular commerce and for which funding is available, often because they have transitioned from emergent to dominant discourses (see Williams, 1977 for a discussion of residual, dominant, and emergent discourses). Instead of using terms like sustainable and resilient in framing food systems, we ought to ask which systems we want to sustain and which we want to break down. Our selection of frameworks and vocabularies either oppose or reproduce historical and contemporary inequity. If the goal is to address injustice in the food system, we suggest food system scholars and practitioners shift the analytical focus from "food systems" to the systems of oppression that drive the food system and use vocabularies that illuminate problems of inequity. Creating socially just food systems requires ontological, epistemological, and pedagogical approaches that center social justice within the context of society and social relations.

Public higher education institutions should prioritize critical inquiry to address inequity in social systems. This requires a reorientation of purpose and resource allocation, engaging deeply with students who will play important and varied roles in transforming the food system in the direction of greater equity. Our hope is that universities increase emphasis on critical inquiry and support faculty and students in this endeavor. Higher education should prioritize the careful conceptual thinking foundational to identifying social equity problems and their causes and developing solutions for transformation. The world has never been in more urgent need of critical pedagogy and critical inquiry in food systems and society. Higher education must step up to the plate or accept its responsibility for accelerating social injustice in food systems and society.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

Both authors listed have made an equal, substantial, direct, and intellectual contribution to the work and approved it for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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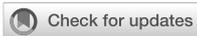
Frontiers in Sustainable Food Systems

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Becoming agroecologists: A pedagogical model to support graduate student learning and practice

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Introduction: Agroecology has multiple beginnings in diverse knowledge systems, growing practices, and social movements which, as a whole, seek systemic transformation to build just food system futures. As graduate students, we have been inspired by agroecological movements and practitioners and endeavored to build our knowledge and capacities as agroecologists. Over the course of seven years, we have worked collectively with an evolving cohort to build relationships, understand critical lineages, and practice participatory processes that we found necessary for our development as agroecologists at the University of Minnesota-Twin Cities. Building on this work, we sought to refine an emergent understanding of the necessary components of an agroecological pedagogy.

Methods: We thus hosted a series of workshops in summer 2019 to facilitate collective reflection and development of a pedagogy, which we further refined through collective autoethnography.

Results: The resulting model contains five key components: a cohort at the heart of the model to facilitate collective learning; critical inquiry as the foundation of knowledge production; relational centering as the basis for building and maintaining care-based relationships with self and others; participatory practice as a space for taking action through and within relationships; and situated knowledge to recognize the unique and incomplete knowledge that each individual brings to their work.

Discussion: We imagine this model as the basis for a dedicated agroecology graduate program, and we close by sharing ongoing implementation efforts, key areas for further development, and our hopes for continued integration with broader movements. Ultimately, we have experienced this process as a transformational agroecological space and hope others are inspired to adapt, imagine, and enact the process, model, and principles in their own places and communities.

1. Introduction

Agroecology is often described as the "ecology of whole food systems" (Francis et al., 2003), a holistic approach to exploring social, ecological, and political relationships that is transdisciplinary, participatory, and action-oriented to create sustainable socio-ecological relationships (Gliessman, 2018). Integrative agroecology emerges at the nexus of science, movements, and practice, which interact in different ways depending upon the specific place, social relationships, and ecological context (Wezel et al., 2009, 2020; Montenegro de Wit, 2014; Rivera-Ferre et al., 2021). Political agroecology acknowledges that collective action is necessary to enact structural change and create institutional frameworks that reproduce agroecological

systems (Gonzalez de Molina, 2013). Integrative and political agroecology, combined, focus on the need for multiple, interconnected systemic transformations to address the colonialism, racial capitalism, and globalization at the root of ongoing food systems crises (Andreotti et al., 2018; Montenegro de Wit, 2021); the goal of such transformative agroecologies is to create and sustain emancipatory and liberatory food systems (Gonzalez de Molina, 2013).

Each of us—Vivian, Sharon, and Jennifer—were drawn to pursue agroecology in our graduate education because of previous experiences with transformative agroecological efforts in community gardens, farms, farmers markets, community arts programs, policy networks, and social movements. Our graduate programs in the agricultural sciences, however, were grounded in Western scientific norms (e.g., reductionism, objectivism, top-down knowledge transfer, technological interventions); as a result, they largely failed to implement pedagogies that aligned with agroecological principles, which is a common challenge in university agroecology programs (Altieri and Francis, 1992; Rivera-Ferre et al., 2021). Yet, the informal spaces in our program, the "hidden curricula" (Rivera-Ferre et al., 2021), created with fellow students, faculty, and practitioner partners facilitated relationships with places and people, both within and beyond academia, that embodied agroecological values such as multiple ways of knowing and horizontal learning. Over the last seven years, we have explored how the "hidden curricula" could move beyond the margins/interstitial spaces, posing the question: "What relationships, values, and experiences are vital in a pedagogy for transformative agroecology learning in our graduate programs?"

In this paper, we present a pedagogy for graduate agroecology education that we collectively developed with students, faculty, and staff at the University of Minnesota—Twin Cities (UMN-TC), as well as the multi-year process from which it emerged. We share both pedagogy and process because, as David and Bell (2018) aptly observe, "agroecological education is not only about content; it is also about process." We begin with an overview synthesizing key pedagogical frameworks for agroecology learning. We then describe our specific context at UMN-TC, focusing on graduate student-led efforts through which key pedagogical needs were identified and later refined in a series of participatory workshops. Ultimately, the proposed pedagogy affirms the need for critical, relational, and participatory pedagogies that are implemented through collective learning structures. We present this pedagogy as a work in progress, and we hope others are inspired to adapt, imagine, and enact the process, pedagogy model, and principles in their own groups, programs, institutions, and communities.

2. Overview of university agroecology pedagogies

While agroecology learning takes place in many contexts, from farmer networks to high school programs, we focus on university-level education. Undergraduate and graduate programs studying whole food systems are located around the world, including North America (Jacobsen et al., 2012; Galt et al., 2013; Hartle et al., 2017; Valley et al., 2018), Central and South America (Intriago et al., 2017; Sarandon and Marasas, 2017), Europe (Code, 2017; Francis et al., 2018; Migliorini et al., 2018; Wezel et al., 2018; Ingram et al.,

2020; Rivera-Ferre et al., 2021), and Australia (Bawden, 2016).[1] These programs are known by a variety of names (e.g., sustainable agriculture), but we collectively refer to them as agroecology education programs because they are connected by an explicit goal to support food system transformation.

2.1. Epistemological conditions and innovations in agroecology programs

Many agroecology programs emerged from and/or are housed within agronomic or agricultural science departments or colleges (Altieri and Francis, 1992; Francis et al., 2003; Intriago et al., 2017; Sarandon and Marasas, 2017). Because of this institutional positionality, Classens et al. (2021) argues that "we make food systems pedagogy, but we do not make it under conditions of our own choosing." Thus, it is important to consider the ways in which agronomic paradigms set the conditions from which agroecological pedagogies emerge (Rivera-Ferre et al., 2021). Many educators have emphasized the particular importance of epistemological awareness to reexamine dominant ways of knowing in sustainable food systems work (Jordan et al., 2008; Code, 2017; Andreotti et al., 2018; Dring et al., 2022).

Epistemologies can be described as our ways of knowing (Dring et al., 2022) and habits of mind (Andreotti et al., 2018; Dring et al., 2022); epistemologies are the rules that shape how we know what we know (Galt et al., 2012), what is defined as knowledge, and who holds or generates that knowledge (Wilson, 2009; Galt et al., 2012; Walter and Andersen, 2013). There is a broad body of scholarship interrogating agronomic epistemologies, and here we provide a brief overview based on prior work by agroecology educators (Altieri and Francis, 1992; Parr et al., 2007; Østergaard et al., 2010; Galt et al., 2012; Rosset and Martínez-Torres, 2012; Montenegro de Wit and Iles, 2016; Code, 2017; Andreotti et al., 2018; Francis, 2020; Bowness et al., 2021; Dring et al., 2022; Shanahan, 2022). Agronomic epistemologies typically approach food systems through reductionism, by breaking them down into individual components that are studied through specialized disciplines. Knowledge is framed through positivism, in which what we know is generated through logical and objective processes that are separate from values/bias and can be replicated across situations. The resulting knowledge is held by expert specialists and transferred to others *via* top-down approaches. Problems are solved by leveraging technological, capital-intensive interventions. Within food systems broadly, these epistemologies are enacted through industrial agriculture and Western agronomic science, which possess "thick legitimacy;" in other words, Western technologies, knowledge, and norms are accepted as credible and supported by science, policy, practice, legal systems, and civil society (Montenegro de Wit and Iles, 2016).

As a result of these epistemological conditions, many argue that agricultural science programs do not—and cannot—provide the holistic and political training necessary to address complex food systems challenges (Altieri and Francis, 1992; Lieblein and Francis, 2007; Francis et al., 2011, 2018; Intriago et al., 2017;

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[1] It is important to note that because of our language proficiencies (English, Spanish, and Italian), there are likely gaps in our review of programs in Africa, Asia, and the Middle East.

Sarandon and Marasas, 2017; Ingram et al., 2020; Rivera-Ferre et al., 2021). Agroecology programs, therefore, must enact alternative epistemologies in order to counter dominant agronomic paradigms and prepare students to engage with food systems work. Prior scholarship has identified four main agroecological epistemologies: holistic systems, action learning, horizontal learning, and multiple ways of knowing (Jacobsen et al., 2012; Hilimire et al., 2014; Horner et al., 2021).

Holistic systems includes multiple frameworks and approaches to understand food systems as whole, connected, and socially constructed. A common approach used in agroecology is systems thinking (Hilimire et al., 2014), which includes methodologies that connect landscapes and social systems to underlying processes and mechanisms (Jordan et al., 2014). It resists reductionism and positivism by accounting for complex and dynamic linkages/relationships (Meadows, 2008; Ingram et al., 2020). Systems thinking is a core component of undergraduate agroecology programs (Galt et al., 2012; Bawden, 2016; Valley et al., 2018; Ebel et al., 2020) and individual courses/certifications at both graduate and undergraduate levels (Jordan et al., 2005; Galt et al., 2013; Runck et al., 2015; Francis et al., 2018; Ingram et al., 2020).

Action learning includes both experiential and participatory learning. Both represent ways to learn through doing, in place-based, context-rich settings where learners experience the complexities and uncertainties of food systems (Lieblein et al., 2004; Valley et al., 2018; Jelinski et al., 2020). However, experiential and participatory learning differ in the learner's level of embeddedness. Experiential learning often involves activities such as field trips, open-ended case studies, internships, farm visits, etc., which are implemented in both undergraduate programs (Galt et al., 2012; Valley et al., 2018; Ebel et al., 2020) and individual undergraduate/graduate courses (Wiedenhoeft et al., 2003; Jordan et al., 2005; Francis et al., 2018; Horner et al., 2021). In participatory learning, students are embedded in collaborations with community partners, which is often used in graduate programs with thesis or dissertation projects (Migliorini et al., 2018; Rivera-Ferre et al., 2021) or in undergraduate research experiences (Parr and Van Horn, 2006; Salomonsson et al., 2009).

Horizontal learning facilitates knowledge sharing between people with different experiences, practices, beliefs, and knowledge systems (Hilimire et al., 2014). The goal is to adapt and apply knowledge and practices in different contexts and places. It resists the "banking model" of education in which knowledge is transferred from an expert teacher to student (Freire, 2000). University programs often leverage dialogue for students, faculty, and practitioners to learn from and with each other (Galt et al., 2012; Domené-Painenao and Herrera, 2019). It is a core component of courses based on the agroecology pedagogy developed at the Norwegian University of Life Sciences (Wiedenhoeft et al., 2003; Jordan et al., 2005; Runck et al., 2015; Migliorini and Lieblein, 2016; Francis et al., 2018). Horizontal learning builds appreciation, empathy, and respect for others; develops abilities to engage with uncertainty; and supports a holistic approach to understanding complexities in food systems (Francis et al., 2018; Ebel et al., 2020).

Multiple ways of knowing enacts the understanding that expertise does not fall within disciplinary boundaries and diverse knowledge and experiences are necessary to address complex food system challenges. As a discipline, agroecology often integrates multiple ways of knowing through transdisciplinarity, which recognizes that knowledge exists beyond and across the confines of academic disciplines (Méndez et al., 2015; Gliessman, 2018). Inter-, multi-, or transdisciplinary learning are key components of university agroecology programs and courses (Parr and Van Horn, 2006; Galt et al., 2012; Hilimire et al., 2014; Francis et al., 2018; Valley et al., 2018; Ebel et al., 2020; Ingram et al., 2020; Horner et al., 2021). While there can be important distinctions between inter-, multi-, and transdisciplinary learning (Francis et al., 2011; Hilimire et al., 2014), some differences reflect evolving language (Parr et al., 2007).

Agroecological pedagogies incorporating holistic systems, horizontal learning, action learning, and multiple ways of knowing have opened important space to contest and create alternatives to agronomic epistemologies. Yet, Dring et al. (2022) argue that it is also important to consider the ontologies that create the foundation for epistemologies.

2.2. Ontologies shape agroecology epistemologies

Because Western institutions and agronomic paradigms set the "material and ideological conditions" (Classens et al., 2021) for university agroecology programs, it is possible that agroecological epistemologies may still perpetuate agronomic ontologies. Epistemologies enact ontologies—our habits of being (Dring et al., 2022) and understanding of what is real (Jordan et al., 2008; Wilson, 2009), which frame how we relate to each other and the planet (Andreotti et al., 2018). Agronomic ontologies, and Western scientific disciplines more broadly, developed with and as a tool of racial capitalism and colonialism (Andreotti et al., 2018; Bowness et al., 2021). Industrial agriculture—the focus of most agronomic research and education—emerged from racial capitalism and the U.S. plantation system, in which unlimited economic growth from monoculture production systems depended on kidnapping, displacing, torturing, and enslaving Africans and their descendants (Perfecto et al., 2019; Robinson, 2020; Montenegro de Wit, 2021). Colonialism is infused in land-grant universities, where much agronomic research is conducted, which were built on and continue to profit from land, resources, and knowledge extracted and stolen from hundreds of Indigenous nations (Lee and Ahtone, 2020). Universities and agronomy programs facilitated the introduction of agrochemicals as part of the Green Revolution, which further disenfranchised Indigenous knowledge/production systems around the world (Intriago et al., 2017). Grounded in assumptions that progress is linear, unlimited economic growth is possible and desirable, and relationships are hierarchical and inequitable, these histories have shaped the ways we understand food systems and the transformations and futures we can imagine (Andreotti et al., 2018; Rivera-Ferre et al., 2021; Shanahan, 2022).

There are several ways that the agroecological epistemologies described earlier may still perpetuate these dominant ontologies. One of the most common emerging critiques of agroecology curricula is that prior scholarship over-emphasizes skill/competency development and professionalization, which perpetuates a neoliberal emphasis on market-based interventions (Classens et al., 2021; Horner et al., 2021; Dring et al., 2022). Emphasizing skills and tools is also more likely to focus on scientific or technical solutions, such as replacing chemical inputs (Migliorini et al., 2018; Rivera-Ferre et al., 2021), resulting in academic and Extension programs that separate

agroecological science from social/political movements (Wezel et al., 2009; Gonzalez de Molina, 2013; McCune and Sánchez, 2019; Rivera-Ferre et al., 2021). Code (2017) further argues that systems thinking can reduce the fullness and complexities of relationships to a focus on elements and linkages. Finally, agroecology programs may perpetuate extractive patterns. In experiential learning, this may result from a lack of attention to the ways in which race, gender, nationality, and ability shape student and community relationships (Newbery, 2003; Lake, 2021; Simmons., 2021). Similarly, integrating non-Western knowledge systems in agroecology programs—without attention to the worldviews, traditions, and relationships underlying those knowledge systems—can perpetuate extractive patterns such as appropriation and romanticization.

In other words, universities enact racial and colonial ontologies, and these material and ideological conditions exist in tension with the agroecological way of knowing and being that agroecology programs are trying to create. This institutional positionality shapes and constrains what is possible (Meek and Tarlau, 2016), and Rivera-Ferre et al. (2021) argue that the result is a type of "reformist agroecology" that maintains current food and agricultural systems instead of transforming them. In other words, though agroecology programs seek to change our ways of knowing and being, they may still fail to address the root causes of "systemic oppression, marginalization, dispossession, and ecological destruction" because they are embedded within institutions that are grounded in racial and colonial ontologies (Dring et al., 2022).

2.3. Toward transformative agroecology learning pedagogies

Tarlau (2014) proposes that while "schools may never be completely emancipatory spaces," we can approach them as "terrains of contestation, where repressive and liberatory processes" exist simultaneously. While reformist approaches can serve as important strategies to reduce harm and open space for contestation, recent scholarship connecting agroecology with anti-colonialism (Andreotti et al., 2018; Dring et al., 2022) and abolition (Montenegro de Wit, 2021) have highlighted the need for continued efforts to enact transformative agroecology learning pedagogies. Meek and Tarlau (2016) argue that critical pedagogies are necessary to connect education with social transformation. In their Critical Food System Education (CFSE) model, they leverage Freire (2000)'s model of popular education to build critical consciousness, a process in which people learn "to perceive social, political, and economic contradictions and to take action against the oppressive elements of reality" (p. 35). This critical approach fundamentally shapes how epistemological structures and pedagogies are enacted.

Critical agroecology education is an emerging area in university programs. An early example of a critical pedagogy in North America is the Sustainable Agriculture and Food Systems program at the University of California, Davis, which incorporates critical theory, community building (on and beyond campus), and civic engagement alongside systems thinking, interdisciplinarity, and experiential learning (Galt et al., 2012). More recently, critical reflection and collective action were included as implicit values in the proposed signature pedagogy for undergraduate Sustainable Food Systems programs (Valley et al., 2018; Ebel et al., 2020). Ebel et al. (2020)

explain critical reflection develops "a habit of mind that recognizes historical and current power differentials within society and their resulting uneven distribution of benefits and harms related to food systems." Habits of mind are the habitual and automatic ways in which we think, so developing new habits of mind builds a set of mental responses to new situations or knowledges. Furthermore, analysis of student artifacts from courses at the University of Minnesota (Jordan et al., 2008), UC Davis (Galt et al., 2013), Trent University (Classens et al., 2021), and the University of Vermont (Horner et al., 2021) have all affirmed that critical reflection can result in transformative learning experiences that shift how students engage with individual and collective action.

But food justice and sovereignty movements have a long history leveraging critical pedagogies to facilitate "collective experiences of learning, organization, exchange, and life" (Casado et al., 2022) and build capacity for collective action (McCune et al., 2014; Migliorini et al., 2018; Anderson et al., 2019; McCune and Sánchez, 2019; Meek et al., 2019; Black Dirt Farm Collective, 2020; Rivera-Ferre et al., 2021). Of particular relevance are two formal, advanced agroecology learning programs that are centered around developing critical consciousness. The Latin American Agroecological Institutes (IALA) are a network of autonomous movement agroecology schools located throughout Central and South America, and food sovereignty organizations select members to attend and study at the IALA for 3–5 years (McCune et al., 2014; McCune and Sánchez, 2019). The Baserritik Mundura extension degree program at the University of the Basque Country in Spain was a 1-year program, and it was implemented twice between 2016 and 2018 (Casado et al., 2022). Both programs emerged from movement-led efforts—specifically La Via Campesina (LVC), a transnational movement for peasants' rights, and its member organizations; this differs from the undergraduate and graduate programs discussed earlier, which emerged from Western university and agronomic contexts. Below, we provide a brief overview of the key epistemologies that structure the critical pedagogies in these two programs.

A key goal of both the IALAs and the Baserritik Mundura program is to facilitate *formación*, which is "the construction of a better human being…through critical reflections and actions" (McCune et al., 2014). It includes building capacity for both self and collective organization (Rosset, 2015; Black Dirt Farm Collective, 2020), representing the interconnected and dialectical relationship between transformation of the individual and transformation of the world (McCune and Sánchez, 2019). Toward the goal of *formación*, both schools enact collective organizational structures to center the educational process on the collective (Casado et al., 2022). Similar to LVC more broadly (Tarlau, 2015), teachers and learners work together in *núcleos de base* (NBs) at IALAs and territorial nuclei (TNs) in the Baserritik Mundura program to make decisions about all aspects of the education process. The schools are guided by Political-Pedagogical Coordination (PPC) groups that include representatives from social movement organizations who support program-level reflection, development, and iteration (McCune and Sánchez, 2019; Casado et al., 2022).

To connect the schools with their broader territories, *diálogos de saberes* (wisdom dialogues) are conducted between cohorts in the schools and with the communities in which they are embedded. *Diálogos de saberes,* a foundational structure in LVC, occur "between people with different historically specific experiences, cosmovisions, and ways of knowing" (Martínez-Torres and Rosset, 2014). Within

IALAs and the Baserritik Mundura program, one of the emergent outcomes of dialogue is to develop participatory action research (PAR) projects (McCune and Sánchez, 2019). Students then conduct the PAR projects *via alternancia*, in which students alternate between "community" and "study" periods. During community periods, students conduct projects directly related to community needs while learning about the place-based political, economic, cultural, and ecological contexts. When students return to campus, they have dedicated time to deepen their study and reflect on their participatory projects with other students and teachers (McCune and Sánchez, 2019; Casado et al., 2022).

Through both critical and collective epistemological structures, McCune and Sánchez (2019) argue that learning moves beyond individual or student-centered goals to instead center on territories, which are places grounded in relationships between land, people, and histories that create specific movement contexts for enacting and scaling out agroecological practices and transformations. There are very few university agroecology programs, however, that pair both critical and collective structures. At the undergraduate level, a notable exception is the agroecology program at the Bolivarian University of Venezuela (UBV), which uses a collective and territorial framing to implement popular education, *diálogos de saberes,* and *alternancia* in coursework and participatory projects (Domené-Painenao and Herrera, 2019). At the graduate level, El Colegio de la Frontera Sur (n.d.) and the University of Córdoba in Spain (Migliorini et al., 2018; Rivera-Ferre et al., 2021) both offer MSc programs that leverage critical approaches, participatory research methodologies, and *diálogos de saberes*.

There is, however, a significant need to develop critical and collective pedagogies for graduate agroecology programs. Much of the existing literature on graduate education focuses on the model developed for a one-semester course in the MSc in Agroecology at the Norwegian University of Life Sciences (NMBU) (e.g., Lieblein et al., 2004; Lieblein and Francis, 2007; Østergaard et al., 2010; Francis et al., 2015, 2018). The course is oriented around open-ended case studies for students to develop skills in observation, participation, dialogue, reflection, and visioning (Francis et al., 2015, 2018). Critical and collective pedagogies, however, are not explicitly addressed in the NMBU model. Furthermore, there is limited scholarship, in general, that expands beyond individual courses to instead explore how to implement an entire master's or doctoral program grounded in agroecological paradigms. As a result, there is a particular need for pedagogical development in graduate agroecology programs. This is a key opportunity because graduate program structures, expectations, and responsibilities differ from undergraduate programs (Francis et al., 2011; Basche et al., 2014; Code, 2017), and those differences represent rich opportunities to adapt collective and critical pedagogies to university agroecology education. Thus, in this paper, we share a pedagogy for graduate agroecology education that emerged from multi-year, student-led efforts at the University of Minnesota—Twin Cities.

3. Institutional context: Building our agroecology education at the University of Minnesota—Twin Cities

When we began our graduate journeys, we knew little about the agroecological learning approaches discussed in the previous section. Instead, the pedagogy for graduate agroecology learning that we share in this paper emerged over seven years of student-led organizing and collective action at UMN-TC. Our masters and doctoral programs consist of both research and coursework requirements; while our research collaborations require us to engage with the political, integrative, and relational aspects of agroecology, most of our required coursework focuses on technical knowledge, such as statistics or sub-disciplinary specialization classes. In this section, we share an overview of the agroecology courses available in our programs and the student-led efforts to pursue opportunities, address obstacles, and create/demand space for transformative agroecological learning.

There is a long history at UMN-TC of innovative agroecology and sustainable food system course development, largely through *faculty-led* efforts, particularly in undergraduate programming (Jordan et al., 2008, 2014; ASA, 2010; Porter et al., 2015; Runck et al., 2015; Valley et al., 2018; Ebel et al., 2020). However, there are two courses specifically aimed at graduate students. "Ecology of Agricultural Systems" is a one-semester, 3-credit course that covers systems thinking, agroecosystem analysis, dialogue, and critical reflection through both didactic lectures and experiential, community-engaged team projects, with the goal to prepare students with tools/skills to participate in collective action (Jordan et al., 2005). It is required for the formal agroecology track in the agronomy program and open to students from other programs. An optional, 8-day summer short-course was also available until recent years, in which student teams visited farms across the Upper Midwest. Course activities facilitated observation through farm tours, dialogue through interviews with growers and other stakeholders, reflections with other students and professors, and visioning futures through a comparative analysis and evaluation of sustainability at different farms (Wiedenhoeft et al., 2003). Despite these efforts, the bulk of our required graduate coursework utilized instruction strategies, content curation, evaluation practices, and outreach training grounded in Western agronomic paradigms that focused on specialized and/or technical knowledge.

In the absence of comprehensive agroecology coursework, *student-led* cohorts emerged as important spaces for agroecology co-learning. Faculty and mentors encouraged students to leverage student cohorts to engage in transdisciplinary learning; the goal was to learn skills and methods from multiple disciplines to explore the relationships between agronomy, research, and broader food systems. Starting in 2015, a small group of students in the Applied Plant Sciences graduate program formed the Food, Environment, and Agricultural Studies (FEASt) graduate student group, which quickly expanded to include students from multiple disciplines, including Sharon, and several faculty allies. FEASt initiatives have included conversation groups, seminars, reading groups, and a symposium (Table 1).

Beyond developing a broader set of skills, FEASt members identified the need to critique, address, and reimagine the political landscapes in which we apply transdisciplinarity. In other words, we needed skills to ask questions such as: Why are we asking our research questions, and what socio-political systems are supported or challenged by this research? Who is generating the questions, and who is ignored? How do our research methods perpetuate or question broader systems? What assumptions are we making and why? These questions can be addressed by using critical theory and related critical approaches to frame transdisciplinarity, yet FEASt members

TABLE 1 Summary of student-led organizing that informed workshop series and pedagogy model development.

Format	Active	Outcomes	Challenges
Food, Environment, and agricultural Studies (FEASt) graduate group	2015–2016	• Horizontal learning • Cohort building • Transdisciplinarity • Shared understanding of critical theory • Community-university connections • Student-led	• Labor limitations • Members adjusting to horizontal management structure
Symposium—"Critical Visions for an Abundant and Just Food System in the 21st Century"	2016	• Relational networks • Critical reflection and inquiry • Community-university connections • Student-led	• Labor limitations • Harassment • Funding
Class—Orientation to Scientific Thought	2016	• Boundary space • Co-learning between students • Cohort building • Student/faculty horizontal learning	• Labor limitations • Bureaucratic resistance • Faculty lack of confidence • Culture of impossibility—repeated claims that class was not relevant to "real" work • Advertising/engagement
Seminar—Participatory Action Research (PAR) reading group	2017	• Interest in focusing on agroecology • Student/faculty horizontal learning • Relational politics • Critical reflection • Praxis • Preliminary model of graduate education • Visioning	• Labor limitations • Lack of clear direction/goals • Barriers to implementing PAR strategies in projects (e.g., limited time in program to form community relations, concerns about project sustainability after graduation)
Conference presentations	2017–2018	• Exposure to Indigenous and intergenerational ways of knowing, along with the importance of care • Accessing (or learning about) decision-making circles at UMN that we didn't previously have access to • Renewed motivation to document and share process as a result of engagement • Identifying institutional barriers, opportunities, and bureaucracies	• Financial costs • "Preaching to the choir" • Bureaucratic obstacles and institutional culture of impossibility

identified that critical theory was almost entirely absent from our programs.

FEASt members with backgrounds in social movements and/or social science disciplines shared their knowledge of critical theory with others in the group by practicing horizontal learning. Initially, FEASt hosted two-part conversations on agricultural case studies; FEASt members discussed the case with each other during the first part and then invited a local expert to the second part. Building on this foundation, FEASt coordinated a symposium in 2016 entitled "Critical Visions for an Abundant and Just Food System in the 21st Century," which was attended by 96 student, faculty, and community participants from across the Midwest. Subsequently recognizing the need for ongoing training in critical approaches, FEASt members designed a colloquium-style graduate course entitled "Orientation to Scientific Thought," proctored by a faculty ally, to explore topics such as ways of knowing, philosophy of science, political economy, intersectionality, and capitalism in food systems. Through these activities, students developed strong relationships, enacted horizontal learning structures, and built capacity for critical, transdisciplinary scholarship. However, FEASt members also faced significant burnout. Though FEASt went into hibernation following the course in 2016, student-led efforts to pursue agroecology learning continued.

While the conversations, symposium, and course helped create new habits of mind, students recognized the need to apply critical theory to practice. Having taken "Orientation to Scientific Thought," Vivian was specifically interested in PAR as a practice that deliberately integrates research, knowledge from multiple ways of knowing, and

grower needs (Méndez et al., 2017). Our programs, however, did not include PAR coursework or training. Thus, in spring 2017, Vivian initiated a 1-credit seminar about the theory, process, and practice of PAR. The seminar participants were students (including Sharon and Jennifer) and faculty involved in projects that worked directly with farmers in a consultative capacity, through on-farm research sites, or as co-developers of research questions and design.

Seminar participants continually returned to the intersection of critical theory and PAR, given that our participatory work is part of political systems and that actions (or inactions) have political consequences. Within this context, PAR requires us to be in relationship with and work with people or organizations who have different worldviews, backgrounds, and positionalities. To facilitate dialogue across difference with growers, policymakers, and others, seminar participants identified the aptness of relational politics, a concept developed by UMN public policy faculty. Relational politics is a framework for people to "interact on public matters in carefully designed processes in which participants use not only their minds and heads but also their bodies and emotions" (Levine, 2016). Dialogue and deliberation in relational politics builds mutual understanding, develops empathy and respect between people, and illuminates areas of alignment to recognize opportunities for collective action (Jordan et al., 2021). By the end of the seminar, the course participants began to imagine a holistic agroecology program at UMN-TC, building a draft pedagogy model that included the emergent themes from our collective learning—critical theory, relational politics, and participatory action research.

Though the draft pedagogy was developed in interstitial spaces that ran parallel to our graduate programs, this structure was ultimately not sustainable. First, the labor burden on graduate students—who led content curation, planning, and implementation for all activities—was significant. While this level of student agency can be beneficial, it can also become extractive; course and syllabi development, in particular, was an example of students taking on responsibilities that generally fall under faculty roles. Students took on these roles because faculty allies articulated discomfort with facilitating courses that were outside their area of expertise or required critical, dialogue-based approaches—which is a broadly recognized challenge in university agroecology programs (Lieblein and Francis, 2013; Hilimire et al., 2014; David and Bell, 2018; Rivera-Ferre et al., 2021). Additionally, student-led activities leveraging critical approaches also faced institutional resistance. While planning the symposium, FEASt members encountered resistance from faculty and administration; some fellow students also publicly mocked the symposium using sexually suggestive and derogatory language.[2] Later, when FEASt members were developing the 2016 class, program leadership described it as too "anti-establishment" and only approved the course after a tenured faculty-ally agreed to proctor the course; we (the authors) faced similar resistance when planning the 2019 workshop series described later in this paper. Thus, institutional barriers, harassment, feelings of inadequacy, and pressure to focus on "real" work (e.g., data analysis, publications) contributed to a general culture of impossibility that made it difficult for students to self-sustain their work.

Reflecting on these challenges, we realized staying in interstitial spaces was limiting our potential for growth. To begin exploring processes to move our pedagogy from informal to formal spaces, we first shared the proposed model through conference presentations (Wauters et al., 2017, 2018; Nicklay et al., 2018). In the resulting discussions, it became clear that (1) there were still under-developed areas, such as how to approach relationships and integrate multiple ways of knowing, (2) implementing the model within the structure of our own university would require building broader networks of individual and institutional allies, and (3) colleagues across North America were interested in using the student-led process to adapt the model to their own contexts. To address these needs, we created and facilitated a three-part summer workshop series in 2019 to refine our pedagogy model, which was an important step toward our long-term goal of creating collaborative, iterative, and collective learning spaces where we can immerse ourselves in agroecological paradigms.

4. Methods

To refine the draft pedagogy, we hosted a series of three workshops during summer 2019 (Table 2) to engage a broader community of agroecologists, largely from UMN-TC. We structured the workshops around three assumptions, inspired by agroecology movements generally and, more specifically, the Sustainable Agriculture Education Association (2018)'s equity statement:

1. At the most basic level, we believe that agroecology is not value-neutral.
2. We believe agroecology should prioritize action-oriented, applied approaches to problems.
3. As a value-driven model, agroecology learning should reject exploitation, making it anti-racist and anti-colonial.

These assumptions were used to design the workshop experience, from activities to food choice. The full workshop facilitation plans, activity instructions, and summaries are provided in Supplementary material. Workshops were attended by 24 unique participants representing 13 departments, including 11 graduate students, 12 faculty/staff, and 1 undergraduate student. The University of Minnesota Institutional Review Board determined this work was not human subjects research.

During each workshop session, participants engaged with all components of our draft pedagogy model and proposed changes. After each session, summaries were sent to participants and members of the broader UMN-TC agroecology community. We included activity instructions, notes, and insights about or revisions to the model so people who could not attend in person were able to complete reflection activities and share their insights, and people who did attend were able to add additional feedback or context. Through this process, students, faculty, and staff working in agroecology spaces were able to "member-check" (Caretta and Pérez, 2019; Horner et al., 2021) the model as it developed, which was an important way to validate our interpretations and analysis.

After the workshop series, further refinements and changes to the model were completed by analyzing planning meeting notes and artifacts from the workshop activities (e.g., pictures, concept maps, notes) through a combination of collaborative autoethnography (Chang et al., 2016) and inductive coding (Lofland et al., 2006). Drafts of the manuscript were shared with the PAR seminar and workshop series participants *via* email to ensure that continued development of the model remained consistent with their experiences. Finally, the manuscript draft was used for reading discussions at a FEASt student group meeting and a laboratory group meeting. Feedback from these ongoing member-checks was incorporated into model and manuscript revisions. This process reflects our commitment to articulating an iterative and reflective learning framework that emerges from and responds to student needs.

5. Results: Building a pedagogy for agroecology learning

Building on years of relationships and collaboration among many students, faculty, and community members, a pedagogy for graduate agroecology education was developed during the summer 2019 workshop series (Figure 1). Focusing on epistemological structures for the pedagogy, workshop participants highlighted the importance of horizontal learning with a cohort, affirmed the value of critical inquiry, and deepened our understanding of the roles of relationships, participatory practice, and knowledge (both individual and collective) in agroecology education.

Participants also engaged in deep discussions to define the purpose of an agroecology program grounded in this pedagogy. Initially, there was a clear tension between focusing on developing broader skill sets or developing new habits of mind:

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2 We share this to highlight that retaliation, in our experience, is often gendered. For a more in-depth discussion of gender discrimination in the sciences, see the reports by Clancy et al. (2017) and Committee on the Impacts of Sexual Harassment in Academia (2018) or the documentary *Picture a Scientist* (Cheney and Shattuck, 2020).

TABLE 2 Overview of goals and activities for the "developing a model of agroecology training for graduate students" workshop series.

Workshop	Goals	Activities
1	• Reflect on and articulate the important experiences and skills that have supported their agroecology work • Engage with the draft model for agroecology pedagogy developed following the spring 2017 seminar • Begin articulating values that inform their work as agroecologists	• "I am an agroecologist because…" reflection, conceptual diagramming, and pair-and-share • "Engaging with the Model" activity to physically embody the model and process with a cohort • Large group discussion
2	• Articulate the assumptions that underlie our work as agroecologists through identification and placement of skills and values within the updated model • Identify the goals for an agroecology program our model proposes. • Evaluate whether the revised model adequately encompasses participant value-driven skill sets	• Skills: Individual free-write • Values: Retirement Party Activity and group discussion • Pair and small-group discussion of personal and program goals. • Group discussion and workshop evaluation analysis
3	• Identify existing opportunities and gaps for implementing our model at UMN-TC • Brainstorm next steps to overcome barriers and identify opportunities for further action—individually and collectively—toward implementing the pedagogy model	• Collaborative mapping of existing agroecology education • Group prioritization of gaps to address and individual reflection activity to envision personal role in moving forward

See Supplementary material for full details regarding communications, facilitation plans, and activity instructions.

FIGURE 1
Pedagogy model for graduate agro ecology learning at the University of Minnesota-Twin Cities (A) and associated definitions (B). The learning cohort is at the heart of our model, serving as a space to synthesize critical inquiry, relational centering, and participatory practices and supported by the situated knowledges of learners.
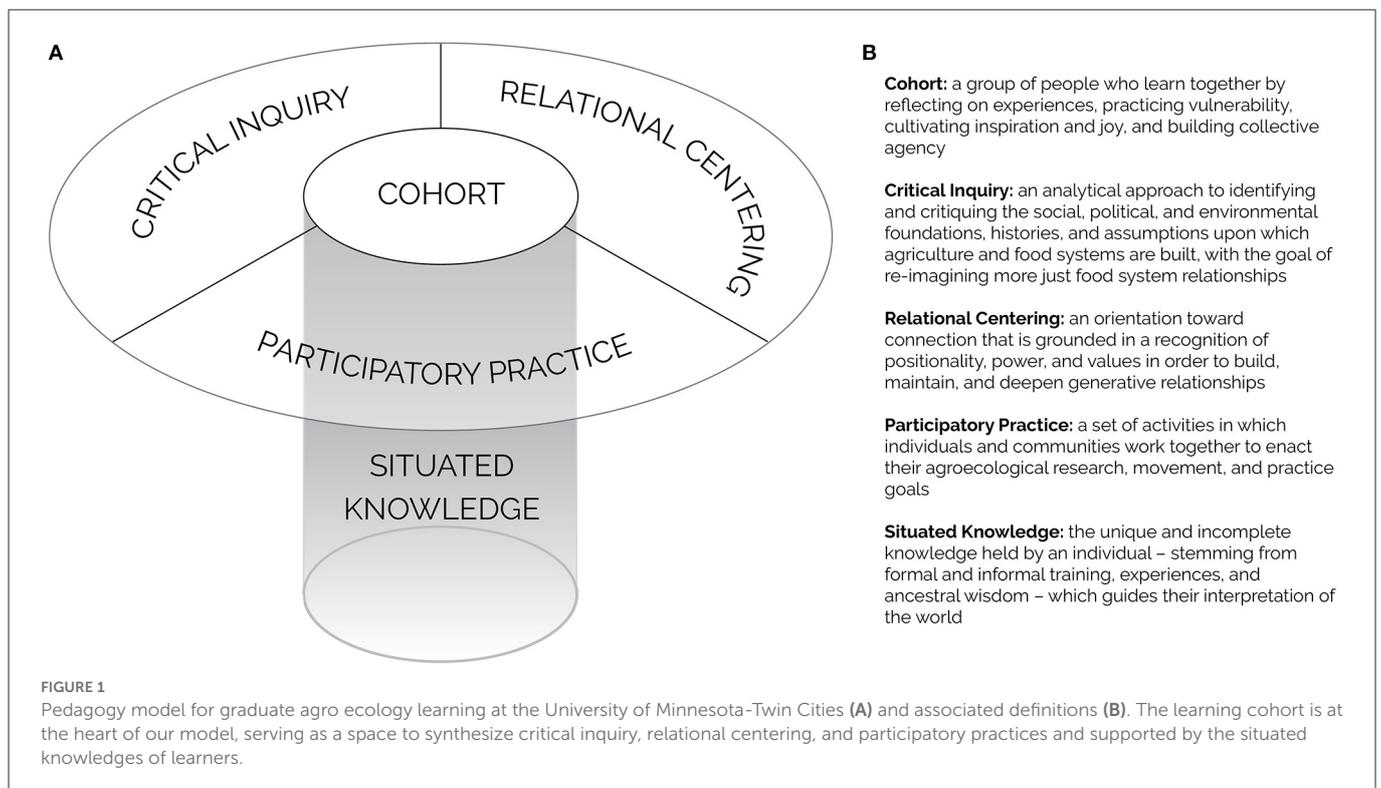
Faculty participant #1: Is the goal training? Or is the goal transformation? Do we want to look at discrete agroecological packets, or some larger transformation in the world? And how are they related?

Student participant #1: It should be baseline training to give you the tools to apply to whatever challenge you're interested in.

Student participant #2: Is having the toolbox then the transformation?

Faculty participant #2: I like the idea of a toolbox.

Faculty participant #1: I always think of the word change-maker. I love the idea that in my teaching, I'm facilitating students becoming change-makers.

Over the course of two workshops, participants ultimately resolved this tension through collective reflection, and the purpose that emerged was that an agroecology program should facilitate a learning community where:

Agroecologists develop knowledge, habits of mind, and skills to be motivated and capable to plan, implement, and evaluate sustained action in collaboration with others, for the purpose of catalyzing transformational change.

It is important to note that participant language around transformational change, broadly, rather than food systems transformations, specifically, was intentional. This choice reflected

an explicit recognition that work in building sustainable food systems will be interconnected with broader movements for justice. The following sections describe the five pedagogy components—cohorts, critical inquiry, relational centering, participatory practice, and situated knowledge—and how they contribute to enact this purpose.

5.1. Cohort

> *A cohort is a group of people who learn together by reflecting on experiences, practicing vulnerability, cultivating inspiration and joy, and building collective agency.*

The cohort is at the heart of our model (Figure 1). However, it was not *explicitly* included in the draft model that emerged from the PAR seminar. Cohorts, instead, were *implied* or *assumed* in the language we used. During the first workshop, we explained that the proposed model of agroecology learning "happens collectively; it should not be individual students taking individual classes and then maybe talking to their advisors, maybe to their committee. You need to have someplace to go to, to go back to, to work through things. You need to do it in and out of the class. To have time to practice and step back and reflect." Workshop participants pushed us to explicitly name the cohort because the model "doesn't *become* until it's collective" (emphasis added), particularly highlighting the role of cohorts to support intellectual and emotional development by creating space for patience, courage, honesty, compassion, heart, and joy. Workshop participants ultimately proposed a three-tiered structure consisting of peer, program, and practitioner cohorts (Table 3).

Building on past informal cohorts (Table 1), the Peer and Program Cohorts would create continuity for support to span beyond single semesters or individual efforts. Through horizontal learning, both were imagined as compassionate spaces to process experiences—"a place to share your errors and [also] what worked." There was particular focus on the potential for the Program Cohort to build faculty capacity, especially as they engage with skills or ways of knowing that were not included in their own discipline-specific training (see Institutional Context). Finally, both Peer and Program Cohorts could continue to facilitate iterative pedagogy and program development.

The Practitioner Cohort, however, represented a new meeting place for people inside and outside university to build relationships, dialogue across multiple ways of knowing, and support collaboration. It addressed a key challenge faced by many student workshop participants: the difficult (and sometimes impossible) task of establishing, building, and maintaining relationships with growers or community partners in the short duration of their program. One participant emphasized that "it seems almost unfair to put this on a graduate student….and it seems *so important* then that this be institutionalized." By building and maintaining relationships within a collective that includes faculty and community practitioners, both of which often have more long-term tenure than students, that burden is removed from graduate students.

Finally, one participant highlighted that cohorts were the most "radical idea" presented, specifically because they are collective structures that resist the individualism that is so heavily prioritized within academia. Many participants identified that cohorts are an important strategy to minimize risk for participants with different identities/positionalities and build solidarity. Early in workshop 1, students and faculty discussed the pushback and retaliation they had experienced as a result of their work:

> *Faculty participant: Remember that students may be low in bureaucratic power, but they likely have more political power within the university because faculty could get fired for this.*
> *Student participant: But students can also experience career consequences too. So it's really about making sure that we minimize risk for everyone.*
> *Faculty participant: You're describing movement building!*

This was echoed by a participant who said, in a later workshop, that they were beginning to realize that one of their roles was to "build the capacity of scientists" to engage in action. During our writing process, we realized that "building a transformative program is about us realizing that we need to build up *everyone's* capacity and confidence" (notes from June 2, 2021). The cohorts, therefore, create collective structures through which to enact agroecological paradigms.

5.2. Critical inquiry

> *Critical inquiry is an analytical approach to identifying and critiquing the social, political, and environmental foundations, histories, and assumptions upon which agriculture and food systems are built, with the goal of re-imagining more just food system relationships.*

Critical inquiry includes both reflection and action in an iterative process of learning and unlearning, a process driven by an underlying commitment to justice and community. The move from "critical theory" in the original model to "critical inquiry" represented an attempt to encompass a broader range of critical approaches. "Critical theory" is grounded in a specific academic lineage that emerged from the Frankfurt School and Marxism (Bohman, 2021). While we wanted to maintain its emphasis on emancipation and liberation, FEASt participants had brought experience in many critical approaches, including critical physical geography, feminist geography, critical pedagogy, critical race theory, and critical environmental justice. We began to use "critical inquiry," which is drawn from social studies education scholarship; it maintains a focus on liberation through inquiry-based experiences where learners can explore the processes and practices that undergird a broad range of critical approaches (Crowley and King, 2018).

Space to learn and practice critical inquiry is vital to grapple with the discomfort of unlearning assumptions. A workshop participant from extension observed that when Extension educators don't have space to learn critical inquiry, they continue to implement programming that lacks attention to systems of power/oppression and relies on one-way knowledge transfer; as a result, programs perpetuate inequitable access (e.g., excluding Black and Indigenous growers) and stunts relationships between universities and agricultural communities. Conversely, a student who conducted international research shared that critical inquiry helped them recognize how past extractive research programs and

TABLE 3 Brief overview of cohort groups, participants, and purposes.

	Participants	Purposes
Peer cohorts	Students in a similar phase of their degree (e.g., incoming students each year enter as a cohort)	• Low-stakes space for co-learning, giving/receiving feedback, addressing challenges, and processing experiences • Explore topics, ideas, and strategies not yet included in program coursework/research requirements
Program cohort	• Peer cohorts • Faculty, staff, and Extension educators working in agroecology	• Horizontal learning between people who share an institutional positionality (university employees) but have different ages, knowledge, experiences, and identities • Challenge academic hierarchies • Collaborate to implement reflective, iterative program, updating program course/research requirements and pedagogy as needed • Build capacity for collective action, minimize risk to individuals
Practitioner cohort	• Peer cohorts • Program cohort • Practitioners from communities beyond academia (e.g., growers, organizers, policymakers)	• Dialogue across multiple ways of knowing • Horizontal learning between people with different roles in the food systems; intergenerational learning • Build and maintain long term community-university relationships and collaborative projects • Create processes to increase practitioner input/control over research projects and Extension programming • Facilitate solidarity across different collective efforts and actions

colonialism had impacted the social and environmental relationships in their research area; this perspective shaped their approach to working supportively and ethically with farmers. Critical inquiry, therefore, is necessary to iteratively reflect on situations and change our actions as we enter relationships and approach our participatory practice.

Workshop participants acknowledged that there would be risks or challenges to move critical approaches from the "hidden curricula" into formal agroecology coursework and programs. Several participants shared ways in which practicing critical approaches in agricultural spaces had negatively impacted their careers. In addition to pushback previously described in Institutional Context, one faculty participant shared that they had faced coordinated retaliation against the use of critical theory in their work—which ultimately contributed to their decision to leave UMN-TC. Some participants theorized that the name "critical theory," specifically, would be more likely to face retaliation due to its intellectual roots. Despite, and because of, these concerns and risks, workshop participants believed it was important to keep this component in the model.

5.3. Relational centering

> *Relational centering is an orientation toward connection that is grounded in a recognition of positionality, power, and values in order to build, maintain, and deepen generative relationships.*

Relational centering foregrounds the importance of *relationships as their own end*. Participants associated humility, engaging with difference, patience, empathy, loyalty, respect, fairness, listening, passion, and love with this model component—all of which go beyond the resources and conditions needed to collaborate on a specific project. The move from "relational politics" in the original model to "relational centering," therefore, represented an important shift from a framework to *work together* toward an orientation to *live together* (notes, January 12, 2022). Relational centering encompasses three types of relationality identified by workshop

participants: deepening one's relationship with self, connecting through relationships with others, and expanding relationships to include the more-than-human world.

Workshop participants all expressed relief and excitement that deepening relationships with self through critical self-reflection broke from agronomic epistemologies of objectivity/neutrality. Critical self-reflection helped them understand how their work was shaped by their positionalities, which encompasses a person's identities and how those identities shape their relationship to others and the broader systems in which we exist. For example, participants discussed the ways in which their identities as researchers and position in academia constituted a position of power and authority within dominant political systems. Strategies to engage with this identity in their work, however, depended on their experience with critical self-reflection. One faculty participant, for example, in talking through their relationship with growers, expressed that "there's a distribution of power, and you want people to relate to you as a person rather than as your position, so you want to erase that power difference." A graduate student participant, however, argued that this desire to erase power differences to assuage our individual discomfort could be harmful by erasing people's very real experiences with structural oppression and the transformative possibilities that they are uniquely positioned to imagine.[3] Through this interaction, we see the ways in which cohorts could support individuals as they develop resilience through learning, making mistakes, and working toward change. As one participant noted, "there's an aspect of cracking open and internal transformation that's required" to participate in broader social and food system transformation.

A deeper understanding of our individual values and positionalities prepares us to be in relationship with others. Students and faculty who provided feedback on early drafts of

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3   The student compared the inclination to erase power difference in research relationships to a "color-blind" approach to racism, which is when white people say they do not see race to avoid discomfort about the ways they benefit from white supremacist systems. The specific example was attributed to an anti-racism training, based on the work of Minnesota social worker and somatic therapist Menakem (2017), that the student had completed outside the university.

this article emphasized that when working across differences, they wrestled with the tension between their own values and those of their partners. As one participant shared,

> There's a narrative of good people and bad people. I think it's important to see people as allies, who we may not see as on our "side." It's important to see people we work with [and ourselves] as complex people that are impacted by systems.

During our writing meetings, we realized that this tension manifested differently depending on the context in which the individual was working, as illustrated by Sharon and Jennifer's research experiences. Sharon often worked "up" the power structure with people who, because they were entrenched in the status quo, did not share her core values; centering in self, then, provided an important space to honor her own values, hold space for others' values, and find ways to move forward together. Jennifer worked with urban growers in predominantly Black and refugee/immigrant communities; she had many values in common with her partners, so possessing a strong sense of her positionalities, as a white woman and researcher, helped her identify ways to mitigate, leverage, or cede power, depending on the situation, and move forward with her partners (notes, February 4, 2021). Vivian highlighted the commonality through these experiences: agroecologists "learn why people care about what they care about, and how to work with them given the things you care about, and in doing so, to care about things together."

Relationships with others, however, also require an openness to be changed by the relationship. During the activity in workshop 1 when we asked participants to engage with the model, a participant doing international research shared that:

> I started out with big community meetings, but they totally failed. So starting with relationship building is really the big thing that should have been done before the needs assessment. Being humble and understanding their way of life. This might have helped me more effectively identify what reciprocity looked like when asking farmers for their time and knowledge. **Centering your social relationships as the basis for your professional objectives** (emphasis ours).

In feedback on early drafts of this paper, we saw faculty grappling with the idea of relationships as "THE basis" of professional pursuits, which led us to realize that this example represents a critical reorientation away from individual-focused and toward collective-focused work. A collective focus recognizes that needs and priorities only emerge through robust relationships with others—and that individual pursuits can, and perhaps should, be guided by these collectively-identified priorities.

The workshops also expanded our understanding of who and what we are in relationship with to include the more-than-human world, which encompasses plants, animals, water, and soil. We saw participants include more-than-human relationships both in concept maps and conversations (Figure 2). Since the participants in our workshop were predominantly white, this was often paired with an acknowledgment of or gratitude for the Indigenous mentors or knowledge systems from which these ways of being in relationships with the world originated. Overall, relational centering—by spanning relationships with self, others, and the

more-than human—connects individual transformation to broader social and ecological transformations.

5.4. Participatory practice

> Participatory practice is a set of activities in which individuals and communities work together to enact their agroecological research, movement, and practice goals.

Participatory practices bring together multiple people with multiple ways of knowing to address food system challenges (Figure 1). It is where cohorts put critical inquiry and relational centering into action through place-based projects with communities. As a result of the workshops, we broadened the scope from "participatory research" in the original model to "participatory practice." Workshop participants emphasized that not all work in agroecology is research-focused and highlighted participatory projects in Extension, farm planning, and city/regional policy. One graduate student further observed that choosing "practice" over "research" implicitly opens space for and honors multiple ways of knowing in knowledge production—a key tenet of agroecology.

Yet, participants affirmed that training in participatory practices, research or otherwise, was largely absent from biophysical science coursework. A participant who worked in Extension gave an example of how lack of training and confidence in participatory processes could perpetuate agronomic epistemologies of top-down knowledge transfer:

> There's this general eroding trust in institutions. So in the crops faculty I worked with, there's this fear that if we open ourselves up to participatory work and admit that we don't have all the answers, then the trust will further erode and people won't come to us as experts. I think there's a lot of fear in opening ourselves up to critique.

In other words, this participant observed that when academics do not have experience navigating critique through learning and unlearning in critical inquiry, they are unprepared to conduct participatory projects. Other workshop participants offered examples of the importance of humility in participatory work; being open to critique and adjusting their actions based on that feedback actually served to build trust and led to stronger relationships with partners and communities.

Many participants had sought training in participatory approaches through other UMN-TC programs, such as public health.[4] A graduate student shared that while completing this public health course was a rich experience, it was framed around "'what's your interaction with public health?' but [as an agroecologist] you're

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4 PUBH 6815: Community Based Participatory Research is a one semester course that was co-developed by a UMN researcher and a community leader who were engaged in participatory research together. It is currently taught by community leaders who conduct participatory research. Graduate students can complete the course for credit, and community members can take the course for free. The course description is available through the UMN Course Catalog (https://onestop2.umn.edu/pcas/viewCatalogCourse.do?courseId=814654).
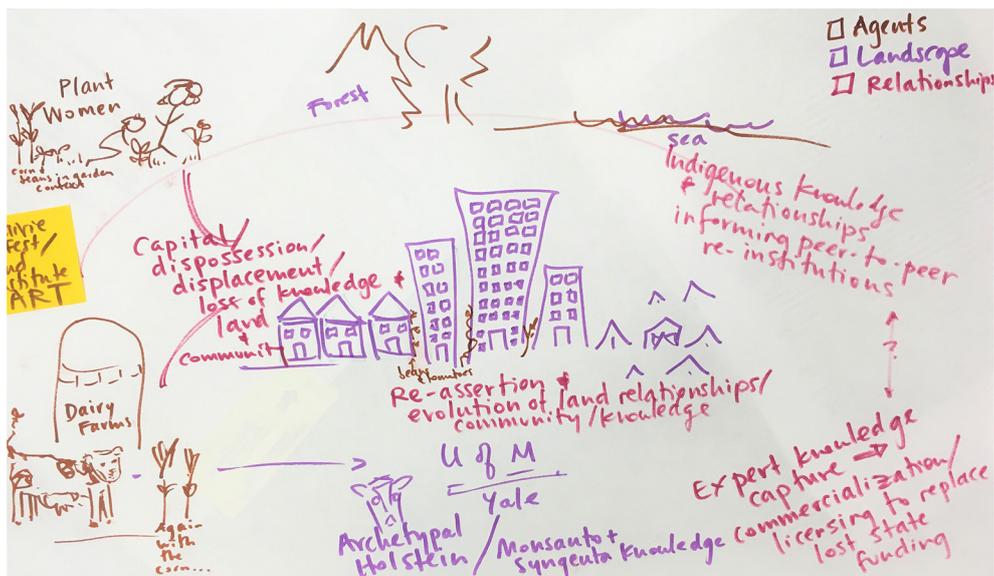
FIGURE 2
Expanding our conception of relationships. During workshop 1, participants were asked to draw conceptual maps of their agroecology practice, including the people, groups, and beings involved in that practice. In this concept map, we see the ways that the more-than-human—beings (such as plants, forests, and animals) and land, water, and air—are being incorporated into the understanding of relationships, as well as the attribution of their inclusion to Indigenous knowledge and relationships.

not really [directly] interacting with that." As a result, there were gaps in the learning experience; for example, in the same course, Vivian and Jennifer struggled with the absence of relationships to land and place, which are critical for participatory agroecological work. Thus, workshop discussions underscored the need for opportunities to learn and practice participatory approaches within an agroecological context.

Beyond coursework, participants also emphasized the need for structured learning environments to practice participatory approaches. Graduate students highlighted that a significant challenge they faced was simultaneously learning participatory strategies and building relationships with partners. Students expressed concern that because both require time, practice, and mentorship that are often not present in graduate training, their mistakes and failures—which are expected when learning new practices—were more likely to harm and alienate partners. Participants proposed short, defined projects would be an opportunity to learn and practice participatory approaches before applying them in longer-term thesis or dissertation projects.

Student and faculty participants reaffirmed the importance of Program and Practitioner Cohorts to collectively hold community-university relationships (see previous section) and provide important access to mentorship from other students, faculty, and community practitioners. A graduate student who was engaging in community food projects shared that:

> *I was originally in arts for art's sake, and through mentorship realized that it's art for social justice. I wasn't necessarily taught that, but it was a process as I was practicing art with my mentor in an environment that was real.*

In this experience, mentorship helped the student deconstruct the separation between art and community, a separation which

is common in Western institutions. Their real-world practice, furthermore, led to critical inquiry that facilitated understanding their work within broader social, political, and economic systems and developing interventions to support social justice through their work. Ultimately, this example demonstrates that participatory practice is one way in which individual transformation connects to broader food system transformation.

5.5. Situated knowledge

> *Situated knowledge is the unique and incomplete knowledge held by an individual—stemming from formal and informal training, experiences, and ancestral wisdom—which guides their interpretation of the world.*

Situated knowledge is represented as a column supporting the cohort to recognize the depths of knowledge within each person and its essential contribution to the collective (Figure 1). However, the original model did not include explicit representation of knowledge. Instead, we assumed implementation of the model would be layered on existing academic programs (such as a certificate or interdisciplinary minor). Therefore, people within the program would likely have different sets of knowledge depending on their home discipline and/or personal experiences.

In planning the workshops, however, we anticipated that some colleagues might be distressed that their disciplinary expertise was not recognized within the model. When we introduced the draft model in the first workshop, Vivian explained:

> *Now, some of you may be thinking "wait, what about my expertise as an agronomist, or visual artist, or historian, or as a 4th generation farmer?" What we're talking about in our model is a type of breadth knowledge. I imagine the model coming out horizontally, providing a lens through which I engage with the world. Complementary to that…is my 'deep knowledge.' Think of deep knowledge as a pillar extending from your feet deep into the ground. It's that disciplinary and/or cultural wealth of knowledge that you personally have access to, that will be particular to you.*

In the conversation and activity that followed, many participants did, in fact, struggle with the lack of a specific, disciplinary knowledge system for agroecology and advocated adding a "disciplinary knowledge" component. Yet, as facilitators, we wrestled with how to move beyond the confines of academic disciplines. In our own agroecology learning (see Institutional Context), we had come to value transdisciplinarity. Furthermore, we had received feedback during our presentation at the 2018 Sustainable Agriculture Association Conference, a space which centered Indigenous ways of knowing, that the model should *explicitly* include other ways of knowing to avoid *implicitly* perpetuating Western academic norms. Therefore, in subsequent workshops, we included a preliminary pillar for "disciplinary and experiential knowledge."

Upon reflection during the paper-writing process, we sought a term that would represent the importance of attending to power and multiple ways of knowing within the cohorts and relational centering to self, more-than-human beings, and to place. We found this in feminist scholar Haraway (1988)'s conception of "situated knowledge," which recognizes the partial perspectives that each person brings to spaces of collective learning and action. Situated knowledge is not simply pluralistic, but rather is sensitive to power; the knowledge of those who have been marginalized by dominant systems—the traditional objects of research (including both peoples and places) are explicitly valued for the unique ways it can imagine sustained transformations in the world. Partial perspectives sustain the possibility for webs of connections and solidarities because "situated knowledges are about communities, not about isolated individuals" (p. 590) and, therefore, calls us to be accountable to each other. Accountability requires that we, as scholars, recognize and reckon with our disciplinary and institutional positionalities as they are (or are not) embedded in dominant Western paradigms. We were also inspired by recent work emphasizing knowledge is situated in places (McCune and Sánchez, 2019). As a result, we expanded our understanding of situated knowledge to include partial perspectives of people and place, an interpretation that is similar to how "situated knowledge" is used by the undergraduate program at the Bolivarian University in Venezuela (Domené-Painenao and Herrera, 2019).

6. Discussion

Critical inquiry, relational centering, participatory practice, cohort learning, and situated knowledge are the epistemological structures for agroecology learning in graduate education that emerged from our specific histories, contexts, and relationships at UMN-TC. The pedagogy for graduate agroecology learning proposed in this paper is an interactive and reflective learning framework to think, be, and act—using our head, heart, and hands (Lieblein and Francis, 2007; Jordan et al., 2008; Valley et al., 2018;

Ebel et al., 2020)—toward catalyzing transformational change. The explicit engagement with equity and justice in the program purpose articulated by workshop participants is rare in the context of graduate sustainable food systems programs; Valley et al. (2020) found that only one third of graduate programs addressed equity, none of which included doctoral programs. While the workshops made significant progress in articulating a focus on justice, much work remains. The workshop participants (including us, as authors) were predominantly white women, and our shared habits of mind and being impact and limit our ability to envision just food and agriculture systems; though these demographics are representative of broader agroecology programs at UMN-TC, it represents a significant limitation in our pedagogy development process. Future efforts will need to be especially intentional to create spaces that are centered on the experiences of those most oppressed by dominant systems.

Creating academic programs and structures that center anti-oppression is necessary for university agroecology education to participate in transformative movements (Montenegro de Wit et al., 2021). Our findings particularly highlighted the importance of critical and collective processes/structures, and we focused on epistemological interventions because, as prior scholarship has shown, they help teachers and learners develop new vocabularies, deepen analysis, navigate discomfort and uncertainty, and overcome cognitive or emotional blocks to dialogue (Andreotti et al., 2018). In this section, we discuss the key contributions to agroecology pedagogy scholarship that emerged from our workshops, identify important opportunities for future development, and share ongoing efforts to implement the pedagogy as a graduate agroecology program at UMN-TC.

6.1. Transform self to transform the world: Engaging in critical inquiry through collective processes

Our results affirm that critical pedagogies are important to build students' capacity for collective action within and beyond university agroecology courses and programs (Meek and Tarlau, 2016; Classens et al., 2021; Horner et al., 2021). Critical inquiry is important in relationships to self, in that it helps individuals navigate their own positionality. In Freire (2000)'s description of critical consciousness, for example, the first step is to "deal with the problem of the oppressed consciousness and the oppressor consciousness…. [and] take into account their behavior, their view of the world, and their ethics." In other words, to reveal oppression, build trust with others, and commit to action, Freire argues that people "must re-examine themselves constantly." Many theories of change engage with this connection between internal, small-scale changes and external, multi-scalar systemic transformations; it is described as tensions between self and world transformation in agroecology (Lieblein et al., 2007; Francis et al., 2015; McCune and Sánchez, 2019; Nicklay et al., 2020; Casado et al., 2022), fractals in Black organizing strategies (Brown, 2017), inward and outward transformation in Christian liberation theologies (Tarlau, 2015; McCune and Sánchez, 2019; Sit, 2020), and adaptive cycling in ecology (Holling, 2005). To navigate these dialectic relationships, our results highlight the importance of pedagogical structures—specifically, cohorts—that reproduce opportunities for critical inquiry.

Workshop participants highlighted that learning/unlearning in critical inquiry can generate strong emotions and envisioned cohorts as a space to collectively metabolize discomfort. This echoes the concept of affective justice in the EarthCARE Global Justice Framework, which positions "re-configuring neuro-biological connections, digesting and composting traumas, fears, denials, and addictions" as a necessary part of environmental and economic justice (Gesturing Toward Decolonial Futures Collective, 2018; Stein et al., 2020). When engaging with discomfort alone, people may become stuck in cycles of inaction. Shanahan (2022), for example, observed that honeybee researchers, students, educators, and others often avoided discomfort by choosing not to ask the "dangerous questions" about industrial agriculture that challenged their beliefs and assumptions; doing so avoided a threat to their work and identity but ultimately enacted a broader harm by protecting toxic systems. Recognizing this challenge, agroecology education scholarship has called for pedagogies that support students through the feelings of despair and discomfort that emerge when learning about social injustices (Galt et al., 2013; Horner et al., 2021).

Cohorts provide a collective structure to process intellectual and emotional discomfort. Kearns (2021) described this as "standing in the gap" for people as they question deeply held beliefs, core assumptions, and ways of knowing/being and as they face the emotions that emerge, such as embarrassment, shame, and fear. In this context, cohorts are also important to process experiences doing participatory work. Workshop participants noted Peer and Program cohorts could provide an important opportunity for students, faculty, and staff to process discomfort, fear, etc. away from their community partners, which is one way to avoid perpetuating harm. This points to an opportunity for cohorts to enact pedagogies of *alternancia,* similar to the Baserritik Mundura program in Spain (Casado et al., 2022) and movement-led agroecology learning programs more broadly (Rivera-Ferre et al., 2021). By creating a space to "stand in the gap" for fellow agroecologists, cohorts create opportunities to experience these emotions and let them change us, our relationships, and our actions (Andreotti et al., 2018; Rigolot, 2020).

Critical inquiry through cohorts, however, is not only imagined as a space for discomfort; workshop participants repeatedly described collective processes and relationships with words like heart, love, and joy. These emotions, too, create transformative learning experiences for students (Jelinski et al., 2020). It is especially important to cultivate joy, gratitude, and abundance as a way to build resilience when facing challenges, trauma, and grief (Kimmerer, 2013; Stein et al., 2020; Kimmerer and Wilson, 2022). Few university agroecology programs, however, explicitly incorporate love, joy, and abundance in their pedagogies, perhaps because cultural/lived experiences and emotions are often designated as unofficial, non-productive, and non-visible in Western academic institutions (Rivera-Ferre et al., 2021). Many pedagogies based in agroecology movements cultivate solidarity, belief for change, and love for the cause through *mística* practices, which are exchanges of culture, theater, ceremony, poetry, art, and stories (Tarlau, 2015; Black Dirt Farm Collective, 2020; Rivera-Ferre et al., 2021; Casado et al., 2022). In the former Baserritik Mundura program in Spain, for example, students, educators, and partners described *mística* practices as one of the most valuable aspects of the program, with benefits such as construction of identity, cohort cohesion, connecting political/emotional and physical/symbolic, encouragement, commitment, creativity, and joy (Casado et al., 2022). Explicit inclusion of abundance, care, and love

in critical and collective processes, therefore, represents an important area for future growth—both at UMN-TC and in the broader field of agroecology education.

Finally, engaging with critical inquiry through cohorts also continues building collective structures that minimize risk. Rivera-Ferre et al. (2021) warns us to not underestimate the difficulties of critical and political agroecology learning in our current historical moment, and our results speak directly to the risks faced by university students, faculty, and staff, particularly for work grounded in critical approaches. Within this context, workshop participants named minimizing risk as a key component of movement building. In developing this pedagogy, one way we (as authors) sought to minimize risk for our cohort was by being very intentional in the names used for each pedagogical component, a strategy that has been used at many other institutions (Jacobsen et al., 2012; Valley et al., 2020; Horner et al., 2021). While writing the initial draft of this paper, for example, we observed the broader social and political pushback against critical race theory (Sawchuk, 2021), which contributed to our decision to rename "critical theory" to "critical inquiry." While this example focuses on minimizing the risks faced by university students, faculty, and staff, the Agroecology Research-Action Collective emphasizes that it is important for those with less precarious positions to leverage their privilege for both colleagues and community partners in agroecological work (Montenegro de Wit et al., 2021).

6.2. Collective, iterative, and long-term participation

Practicing critical inquiry through cohorts builds capacity for participants to learn agroecological values/knowledge and engage with broader social, political, cultural, and ecological systems. According to McCune et al. (2017), such "processes of internalization" must be connected to "processes of socialization"—spaces where participants can integrate what they have learned to support collectively determined needs and goals. Within our model, the link between cohorts and participatory practice supports processes of socialization, connecting individual (self) transformation with collective (world) transformation. Participatory practice builds on the long history of participatory action research (PAR) in agroecology (e.g., Fals-Borda, 2001; Montenegro de Wit, 2014; Méndez et al., 2017; Nicklay et al., 2020; Montenegro de Wit et al., 2021; Utter et al., 2021). Our results affirmed the centrality of participatory work to agroecology but highlighted emerging opportunities for a broader understanding of participatory practice, supported by interconnected cohorts, to reorient agroecological work toward collective needs.

Workshop participants shared experiences that demonstrated their work was motivated by collectively identified needs/opportunities, which is a departure from the focus on individual curiosity or skill development in Western academic institutions. The shift toward the collective echoes recent calls for pedagogies to expand learning beyond the individual (McCune and Sánchez, 2019) and "place the territory at the center of the education process" (Domené-Painenao and Herrera, 2019). A territory is a place defined by specific relationships between people, histories, land and ecologies, and McCune et al. (2017) have previously described

territorial transformation as a process in which "diverse subjects assume specific tasks in specific moments, creating social feedbacks and emergent principles." Using this lens, we open the possibility for university faculty, students, and programs to fulfill a broad range of roles in territorial (collective) transformation. The Agroecology Research-Action Collective similarly argues that researchers and students can provide a wide range of "valuable work," whether that is through research, grant-writing, or digging post holes. When roles align with needs, participatory efforts "build capacity in all areas of expertise—in both research and partner communities—such that interdependence cultivates equity" (Montenegro de Wit et al., 2021). This was reflected in our workshops, where participants encouraged us to expand our model from a focus on participatory research to a broader understanding of "participatory practice." Furthermore, it became evident that cohorts could provide important structures to hold the relationships that create a "territory" for agroecological transformation and through which participatory practice emerges.

Interconnected peer, program, and practitioner cohorts (Table 3) create a structure to build, maintain, and hold long-term community-university relationships. Rather than relying on individuals to build and nurture relationships, this model would instead create webs of relationships between community partners and university students, faculty, and staff. Cohorts create an institutional structure for connections, which Méndez et al. (2017) argues is important to "facilitate the succession of active participants without losing forward momentum." Thus, cohorts address two key challenges identified by both workshop participants and broader literature: the limited timeframe of graduate programs (Bruges and Smith, 2007; Delate et al., 2017) and academic reward structures that don't recognize or support the resources required to build and maintain relationships, including the emotional labor, time, and financial resources (Robinson, 2008; Hilimire et al., 2014; Montenegro de Wit et al., 2021). Furthermore, the research needs identified by partners often require knowledge, expertise, or skills beyond those of an individual faculty/educator (Montenegro de Wit et al., 2021); whereas an individual student or researcher may try to stretch beyond their capacity to fulfill that role in the current university structure, holding relationships collectively could open the opportunity to connect partners and other university cohort members who already have the relevant skills, knowledge, and capacity. This structure would also complement movement-based spaces for collective learning, which are vital to broader agroecological movements (e.g., Martínez-Torres and Rosset, 2014; Fernandez et al., 2015; Meek et al., 2019). For example, within the European Agroecology Knowledge Exchange Network, Anderson et al. (2019) described the importance of dialogue across three dimensions: among food producers, between food producers and other actors, and between food producers and formal education/research institutions. Incorporating cohorts in university programs, therefore, represents an opportunity to engage in multi-scalar, movement-led networks.

Workshop participants particularly highlighted the potential of the Practitioner Cohort to facilitate dialogue across multiple ways of knowing and divergent views, values, and visions. Dialogue, therefore, is critical to create the emergence of participatory projects that serve collectively identified needs and opportunities. This conception differs from the ways dialogue is commonly employed in existing university agroecology programs, where it is often framed as a way to expose students to other ways of knowing or instrumentalized to learn communication skills (Galt et al., 2012;

Francis et al., 2018). Instead, our understanding of dialogue in Practitioner Cohorts is similar to the undergraduate agroecology program in at the Bolivarian University of Venezuela, where students conduct participatory research projects that emerge from ongoing *diálogos de saberes* with communities; projects span academic years to ensure the continuity of collaborations and ongoing project development/growth (Domené-Painenao and Herrera, 2019). The language of "emergence" is key here. Martínez-Torres and Rosset (2014) argue that *diálogos de saberes* facilitate the emergence of "new collective understandings, meanings and knowledges [that] may form the basis for collective actions of resistance and construction of new processes." Emergence occurs as the result of participants both exchanging knowledge and engaging in collective critical reflection. During the workshops, we observed a small example of emergence in the activity to develop a program goal. Participants started with divergent views on whether the goal was to develop a toolbox, change farming practices, or transform systems. Through dialogue, a new articulation of the program goal emerged, created from the multiple viewpoints of the participants in the room so that all were excited about it. This example highlights that in our model, the combination of critical inquiry, cohorts, and participatory practice create a unique opportunity to engage in dialogue that leads to emergent collective action.

We recognize, however, that there are many challenges to implementing dialogue processes in the Practitioner cohort that facilitate emergence. First, one of the most commonly cited challenges in existing university agroecology programs (including UMN-TC—see Institutional Context) is that faculty are often uncomfortable facilitating courses that require critical, dialogue-based approaches because their own education did not provide opportunities to practice dialogue (Lieblein and Francis, 2013; Hilimire et al., 2014; David and Bell, 2018; Rivera-Ferre et al., 2021). Even when university educators do have experience with dialogue, they are often still immersed in Western ontologies that are oriented to understand consensus as a midpoint between two different views (Lieblein et al., 2004; Martínez-Torres and Rosset, 2014; Andreotti et al., 2018). Mid-point consensus ultimately functions to narrow possibilities, as described by activist and organizer Brown (2017):

> I have been in countless meetings where there was a moment of creative abundance and energy, and then someone said we needed to pick one thing to get behind, or a three- or five- or ten-point plan… [the] tragedy of this narrowing is that people get left out, not just in a slightly hurtful way, but left out of how we construct every aspect of society, infrastructure, and culture (p. 156).

In other words, the way in which we conduct dialogue determines whether the visions of those most marginalized by dominant food systems are excluded or centered in our programs and broader visions for food system transformations. In implementing cohorts, therefore, it will be important to create processes and structures that expand possibilities, rather than narrow them.

Thus, it will be important to build capacity for dialogue as the cohorts and broader pedagogy is implemented. Practicing collective critical inquiry, described in the previous section, is an important foundation. Additionally, workshop participants emphasized the need for structured opportunities to engage in existing participatory

projects that were co-developed within broader and ongoing community-university networks, allowing them to focus on building skills to engage in critical and collective participatory practices. Participants provided examples of courses or programs at the UMN-TC where instructors maintain long-term community-university relationships and connect students to these networks through coursework and research experiences, which are also common in agroecology programs more broadly (Salomonsson et al., 2009; Hilimire et al., 2014; Runck et al., 2015; Francis et al., 2018; Jelinski et al., 2020; Montenegro de Wit et al., 2021). While supported participatory experiences require significant preparatory work to design projects and mentor students (Salomonsson et al., 2009; Francis et al., 2011; Montenegro de Wit et al., 2021), the interconnected cohorts would hopefully reduce this labor burden on individuals (as discussed in the previous section). This supported practice in short-term participatory projects through coursework would prepare students to engage in longer-term participatory work for their thesis/dissertation projects, with access to ongoing mentorship through the Peer, Program, and Practitioner Cohorts. Through the proposed pedagogy, therefore, workshop participants imagined potential strategies to facilitate collective, iterative, and long-term relationships that lead to the emergence of new ideas and roles for university programs in participatory projects.

6.3. Expanding relationality is necessary but requires networks of accountability

At its core, relational centering understands that knowledge is inseparable from the relational context in which it is held or from which it emerges—an idea that is grounded in feminist and Indigenous epistemologies (Wilson, 2009; Arora and Van Dyck, 2021). In previous sections, we discussed the importance of relationships to self in critical inquiry and relationships with others in participatory practice, both of which are supported through cohorts that provide space for collective dialogue and hold long-term relationships. Our results, therefore, affirm the importance of relationship building to facilitate horizontal learning, community co-production of knowledge and, ultimately, transformative learning (Nicklay et al., 2020; Horner et al., 2021). Relational centering provides a framework for agroecology education to focus on ways to live together (instead of solely on professionalization), which echoes the focus on *formación* in movement-based pedagogies (McCune et al., 2014; Rosset, 2015; McCune and Sánchez, 2019; Black Dirt Farm Collective, 2020).

By connecting self, others, and the more-than-human world, relational centering aligns with scholars and organizers who argue that *formación* does not only transform relationships between people, but also relationships between people, land, and more-than-human beings (Martínez-Torres and Rosset, 2014; McCune and Sánchez, 2019; Black Dirt Farm Collective, 2020). While this expanded understanding of relationships is nascent in agroecology pedagogies, it is important in broader movements for justice. The EarthCARE Global Justice Framework, for example, includes relational justice, which emphasizes ways of relating that enact collective entanglement (Gesturing Toward Decolonial Futures Collective, 2018). In Indigenous struggles for decolonization, radical relationality focuses on interdependence, reciprocity, equality, and

responsibility in kinship relations, land body connections, and multidimensional connectivity (Yazzie and Baldy, 2018). Building agroecology spaces that center, recognize, and honor Indigenous and Black agricultural knowledge is especially important because many agroecological practices and principles are based on knowledge appropriated from Indigenous and Black farmers and land stewards, both of which are consistently underrepresented in discussions of agroecology (Cadieux et al., 2019; Montenegro de Wit, 2021).

Expanding relationality and reciprocity are clearly central educational tasks, and we believe it is important to include our articulation of relational centering, even if it is not perfect, so we avoid perpetuating human-centered ontologies/ways of being (Kimmerer, 2013), and instead use pedagogies to create space for alternatives to emerge (Classens et al., 2021). Dring et al. (2022) caution, however, that this is a complicated task for non-Indigenous students, educators, and scholars. Haraway (1988) broadly addresses the dangers of romanticizing or appropriating the visions of "subjugated knowledges," the knowledge of those marginalized by dominant systems; Dring et al. (2022) specifically explores the ways in which this happens within sustainable food systems and agroecology education when multiple ways of knowing are incorporated without awareness of the epistemological and ontological roots of relationality. Within this context, we acknowledge that part of the reason it is important for us to share this evolving understanding of relational centering is to remain accountable to our communities both within and beyond academia.

We attribute the frequent inclusion of relationships with more-than-human beings among our workshop participants (and ourselves) to mentorship in local and international Indigenous-led efforts. Many participants worked with the UMN-TC Native American Medicine Garden under the guidance of the (now former) garden steward, Oglala Lakota, Oceti Sakowin Cânté Sütá Francis Bettelyoun.[5] Additionally, many participated in decolonization cohorts facilitated by a former UMN-TC doctoral student and in movements to stop the Dakota Access Pipeline in North Dakota and the Line 3 Pipeline in Northern Minnesota (Estes and Dhillon, 2019; Andrade, 2021; Science for the People - Twin Cities, 2021). These efforts have demanded that non-Indigenous (particularly white) researchers and students acknowledge that UMN-TC stands on Mní Sóta Makhóčhe, the unceded traditional, ancestral, and contemporary land of the Dakhóta Oyáte,[6] and take anti-colonial actions toward reconciliation and repair. Doing so relies on the connection between critical inquiry, relationships to self, and cohort support described previously to engage with discomfort that surfaces as non-Indigenous people build new habits of mind to expand relationality.

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5   Nearly a year after the workshop series, the University of Minnesota chose to not renew their employment contract with Cânté Sütá Francis Bettelyoun, the Native American Medicine Garden steward. For more information on the ways this process perpetuated colonial violence, see Demmings (2020) and Snow (2020).

6   The land was ceded in the Treaties of 1837 and 1851. When the U.S. later abrogated those treaties, the land was not returned to the Dakhóta, as is legally required when treaties are revoked (Case, 2018), and was instead "granted" to the UMN in the 1862 Morrill Act (Lee and Ahtone, 2020).

6.4. Process as practice: Ongoing efforts and next steps

While the content of our proposed pedagogy for graduate agroecology education is important, the process of creating it has also been an opportunity for transformative learning. Casado et al. (2022) reflected that collective pedagogy design has "the enormous potential to leave a permanent impression on the participants and to give meaning to and reinforce collective political work," and developing the proposed pedagogy model has impacted each of us—and our broader UMN-TC community—in deep and lasting ways. Through critical inquiry, we have learned new ways of thinking—new habits of mind—to learn and unlearn the ways in which current social, economic, political, and ecological systems shape food systems. In relational centering, we developed ways to be in relationship with ourselves and others (human and more-than-human) that connect individual transformation with broader social transformation. Together, critical inquiry and relational centering shape the challenges we address through participatory practice, and our experiences working with others, in turn, change how we understand the world, which drives further critical inquiry. Our work is supported by collective learning through cohorts, composed of people and places with deep situated knowledge, that create space for dialogue across multiple ways of knowing, provide intellectual and emotional support, and build our capacity for collective action.

Our ultimate goal remains to enact the pedagogy for graduate agroecology learning through a dedicated degree program. To build capacity in critical inquiry, an elective, one-credit course entitled "Critical Approaches to Agroecology" was co-developed by Vivian, Sharon, and two faculty members and has been offered twice. Building on energy and connections from the workshop and courses, the FEASt student group was re-started in 2020 and serves as an informal peer cohort. Graduate students continue to pursue participatory training through various departments and institutions. These efforts are slow and vary as student capacity fluctuates, but it remains valuable work; agroecology topics and approaches explored by student groups may become part of required coursework, such as at the National University of General Sarmiento in Argentina (Sarandon and Marasas, 2017), or inform the development of degree programs, such as the Sustainable Agriculture and Food Systems undergraduate major at UC Davis (Parr and Van Horn, 2006; Galt et al., 2012). As a result, many educators have highlighted that such student-led efforts play an important role in creating transformative agroecology education pedagogies (Parr and Van Horn, 2006; Code, 2017; Intriago et al., 2017; Sarandon and Marasas, 2017). However, to create an agroecology program, prior scholarship has found that three components are necessary for success: key players (e.g., students, faculty, staff, partners), support networks and assets, and a programmatic opportunity (Jacobsen et al., 2012). While the ongoing efforts described above continue to build the first two, further work is needed to address institutional challenges and further develop the pedagogy in order to take advantage of programmatic opportunities in the future.

Broadly, there is important work to do at an institutional level. Agroecology programs will need to create grading, qualifying exams, thesis/dissertation expectations, and promotion/tenure processes that support critical, collective, relational, and transdisciplinary agroecology work (Montenegro de Wit et al., 2021), rather than dominant university systems that reward individual productivity and
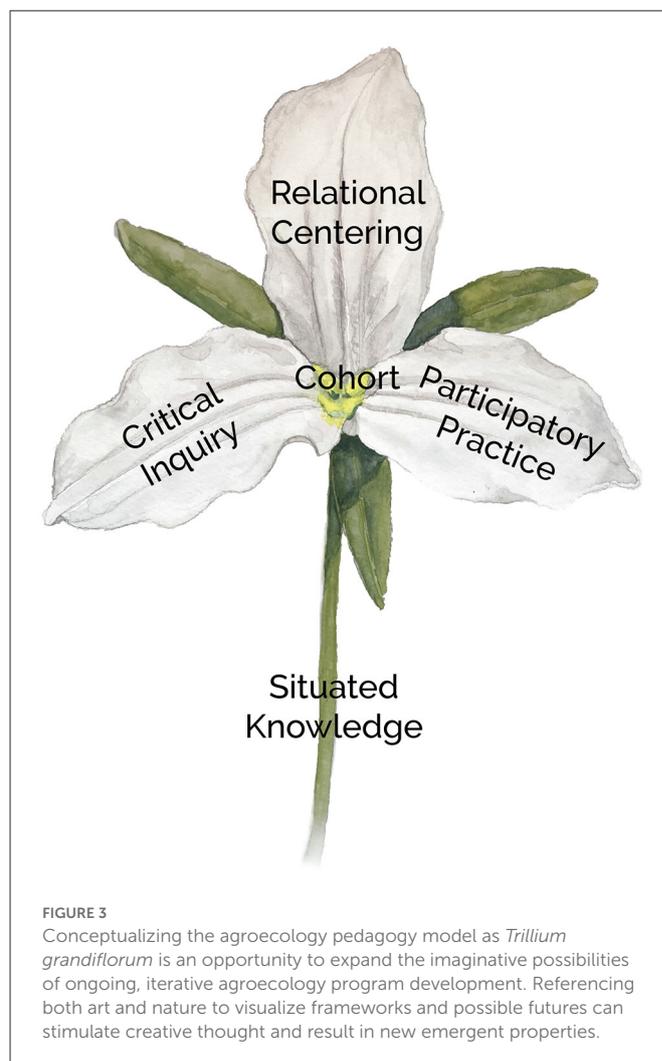
FIGURE 3
Conceptualizing the agroecology pedagogy model as *Trillium grandiflorum* is an opportunity to expand the imaginative possibilities of ongoing, iterative agroecology program development. Referencing both art and nature to visualize frameworks and possible futures can stimulate creative thought and result in new emergent properties.

specialized expertise within legible disciplinary boundaries (Boyer, 1997; Diamond, 2002; Bateman and Hess, 2015; Klein and Falk-Krzesinski, 2017). Identifying an institutional home that can support inter- and transdisciplinary work is also important. Prior scholarship has described programmatic challenges when faculty and courses are fragmented across multiple departments (Valley et al., 2018; Ebel et al., 2020), as well as bureaucratic challenges to share resources and coordinate incentives across departments (Russell, 2005; Carroll et al., 2014; Lawrence, 2015; Fiala et al., 2018). Finally, there will need to be significant work to develop strategies to coordinate and maintain the interconnected cohorts, including overcoming distrust from past histories of extractive university research (Cadieux et al., 2019), funding structures to compensate participants (especially community partners), and learning ways of being and knowing that can manage divergence (Casado et al., 2022).

The proposed pedagogy focuses on program epistemologies, but it is also necessary to articulate the desired student outcomes and identify the values from which epistemologies and outcomes emerge (Galt et al., 2012; Valley et al., 2018; Ingram et al., 2020). During the summer 2019 workshop series, we attempted to explore these aspects of pedagogical development through activities to identify "value-driven skill sets" (see Workshop 2 activity descriptions in Supplementary material). However, participants often struggled to

distinguish between skills and values (e.g., participants categorized listening as both a skill and value) or provided very general examples (e.g., "writing" as a skill for participatory practice rather than "writing partnership agreements"). These challenges indicated that our activities did not provide sufficient scaffolding for participants to engage in these conversations. Future efforts focused on articulating values and outcomes (and refining epistemologies) should also include partners from beyond the university. To develop structures for partners to inform program development, one example to consider is the pedagogical political coordination (PPC) groups for the IALAs in Central/South America and the Baserritik Mundura in Spain (McCune and Sánchez, 2019; Casado et al., 2022). Composed of people and organizations who partner with the agroecology programs, the PPCs "focus and work pedagogically on the worries, concerns or unforeseen events that arise in the group during the training process, trying to politicize the learning process as the course develops, as well as incorporating the questions and proposals for improvement that the participants suggest" (Casado et al., 2022). Including community partners in the program development process is an important step to ultimately create a program that can facilitate dialogue across multiple ways of knowing and reorient agroecology efforts in university agroecology education toward collective (territorial) needs.

We hope that the iterative and reflective process described above, as well as the proposed pedagogy itself, both serve as inspiration for other agroecologists to develop their own models for agroecology learning that are unique to their communities, their context, and their place. Through the process of writing this paper, our ongoing efforts to implement the pedagogy, and envisioning the next steps, our understanding of agroecological learning has continued to grow and deepen. We sought to visualize the proposed pedagogy (Figure 1) in a way that could incorporate future areas of development and reflected the joy we experienced while co-writing this paper, particularly as each of us transitioned to new roles, jobs, and places. Thus, we began conceptualizing the pedagogy as *Trillium grandiflorum* (Figure 3). Because *T. grandiflorum* is a perennial wildflower native to Minnesota, it is an image that reflects our place and collective identity. The three petals represent the main components—critical inquiry, relational centering, and participatory practices—while six stamens at the center of the flower represent the cohort, all supported by the stem, representing situated knowledge. *T. grandiflorum* spreads through underground rhizomes and grows in dense stands, representing both horizontal learning and building networks for collective action (Case and Case, 1997). It is slow to mature in the understory of deciduous forests, representing the need to "move at the speed of trust" (Brown, 2017) in relational centering, even as we face urgent challenges. Other relationships, such as the sun or water that nurture growth, could represent emotional support and hope. The EarthCare Framework for Global Justice, for example, uses a sun and rainbow to indicate healing, rain to encompass lessons from those most marginalized by current systems, and wind to represent hope (Gesturing Toward Decolonial Futures Collective, 2018). Other structures, such as the sepals to the broader deciduous forest ecology, could represent the broader institutional structures and conditions that support transformative learning. By using both art and nature for this conceptualization, we create space to continue imagining future possibilities in our ongoing work. Ultimately, "becoming agroecologists" (Lieblein et al., 2004; McCune et al., 2017) is a life-long pursuit, a commitment

to trying, failing, repairing, reflecting, and acting toward collective agroecological transformations within ourselves, academia, food systems, and beyond.

Data availability statement

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

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

All authors collaboratively developed, planned, implemented the summer 2019 workshop series, and contributed to writing and editing this publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2023. 770862/full#supplementary-material

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