

Teaching an interdisciplinary course in sustainable food systems: science and history meet in “a world that works”

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Abstract

Purpose – The sustainability of the global food system hinges on its environmental resiliency and safety, including the health and well-being of its labor force. Single disciplinary courses in liberal arts or science often fail to highlight the overlap between environmental and social vulnerabilities that lead to food insecurity and diminish the sustainability of food systems. This paper aims to present the design and delivery of a successfully co-taught, interdisciplinary module on agricultural labor and sustainable food systems as a case study.

Design/methodology/approach – The authors designed a co-taught module in which they joined each other’s respective history and science class sessions at the undergraduate business college where they teach. Innovating the cross-disciplinary content of food security, immigration status, labor exploitation and pesticide exposure, they approached sustainability from the disciplinary perspectives of labor history and environmental science to show how these elements had both unique and overlapping impacts across food systems levels. Comparisons between pre- and post-module survey responses, alongside assessments of a co-authored exam question, measured the effectiveness of this module in changing students’ perspectives as food consumers and as citizens.

Findings – This module altered students’ understanding and perspectives around issues of food systems sustainability. Assessments indicated that students increased their awareness of agricultural workers at the front end of the food system, during production; students also gained awareness beyond consumption as they came to see the connections between workforce invisibility and ecosystem degradation.

Originality/value – These insights are valuable to educators at all institutional levels who seek to collaborate on sustainability initiatives and teaching, both in the singular, robust modules and in building modules that will lead to the development of entire courses focused on sustainability. The module described here builds on previous demonstrations of the value, significance and effectiveness of cross-disciplinary collaborations; it pioneers the use of the food system as the link between social and environmental sustainability education.

Keywords Sustainability, Interdisciplinarity, Food systems, Labor history, Co-teaching

Paper type Research paper



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Introduction

Background and relevant literature

Colleges and universities are sites of research in sustainability and also serve as models for sustainability in communities. While experts formerly thought only of economic development as connected to unlimited natural resources—so that the economic, social and environmental dimensions of sustainability were seen as discrete and unconnected—new models exemplify the interconnectedness of economic, social and environmental sustainability (Amador and Oliveira, 2013). Scholars debate the competencies that might undergird sustainability's role in higher education and whether behavioral change can result from classroom teaching, comfort with ambiguity is just one component seen as an important strategy in sustainability education (Wals, 2011). Across the world, using diverse strategies, faculty and staff alike are integrating sustainability into colleges and universities (Disterheft *et al.*, 2013; Tilbury, 2011). Furthermore, these observations recognize the world-ready application of systems-thinking (Meadows, 2013) where society, the economy and the environment are all connected and impact the reasons sustainable decisions are made (Abson *et al.*, 2017).

Introducing sustainability into higher education

Previous research, models and reviews have identified different ways to introduce sustainability into college curricula. In degree programs across dozens of colleges and universities worldwide, as yet no universal text or set of requirements for what constitutes a sustainability degree exists (O'Byrne *et al.*, 2015). Thus, faculty innovate and experiment in when and how to teach sustainability, often exploring the topic through multiple disciplinary lenses. Faculty examined the benefits and challenges of creating an interdisciplinary, introductory-level sustainability course for students in all programs at the University of British Columbia (Coops *et al.*, 2015). A group of faculty at the University of Leeds analyzed the specific requirements and assessments used in designing a novel course required for all students working toward the BA in Environment and Business to prepare them to be “sustainability change agents” in the business world (Lozano *et al.*, 2014). This course, which links sustainability with organizational change management, represents a department-wide effort to incorporate sustainability into a degree program that will reach a portion of the university's students.

Similarly, through a National Science Foundation grant, James Madison University used Bloom's Taxonomy to integrate the multiple contexts of sustainability (economic, social, environmental and technical) across different programs within the School of Engineering; this group of faculty took advantage of students' having common course requirements to continue to develop their systematic incorporation of sustainability (Pappas *et al.*, 2013). James Madison's examples, in particular, highlight the “negative consequences of the common single-discipline model” in sustainability education, arguing for a fuller integration of sustainability into all curricula via multiple disciplines (Pappas, 55). Other research investigates the innovative, interdisciplinary, sustainability teaching in discrete modules. After a module on the clothing industry at the University of Auckland in New Zealand, chemistry and psychology students showed increased knowledge of the environmental and scientific impacts of the industry, as well as a change in materialistic values and habits of clothing consumption (Harré *et al.*, 2020).

Introducing food systems into higher education

This paper incorporates research into the value of interdisciplinary food systems curricula in higher education (Hilimire, 2016). This model recognized the lack of socio-cultural

connections to food systems taught in traditional and sustainability-based agricultural programs. By recognizing the importance of experiential learning paired with disciplines including political and agroecology in addition to community development, a sustainable food system was recognized as more than just the agricultural aspect and highlighted the similarities and differences across regional and global food systems. Scholars have explored the many intersections of sustainable food systems with campus life, for example, both in terms of curricula and with issues such as the impact of student food insecurity on campus (White, 2020).

The concept of food security is drawn from the United Nations Sustainable Development Goals, 17 precepts agreed upon in 2015, designed as a blueprint for sustainable development for all nations; they call for an end to poverty and conflict and for protection of the planet (UN, 2015). Sustainable Development Goal 2 (SDG2) focuses on “zero hunger,” with the promotion of food security and sustainable agriculture as a means to that end. Scholars have examined the role of universities in working toward all SDGs (Neary and Osborne, 2018; Owens, 2017). They have also studied SDG2 and its diverse intersections with agriculture (Juliana Dias *et al.*, 2019), diet (Fanzo, 2019), gender equality (Agarwal, 2018) and climate change (Mugambiwa and Tirivangasi, 2017), to name but a few. The idea of incorporating UN sustainable development objectives into higher education was reviewed before the SDGs were developed (Wals, 2014). This paper offers a close examination of one effective interdisciplinary module on sustainability, food security and food systems and incorporates it into higher education. It presents curricular materials and evidence of the efficacy of the curriculum on changing students’ views. As faculty innovate how to address issues of sustainability on campus, this paper offers a model not only of curriculum planning but of curriculum planning that draws from two disciplines—history and science—whose intellectual intersections are most often overlooked.

Sustainable food systems: from production to consumption

A sustainable food system has many different meanings and must encompass stability in food production, food distribution and food access while minimizing food waste. As the world population continues to grow, producing enough food responsibly and without cruelty, ensuring that it is equally distributed, protecting the humanity and human rights of its producers and minimizing the use of diminishing natural resources are becoming more important focal points in the sustainable intensification movement (Godfray *et al.*, 2010; Tilman *et al.*, 2011). Considering the multiple dimensions of the food system highlights how there is not one universal problem within the food system that must be fixed to make it sustainable. Environmental, social and economic assessments must be performed to balance yield versus environmental consequences, agricultural labor health and well-being and economic availability of food for all people across the world. Analyzing sustainable food systems from production to consumption requires a cross-disciplinary approach so as to teach students who are oftentimes removed from most of the steps outside of their interaction with food in grocery stores, dining halls, restaurants and delivery systems.

Food security

The United Nations Principles for Responsible Management Education (UN PRME) sustainable development goals (Haski-Leventhal and Concato, 2016), the Food and Agriculture Organization (FAO) definition of food security (Jones *et al.*, 2013) and a *Science* article by Godfray *et al.* that has been cited over 6,000 times, as its publication entitled “Food Security: The Challenge of Feeding 9 Billion People” (Godfray *et al.*, 2010) contextualize what it means for a food system to be food secure. Globally, societally or individually, when

safe and nutritious food is consistently available and accessible at all times, the population has food security. When one or more of these aspects is lacking, the population is considered food insecure. A lack of money (accessibility), a disruption in supply (availability), a lack of variety and sanitation (utilization) or a conflict or natural disaster in a specific region (stability) all impact food security.

Production (including harvesting and processing)

Food production includes growing or raising, harvesting and processing food to prepare it for eventual distribution. Food encompasses both plants and animals and is often measured in terms of yield with goals to close the yield gap by addressing a host of limiting and reducing factors (Mueller *et al.*, 2012). Diversified and industrialized farming practices require different maintenance strategies that use a variety of inputs and resources (e.g. land-use changes, fertilizers, water through irrigation) and produce outputs in addition to yield (e.g. greenhouse gas emissions (GHGe), nutrient runoff, medical consequences that range from acute to chronic) (Pretty, 2007). These practices affect the ecosystem in which they are grown (deforestation, monocultures and loss of biodiversity, eutrophication), the workers who grow, harvest or process the food (agricultural laborers in the field or meatpackers in the processing plants) and people in surrounding communities who may directly or indirectly come in contact with contaminants (such as fertilizers or pesticides in drinking water or air, antibiotic-resistant bacteria on crops or in water).

Consumption (including preparation, points of sale and waste)

Following packaging, food is distributed to grocery stores for direct sale to consumers or buyers for restaurants, where the food is prepared prior to consumption by consumers or restaurant workers. Farms are affiliated with different supply chains and distribution systems to move food from the production to consumption stages of the food system. While food loss occurs at the front end of the food system during the production and processing stages, food waste occurs upon the entrance of food into these points of sale and beyond (Lipinski *et al.*, 2013). At this point, consumers choose which foods they will eat and indirectly, which farming practices they support. However, the information that informs these choices—regarding farming practices, pesticide use and working conditions—lacks consistency and even clarity. Within grocery stores, products may be marked with approved labels indicating they have been certified to be grown or harvested using practices considered organic, certified as fair-trade or approved by the Rainforest Alliance, as examples. Otherwise, consumers are largely uninformed about how their food was grown and raised and how the agricultural workers were paid or treated. While farmers' markets look to offer more information, the amount of food consumers purchase through this point of sale remains extremely low (Stewart, 2018). The same holds true for restaurants. Saru Jayaraman's *Behind the Kitchen Door* outlines the abuse, inequality, low wages and the misappropriation of tips experienced by restaurant workers but largely unseen by consumers (Jayaraman, 2013). Jayaraman labels this exploitative system "unsustainable."

From production to consumption, therefore, there is a disconnect between how food is produced and how consumers are led to think about it. The treatment of agricultural workers, truckers, meat processors and restaurant labor is largely and pointedly invisible to the consumer, leading to narrow and inaccurate understandings of what comprises a truly sustainable food system. These observations readily support the need for incorporating science, history, economics and other disciplines into defining a sustainable food system.

A world that works module

In evaluating the many approaches to teaching systems-based sustainability in higher education and recognizing the wide-ranging characteristics that comprise a sustainable food system, the “A World that Works” module bridges the gap between consumers and their food in a way that leverages the importance of both history and science disciplines. Individually, a historical approach might focus singularly on the labor force used to bring food to populations, including enslaved, indigenous and Black laborers prior to the Civil War, European and Asian immigrants in the early 20th century and the undocumented and H-2 visa immigrant Latinx workers of today. These labor systems were largely un- or underpaid, unprotected and unregulated. Students would learn about agricultural exceptionalism, the full absence of workers’ protections such as minimum wages, workers’ compensation and overtime, for farm workers (Rodman *et al.*, 2016) after the Great Depression’s New Deal workers’ rights reforms and indeed into today.

A scientific approach might focus on the environment and connect all of the resources (e.g. land, water and nutrients) and land-use changes (deforestation, overfishing, nitrogen runoff, GHGe) to built-in resilience to year-to-year fluctuations in yield. Both highlight how these topics are vital to a sustainable food system, but they miss the connection. The collaboration that produced the module described in this paper takes seriously the idea that faculty can and should serve as sustainability champions and those sustainability initiatives that “empower and strengthen many programs”—in this case, crossing the disciplinary boundaries of history and science—will gain widespread support (Clugston and Calder, 1999). Bill McKibben, founder of 350.org, a giant in the world of climate change activism, endorsed by the Labor Network for Sustainability by offering the following quote from which the name of the module was chosen: “We need a world that works, in every sense of that word, but it can’t work unless we pay attention to both what science demands and what regular people need.” In this module, students learn specifically about the abridgments of human and labor rights in the working lives of agricultural laborers, as well as about the application of pesticides in industrialized farming. These lessons highlight how agricultural labor and the environment are both impacted and they make students more aware of what happens to their food before it reaches their plate; as consumers, then, they are able to evaluate the sustainability of the practices that bring the food to them.

Methods*Course background*

Professors from two disciplines, history and science, developed a co-taught module to be delivered to their two courses (history: “Working in America” and science: “Case Studies in Sustainable Food Systems.”) In “Working in America,” a modern US Labor History course, students analyze how racism, sexism, ableism, immigration status and other forms of discrimination offer ways for US employers to pit workers against each other, ultimately relying on a new group to exploit when workers make demands for rights and resources that will ensure their access to a better quality of life. In “Case Studies in Sustainable Food Systems,” students analyze the food system from production through consumption and waste. By considering the present and the future, developed versus developing countries and the environmental impacts of agriculture, students understand the drivers of food security that affect our ability to feed a growing world population. A flowchart outlining the population and module design, data collection and analysis methodology and conclusion can be found in [Figure 1](#). It is detailed in the text below.

Undergraduate students from a U.S. Labor History or Sustainable Food System science course at a business college were co-taught a module linking together agricultural labor working conditions and practices by history and science faculty over three class sessions. The module explored food security, pesticides, demographics, and the disconnect with consumer related food movements.

Class Session & Objective	Readings	Assessment
1 – Intersections of sustainability, food security, and labor	Why Food Security is a Global Farmworker Issue (Held, 2018)	Word Cloud Exercise Report out on food organizations
2 – Systematic Disconnect in Food Movements	Farm to Table May Feel Virtuous (Reusing, 2017) AND <i>Public Health, Immigration Reform, and Food System Change</i> (Fitch et al., 2017) OR Labor and the Locavore (Gray, 2014) AND <i>Human Exposure to Pesticide Drift: Washington State Report</i> Ford et al., 2017)	In class discussion re: questions in Table 1. Share findings after search of social media for food-based topics.
3 – End of Module Food Label Design	Watched "Food Chains" before class	Review CIW's Fair Food Program Label Design Assignment
Data Collection		
<ul style="list-style-type: none"> • Pre-module Survey (n=92; see Table 2 Q1 & Q4) – completed before co-taught classes began • Post-module Survey (n=71; see Table 3 Q2 & Q3) – administered following final class and completed within 3 days • Midterm Exam Question – administered one week after co-taught module concluded 		
Data Analysis		
<ul style="list-style-type: none"> • Survey results for the same questions were averaged together across all classes and evaluated via a two-tailed Student's T-test and Cohen's d for student responses before & after the module. • Exam responses were evaluated to determine how many social (immigrations status, leverage and workers' rights, low wages, and legal and government protections) or scientific (pesticide exposure, protection and training, and medical conditions) components were included. 		
Conclusions		
<p>Students' perspectives shifted re: the role of agricultural workers and pesticide use as it related to their decision making as consumers, regardless of their original background.</p> <p>Students' perspectives did not shift re: food system content we did not cover in this module, which highlights specificity of focus and a need to better integrate environmental and labor components with consumer behavior.</p> <p>Exam responses did mention both social and scientific components, but leaned toward highlighting more social issues, likely due to the way the question was communicated where the science component answered the question but was not the obvious response.</p>		

Figure 1.
Module design and materials

Module setup background

"A World that Works" aimed to emphasize both environmental and social sustainability in agricultural food systems by highlighting that exploitation exists in both labor and the environment during the growing, harvesting and distribution of food. To show that these two concepts were intricately linked, content topics were identified and co-teaching was used to align the material across three classes with associated class readings. In-class activities were designed and used to link the module to the current, independently taught courses.

The developed module resulted in co-teaching three consecutive 95-min class sections (two sections of Case Studies in Sustainable Food Systems with 28 students per section and two sections of Working in America with 20 students per section). Classes meet twice per week, so the module spanned one and a half weeks of our courses. Based on scheduling, co-teaching occurred first in a class with food systems students only; the second section consisted of students from the food systems and the labor history class; the third section was made up solely of students in labor history. This first iteration of the module

experimented with teaching space, styles and logistics in terms of teaching students exclusive to either class or by combining students enrolled in both classes. All student feedback was in this way refracted through different lenses, assessing the impact of the module on student learning when standalone classes were taught by an additional faculty member as opposed to when students sat side by side in a mixed classroom, taught by both faculty members.

Module design and learning objectives

The module's broadest goal was to help students understand that in addition to the conventional narrative that "growing economies" create jobs, these economies can and do also contribute to the growth of poverty, inequality, community disintegration and environmental degradation. Focusing on food systems from the vantage point of labor and science, students came to define sustainable food systems as those that are, as the Alliance for Sustainability terms them, "ecologically sound, socially just, economically viable and humane" (Alliance for Sustainability, 2017) and highlighted the gaps within our current local and global food systems in accomplishing this goal.

A *World that Works* offers students a clear case in which real-world examples incorporate aspects from multiple core courses required for graduation and combines them into one module co-taught by professors within their respective fields. This three-class-session module integrated sustainability, ecology and labor history into an exploration of current food and health insecurity among agricultural workers in the USA (Ziegler, 2004). *A World that Works* accomplishes its objectives by meeting the following three learning goals:

- (1) Students will gain a broader, systems-based perspective on the food system workforce, thinking about workers' roles beyond those with which they typically interact as consumers or that they might occupy (in part- or full-time jobs, e.g. cook/host/server)—and be able to visualize and describe the demographics, working conditions, quality of life, immigration status and exploitation of the agricultural/food workforce.
- (2) Students will gain a systems-based perspective on the role of pesticide use in agriculture: they will understand its usage to increase crop yield while also thinking about its impact on the health and safety of farmworkers and that of the broader ecosystem; they will be able to identify the significance of methods, timing and location of pesticide application on human and ecological health.
- (3) Collectively, therefore, students will gain insights into the complexity and interconnectedness of science, history, human rights, social justice and innovation as these relate to creating a sustainable food system.

The module aimed to integrate the impacts of agricultural decisions from social, environmental and economic perspectives to highlight that there is no single solution that could make the food system sustainable across these three aspects of the community. Class session 1 examined the individual components of food security as they related to people inside and outside the agricultural workforce. Class session 2 studied numerous existing food movements and highlighted their disparate focuses, especially the fact that they do not include labor and are not systems-based in their approaches or missions. Class session 3 reviewed the visuals provided in the documentary *Food Chains* and encouraged students to design a systems-based food label that integrated human and environmental well-being.

Class one: intersections of sustainability, food security and labor

The *A World that Works* module began with a brief slide deck that illuminated how the courses would intersect for the three classroom sessions. This slide deck worked to show students how their two individual courses were connected around all aspects of food production and consumption. The slides explained food security, linking it to the need for sustainable wages and workplaces in making the food system sustainable. The conclusion of this component of the first-class noted that the module represented both a *critique* and a *corrective*: the group critiqued both the dearth of consideration given to labor in environmental science discussions of sustainability and of science in labor considerations of the same. The module would be corrective in encompassing a comprehensive and ambitious series of lessons on both labor and the environment.

The in-class reading included “Why Food Security is a Global Farmworker Issue” from *Civil Eats* (Held, 2018). Students researched the organizations highlighted in the article such as the Food Chain Workers Alliance and WhyHunger and explained their connections to labor, food security and/or sustainability. Students talked about how these labor organizations rarely address environmental issues, instead of focusing on issues of justice for workers such as access to health-care, livable wages and decent housing. Held’s article itself mentions pesticides briefly in a way inconsistent with the depth that would be provided in a science class, which guided the development of class two. These deeper explorations of the impact pesticides have on both the ecosystem and agricultural workers highlights the need for science and labor scholarship to join forces.

Class two: systematic disconnect in food movements

The second class of the module focused on evaluating the motivations for different food movements that exist across the country. These movements are growing as people pay increased attention to the food they consume, where it comes from and its impact on our health: from the keto diet to GMO-free to eating only cage-free and grass-fed animal products to the farm-to-table movement. Social media plays a large role in this, especially the many Instagram accounts that show pictures of different products consumers are about to eat with diet, production or nutrition-related hashtags. Essentially, these movements focus on the relationship between consumers and their food, putting a series of gaps on display: between the individual food movements and the agricultural labor responsible for producing the food and between the food movements and the environmental impact of growing the food. Students connected this to the module’s first reading on global farmer workers and its near-exclusive focus on the workers who grow and harvest food.

Highlighting this juxtaposition of consumer health and the dangers faced by agricultural labor, the students’ subsequent readings evaluated the major focal points of farm-to-table (Reusing, 2017) and locavore (Gray, 2014) movements. They also read public reports (Fitch et al., 2017; Ford et al., 2017) that outlined conditions laborers experienced on the farm and the abridgments of their human and labor rights.

In class, students responded to a set of questions on a slide (Table 1) that they could answer alone or with a partner. Several of the questions asked them to assess the evidence internal to individual articles, while others asked questions that encompassed all of the readings. One question, for example, asked if farm-to-table restaurant offerings were all organic or if the chefs in those restaurants collaborated with farmers to prepare menus. Another question had them rank the people who were “most harmed by pesticide use in the food system.” Questions such as these helped them move toward understanding that most of the food movements operate in isolation from each other and that it was extremely rare for any to consider the workers who harvested the food. The final question tapped into a significant theme, that of “potential

Table 1.
Questions presented
to students in class
during Day 2
discussion

Question 1	Which of the following statements about the farm to table and locavore movements is TRUE? <i>Please explain why the others are false</i> a) <i>All of the food with this label served in the restaurant or sold in the market is grown organically</i> b) <i>The food and recipes provided in the restaurant/market are authentic to the region</i> c) <i>The farmers work together with the chefs to plan and prepare the daily offerings</i> d) <i>All of the food is grown within a set distance from the restaurant/market</i> e) <i>These movements have become more idealistic and expensive and moved away from the original objectives</i> f) <i>They are all false</i>
Question 2	Who is MOST harmed by pesticide use in the food system? <i>Explain how each is affected</i> a) <i>Farmworkers who manually mix or apply the pesticides to the crops</i> b) <i>Farmworkers performing activities that do not require mixing or applying the pesticides</i> c) <i>Consumers who eat the food treated with pesticides</i> d) <i>Farmworkers, their families and the community located nearby to farms that apply pesticides</i>
Question 3	Q3 What food movement did you read about? Identify three of the author's critiques of this movement. What does the author criticize about the movement and why?
Question 4	Compare and contrast the focus, ideas and data outlined in the first article with those of the second article: a) How do the two pieces support or contradict each other? b) What does each offer us in looking at the sustainability of our food systems by examining labor and/or the environment?
Question 5	What proposals do these authors have as potential remedies to the problems they present? Why do you think they would work based upon the data you read? What might be the barriers to their implementation?

remedies to the problems presented.” It was important that the module emphasized both the problems and potential solutions. Solutions posed by the articles included: greater state regulation, paths to citizenship for undocumented workers and the extension of job protections to these “excepted” categories of the US workforce.

The follow-up assignment after this class asked students to search social media accounts to evaluate the focus of a consumer-oriented food topic that interested them (e.g. genetically engineered, vegan, vegetarian, pescatarian, flexitarian, avoiding gluten or dairy, following the paleo or keto diets, only eating organic). In searching social media, students were asked to evaluate 10 different posts to determine if those posts discussed a scientifically/medically supported theme, a labor/society related theme and/or a food systems related theme (i.e. multiple topics were covered).

Class 3: end of module food label design

Before the third and final session of the module, students watched the *Food Chains* documentary produced by Eric Schlosser and Eva Longoria in 2014 ([Schlosser and Longoria, 2014](#)). The film focuses on the Coalition of Immokalee Workers (CIW), a courageous group of tomato pickers in Florida who united to fight for decent living conditions, treatment and wages for farmworkers and “a more humane, transparent food chain.” The CIW works to alert consumers to the living and working conditions of those who harvest tomatoes and to target many large corporations to remove the intentional obfuscation of the origins of food to reap terrific profits. Fast-food chains and grocery stores alike pledged to buy only from CIW’s Fair Food Program, which cost consumers only pennies more than they paid prior to enrollment in the program. The program meant agricultural workers earned closer to a living wage and that

mechanisms were in place for reporting sexual harassment, a widespread problem in the industry. The documentary interviews workers show their living conditions and follow the CIW members in their attempts to sign Publix Supermarkets to buy only CIW tomatoes. As of this writing, Publix still refuses to sign on.

Class discussion that day began with an analysis of the following quote from our readings:

“We talk about labor, we talk about food, we talk about housing, we talk about water, we talk about the environment – and increasingly we’re understanding that these are all deeply, deeply interconnected” (Held, 2018).

Students examined CIW’s Fair Food Program and their food label (located on the CIW homepage: www.fairfoodprogram.org), which states “Consumer Powered, Worker Certified” (Fair Food Program, 2011). They compared the portrait of the worker on the CIW label with other food labels such as the “Sunmaid Girl” (the icon for Sunmaid raisins) and Organic Valley Milk. Students responded to the following questions: How do these brands perpetuate/reinforce the invisibility of the labor of food systems? And how does the Fair Food Program icon work to counter that invisibility? They discussed issues of power and partnership, race and gender.

To assess the collective assimilation of all three class sessions combined with the food label discussion, students were asked to design a label for a product that made clear the product was produced and grown responsibly, integrating all the factors we discussed in this module: people/earth/health, food insecurity and labor visibility. Students were encouraged to use images and text, explaining how the label would be helpful to consumers who might buy their products. They also had to explain, explicitly, how the label they produced met these guidelines. The bulk of the class time was dedicated to having students design their labels and then post them around the room. During the last part of the class, students presented their labels to each other. The students worked in groups of 4 and in the combined class 2 students from each course comprised each group.

Surveying student’s perspectives

The learning objectives show that this module was designed to introduce students to new ways of thinking about labor across the entirety of the food system. To assess the success of the module, data needed to be collected both prior to starting the module and after the collaborative teaching to assess whether or not the module changed students’ thinking about labor across the food system. The survey measured the perspectives and thinking that inform their behavior while not measuring behavior.

Students received a pre-module survey one day before the module began and a post-module survey one day following its completion (see [Tables 2](#) and [3](#) for complete survey questions). Both surveys asked a series of questions related to what factors students consider when purchasing and consuming different foods and how much they think about the workers involved at each step responsible for bringing the food to their plate.

The survey responses to the questions asked before and after the module provided a starting point to evaluate whether or not students changed their evaluation of where labor fits into the food system (i.e. everywhere, even if consumers do not necessarily see it until the food gets on their plate or in their grocery cart). Two specific questions were asked both prior to and immediately following completion of the module. Question 1: “Use the scale (1 = always, 2 = frequently, 3 = sometimes and 4 = never) to answer the question: When you make dietary choices, how often do you consider each of these components?” The components included labor practices, environmental impact, treatment of animals, the

Table 2.
Pre-survey questions

Question 1	Please use the following scale to answer the question below. 1 = always 2 = frequently 3 = sometimes 4 = never When you make dietary choices, how often do you consider each of these components? labor practices of those involved in the food systems that brought you the food [a] the environmental impact of the food (chemicals used, transport's carbon footprint, packaging, etc) [b] treatment of animals that are ingredients in the food [c] nutritional content of the food [d] whether or not GMOs are in an ingredient in the food [e] gluten content of the food [f] whether or not the food was grown with organic practices [g] other [h]
Question 2	How would you describe agricultural and food service workers' access to food? Greater than the average person Less than the average person Equal to the average person
Question 3	Have you encountered information about the sustainability of food systems agriculture and labor? Please indicate (Y)es or (N)o for each prompt. For others, please elaborate if it is relevant. from media [a] from religious/cultural institutions [b] from family and friends [c] from middle/high school [d] from college classes [e] from restaurant/grocery store [f] from food labels [g] other [h]
Question 4	Please use the following scale to answer the question below. 1 = always 2 = frequently 3 = sometimes 4 = never As you are consuming food (that you cooked/ordered), how likely are you to think about the workers responsible for each of the following steps? those who grow/harvest the food [a] those who transport the food to a processing plant or grocery store [b] those who process the food for it to be sorted, cut up and or packaged [c] those who order and stock the food to be displayed in the store or used in the restaurant [d] those who cook the food and serve it to you at a table in a restaurant [e] those who cook the food before packaging it for shipping [f]

nutritional content of food (including GE or gluten ingredients) and if it was grown using organic practices. Question 2 asked the students to use the same scale to answer the question "As you are consuming food (that you cooked/ordered), how likely are you to think about the workers responsible for each of the following steps?" The steps included growing/harvesting the food, transporting the food, processing/packaging the food, ordering or stocking the food in grocery stores or restaurants or delivering/serving the food. Results were averaged together across all classes and evaluated via a two-tailed Student's T-test and with Cohen's d to evaluate the effect size, given a large number of responses.

Additional pre-module questions asked students where they may have heard about agricultural labor and the relative food security of agricultural laborers to other workers. The post-survey questions asked specifically about the individual texts, class assignments and the overall effectiveness of the module.

Assessing student comprehension through a common exam question

As a result of co-teaching this module prior to the middle of the semester, midterm exams for both classes included a common essay question, which was analyzed to assess student comprehension of the connectedness between environmental and social sustainability.

The question read as follows:

When we discussed the fragility of the US food system, we identified agricultural workers as particularly vulnerable and food insecure. According to the FAO, a population has food security "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life." This question has two parts: First, describe two ways in which these workers are vulnerable and food insecure; second, argue that this vulnerable and food-insecure status contributes to their poor working conditions. Make these connections clear.

Question 1	Which course are you enrolled in for this semester? NST2040 case studies in sustainable food systems AMS4672 working in America: labor in the USA since 1892
Question 2	Please use the following scale to answer the question below. 1 = always 2 = frequently 3 = sometimes 4 = never When you make future dietary choices, how often might you consider each of these components? labor practices of those involved in the food systems that brought you the food [a] the environmental impact of the food (chemicals used, transport's carbon footprint, packaging, etc) [b] treatment of animals that are ingredients in the food [c] nutritional content of the food [d] whether or not GMOs are in an ingredient in the food [e] gluten content of the food [f] whether or not the food was grown with organic practices [g] other [h]
Question 3	Please use the following scale to answer the question below. 1 = always 2 = frequently 3 = sometimes 4 = never As you are consuming food in the future (that you cooked/ordered), how likely are you to think about the workers responsible for each of the following steps? those who grow/harvest the food [a] those who transport the food to a processing plant or grocery store [b] those who process the food for it to be sorted, cut up and or packaged [c] those who order and stock the food to be displayed in the store or used in the restaurant [d] those who cook the food and serve it to you at a table in a restaurant [e] those who cook the food before packaging it for shipping [f]
Question 4	Please use the following scale to rate the individual components of each of our joined class sessions. 1 = great 2 = good (closer to great than poor) 3 = fair (closer to poor than great) 4 = poor Class one: Intersections of sustainability, food security and labor Introductions to Food Security and Labor History [a] Text: "Why Food Security is a Global Farmworker Issue" from Civil Eats [b] In-class Exercise: read about the organizations highlighted in the article and explain their connections to labor, food security and/or sustainability [c] Class Two: Class two: Systematic Disconnect in Food Movements (only rate the two you read in class) Text: Reusing, "Farm to Table May Feel Virtuous" [d] Text: Johns Hopkins, "Public Health, Immigration Reform and Food System Change" [e] Text: Gray, "Labor and the Locavore" [f] Text: "Human Exposure to Pesticide Drift, Washington State Report" [g] In-class discussion: critiques of food movements, analysis of pesticide use, connections between labor and the environment [h] Class three: Making a World That Works In class assignment – label design for responsible food production [i]
Question 5	On a scale of 1 to 10 (with 10 indicating the highest level) rate how effective this three-course module was in enhancing your knowledge of your course subject, either sustainable food systems OR US Labor History
Question 6	Explain your rating for Question 2
Question 7	The most effective component/aspect of this module was:
Question 8	The least effective component/aspect of this module was:

Each student response was evaluated for the presence of seven components that fell within categories that were social (immigrations status, leverage and workers' rights, low wages and legal and government protections) or scientific (pesticide exposure, protection and training and medical conditions). Responses were tabulated for US Labor History and Sustainable Food Systems students and assessed based on whether students provided single response groups or if their responses included both categories.

Results

Survey response results

The students' responses to the two questions asked on both the pre- and post-module surveys are shown in [Table 4](#) (termed Question 1 – it represents the first question asked in the pre-survey and the second question asked in the post-survey) and [Table 5](#) (termed

Question 2 – it represents the fourth question asked in the pre-survey and the third question asked in the post-survey).

The results for Question 1 (Table 4) clearly show that student responses regarding whether they consider labor practices when making dietary choices changed most significantly. Before the module, students' average response rates equaled 3.33, meaning they considered these components somewhere between "sometimes and never"; after the module, students used the value of 2.41, which showed that their responses were more likely to occur within the "sometimes and frequently" range. Students also showed significant changes in their consideration of environmental impacts and the treatment of animals. No notable change in students' decision-making processes as a result of this module was observed regarding the nutritional content of food, whether it contained GE ingredients or gluten or if it was raised organically.

The results for Question 2 (Table 5) demonstrate that student responses regarding when they think about food system workers changed almost across the board – from growing and harvesting food through processing food. All significant responses changed from "sometimes and never" (3.12–3.58) to "sometimes and frequently" (2.24–2.70). The only response that did not change related to thinking about the food systems workers who cook or serve the food – this remained within the always range (1.99 before, 1.86 after the module). Students showed the greatest awareness of workers who grow and harvest the food they are consuming following completion of the module.

Food label design results

The student assignment creating food labels that represented environmental, social and economic issues associated with food production, environmental impacts and quality of life for farmworkers evidenced how students tried to demonstrate their mastery of the complexity of these relationships. Representative labels, below, highlight the range of conclusions students drew from the assignment prompts following the three-day module. A broad review of the labeling exercise displayed the different levels of effectiveness the

Table 4.
Survey response
results (dietary
choice
considerations)

Dietary choice considerations	<i>n</i>	Labor practices	Environmental impact	Treatment of animals	Nutritional content	GE ingredients	Gluten content	Organic
Pre-module	92	3.33	2.95	2.84	1.61	3.02	3.47	2.72
Post-module	71	2.41	2.31	2.21	1.59	2.76	3.29	2.37
% Increase in consideration		27.6%	21.6%	22.1%	1.1%	8.6%	5.2%	12.7%
<i>p</i> -value (two tail)		5.4E-13	2.1E-05	3.1E-05	0.88	0.05	0.16	0.02
Cohen's D		1.27	0.70	0.67	0.02	0.31	0.23	0.39

Table 5.
Survey response
results (think about
food system workers)

Think about food system workers	<i>n</i>	Grow/harvest	Transport	Process for packaging	Order/stock	Cook/serve	Process for delivery
Pre-module	93	3.18	3.58	3.39	3.24	1.99	3.12
Post-module	70	2.24	2.63	2.51	2.70	1.86	2.38
% Increase in consideration		29.5%	26.6%	25.8%	16.6%	6.6%	23.6%
<i>p</i> -value (two tail)		2.8E-12	6.0E-13	2.8E-11	2.9E-05	0.29	1.5E-07
Cohen's D		1.24	1.29	1.14	0.69	0.17	0.88

module had in the three-class sections, as the group assignment included students with one or combined backgrounds—in Labor History and in Sustainable Food Systems.

The labels completed by students in the course section comprising history and science students taught together emphasized both social and environmental connections in greater frequency than the labels produced by students taught the module in exclusive science or history classes. Students with either a science or history background who worked together after taking the module in the combined class tended to present both labor and earth focus on their labels (Figure 2A). The science students who learned the module without labor history students alongside them took a much larger systems view: their label looked both at environmental production and a respectful relationship between farmers and distributors (Figure 2B). Connecting people and ecosystems, this label incorporated labor, making clear that responsibly grown food does not just focus on the earth. Perhaps, predictably, students taught the course alongside only other history students designed labels that were skewed more toward a labor focus than a combined environment and labor/food systems focus. In the class with just labor history students, the representative label shown in Figure 2C shows how students used the term “equitably grown” with a picture of hands and grapes to highlight the societal and environmental impacts of food production. The image shows the product of the land (the grapes) within the visible hands of the workers who harvested them, which may indicate a greater visual focus on the social and employment aspects.

Exam question response results

In reviewing student responses to the exam question (Table 6), history and science students used similar numbers of components in their responses to the question (3.85 versus 3.87, respectively). Students most frequently mentioned (greater than 50% response, Figure 3) low wages, leverage and workers’ rights, immigration status and medical conditions. In addition to being covered in class discussions and readings, these components were brought to life in the film and other sources. Although not all students connected pesticides to illnesses, they were able to demonstrate a basic understanding that farmworkers’ hard work, alongside their difficult working and living conditions, made them sick.

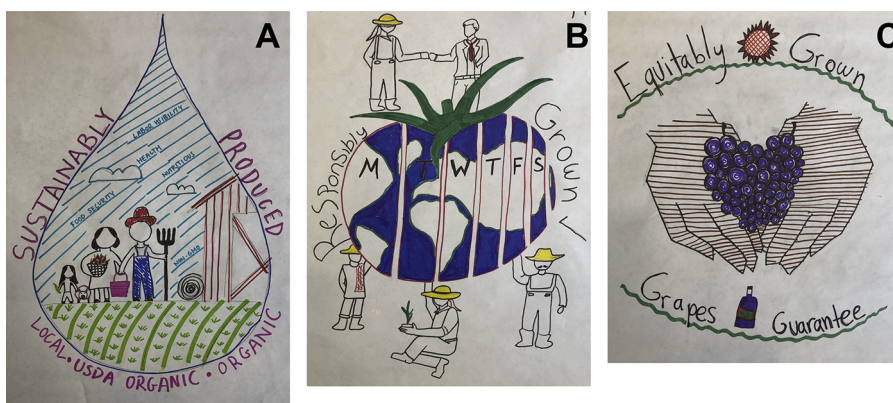


Figure 2. Representative student created food labels to highlight the intersection between environmental and social factors that consumers should consider when selecting their food. A was created by a team of history and science students, B was created by a team of science students, and C was created by a team of history students

Furthermore, after the module, the vast majority of history and science students displayed a comprehension of social and scientific contexts in nearly equal amounts (64.1% and 63.0%, respectively) (Figure 3). Collectively, these responses showed a basic understanding of the lives and working conditions of the people who grow/harvest our food and highlighted the interconnectedness of the social and environmental issues involved in food production.

Student perception results

The two farm-to-table readings were generally received as being too critical of a movement that had numerous positive features regarding environmental health, community development, small business success and a clearer outline of where food was grown (data not shown, results from post-class survey). Students recognized the increased cost associated with the farm to table movement but did not observe that cost as going back to the agricultural workers. While the original aim of this part of the module looked to highlight the poor working conditions of agricultural laborers by showing their absence in many of the most predominant food movements, the approach taken was found not to be systematic in observing what the movements do well and what they could improve upon. The other set of readings, the public reports, were generally well-received and clearly laid out the dangers of agricultural workers' exposure to pesticides, the general lack of personal protective equipment, scheduled applications and clear instructions in spoken languages. At the end of this discussion, students realized that concerns about pesticides on their food (for them, as consumers of the food) will result in significantly less exposure for them than it would for the workers who are around these chemicals every day in the fields. The social media assignment validated these results as it highlighted the linear nature of many of the latest diet or food trends that miss opportunities to provide more reasons for supporting one

Table 6.
Student responses to an exam question

Exam question: student responses	Mean social factors (of 4)	Mean science factors (of 3)	Mean total factors (of 7)	% students who included both social and science factors
<i>History students (n = 39)</i>	2.49	1.36	3.85	64.1
<i>Science students (n = 54)</i>	2.72	1.13	3.87	63.0
<i>All students combined (n = 93)</i>	2.62	1.23	3.86	63.4

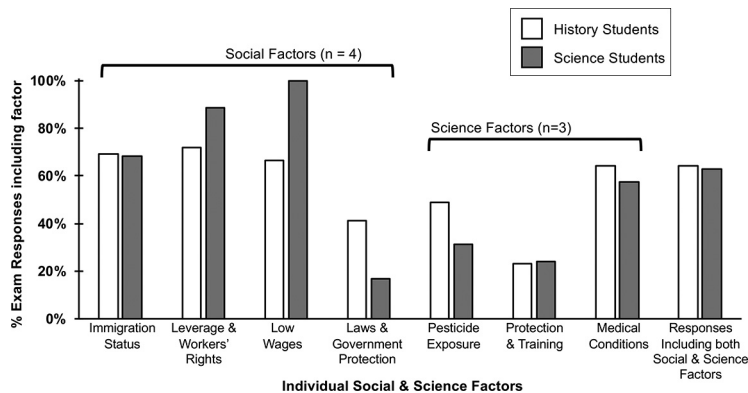


Figure 3.
Individual social and science factors

type of diet or another; they focused largely on consumption with little to no focus on what happens prior to consumption and the impacts agricultural workers and the environment face as a result of food production methods.

Discussion

Overall, the experience of co-teaching this module was valuable to both instructors and students. By engaging in the module, the science and history courses were more complete and comprehensive because of the cross-disciplinary resources and expertise used to instruct the class. The outcomes observed via survey responses, mid-term exams, the student food label design assignment, as well as the in-class discussion questions, helped identify content and activities that were either successful or in need of improvement in meeting the learning objectives.

The learning objectives, as a whole, aimed to show how learning about a sustainable food system incorporates cross-disciplinary lessons. By both describing the demographic and socioeconomic characteristics of the agricultural workforce and providing a specific example of their various levels of exposure to an agricultural practice like pesticide application, we were able to introduce the social, economic and environmental impacts of one aspect of our food system that relates to its individual, regional and global sustainability. Importantly, these science and social issues overlap as they relate to ecosystem health and the manner in which consumer choices can drive agricultural practices. Educating students to work to make them more informed consumers by encouraging them to think about the interrelated components that make a food system sustainable.

The surveys were completed immediately following the module and the results clearly showed how students' appreciation for and recognition of the working conditions of agricultural workers changed as a result of this module. Before the class, students generally lacked recognition of these workers; as the data show, teaching this module increased students' awareness of agricultural labors—nearly to the level of their awareness of the servers in restaurants or delivery workers, positions of greater visibility. The co-disciplinary teaching methods helped to show how a sustainable food system does not just relate to where a consumer physically sees or uses food; it also relates to how the food makes it to a shelf or a plate, the idea of production to consumption. The survey results show a shift in the students' perspectives, then, on food systems. The survey responses showed no change in students' perception on whether foods containing GE ingredients, whether they contained gluten, their nutritional content, whether they were raised organically or how frequently they thought about workers who delivered their food. While this is not surprising, given that these areas were not the subject of this module, these areas and topics should be discussed in a larger course about sustainable food systems and an overview of all topics from production to consumption. They are topical and relevant, but students did not make any leaps in changing their perception on them as a result of discussing topics indirectly related to them.

Surveys did not encompass a metric for changes in the students' long-term consumer behaviors. The module's final class, which included a review of the documentary, occurred immediately before spring break and a number of student-athletes in the module classes traveled with their teams to Florida for training and tournaments. Five students reported that their teams had purchased tomatoes at Publix but that they had refused to eat the tomatoes and had talked to their teammates about the documentary, about the lives of the agricultural workers who had harvested those tomatoes. While certainly not a formal assessment of changed behavior, this informal anecdote helped to demonstrate a new

awareness among some of the students after the module. Whether the students, as consumers, still practice this shopping practice today or if they have shared what they have learned with family, friends and co-workers is beyond the scope of this study, but bears further exploration to determine if consumer behaviors were temporary or life-changing and to see if they applied to other practices involving invisible labor and environmental degradation, like fast fashion (Bick *et al.*, 2018) or diets high in red meat (Godfray *et al.*, 2018).

The exam question, labeling assignment and in-class discussions highlighted how the second learning objective, which specifically focused on pesticide use, was less universally received by all students – only slightly more than a third of students included pesticide exposure in their exam answers. Class sections that included science students had access to information on why pesticides were used for crop production in terms of maximizing yield and these ideas emerged in discussions; the history students were not familiar with the concept of yield gaps and the role of pesticides in overcoming yield-reducing factors. While they may have appreciated the negative side effects experienced by workers due to direct or chronic exposure, and understood that community members felt the impact of indirect transfer through clothing or water supply, the reason for using pesticides in the first place was not as clear as it could have been. As a result, some students may have walked away with the impression that the potential consequences to agricultural workers and their communities upon direct exposure to pesticides was completely unnecessary, and that pesticides should not have been used. In teaching materials and in crafting the exam question, we could have placed equal focus on pesticide use as a working condition in the same way as we did low wages or immigration status. The way the exam question is written puts more primary focus on directly social factors than some of the more environmental factors that have impacts on workers and the community. Similarly, the labeling assignment also makes clear that the environmental content of the module requires supplementation and that the module alone did not offer a fully systems-based understanding of sustainable food systems.

To expand on the labeling assignment limitations described above, the results did show that students came to understand the multi-aspect nature of food production and were also able to grapple with the role of representation in rendering aspects of the food system visible or invisible. As noted above, their representation of those systems and their choices in illustrating them demonstrate that their understandings were colored by their background learning in their individual, disciplinary classes. This assignment fostered collaboration among the students, stimulated creativity, and also created a visualization to showcase as products of the module. These data highlight the potential benefit of a semester-long, integrated course in which students receive equal amounts of information on all issues leading up to a module such as the one here described.

In future iterations of this module, when taught in separate classes, the authors will focus more on the science content, as indicated above, especially the function of pesticides and their application, relate their impacts on humans to their potential impacts on the ecosystem and balance out the different types of pesticides with safer methods of application that investigate types of contact, duration and concentration, method of action, impact on workers, ecosystems and food security, as well as best practices as elaborated on in Fitch *et al.* (2017) and Ford *et al.* (2017). We focused mostly on the impacts of pesticides in general, and a more in-depth analysis of why and how pesticides are used and chosen may better link the environmental and social concepts together regarding the impact. This strategy will provide a more comprehensive overview that will allow students to compare and contrast the advantages and disadvantages of using pesticides and allow them a fuller systems-

based understanding of sustainable agriculture. It will also allow a differentiation of the types of pesticides (and fertilizers) used in conventional versus organic agriculture, which could help clear up the additional misconception that organic produce is grown in the complete absence of pesticides. This misconception explains why some history students showed a much larger increase in being concerned about whether their food was raised organically when measured against science students, who had learned about conventional and organic farming practices. In future iterations, this assignment will also remain current by drawing from literature authored close to the time the module is taught.

Conclusion

This paper describes a successful, interdisciplinary, co-taught module that focuses on the interconnecting historical, societal and environmental issues essential to a food system's sustainability. Integrated into two discrete courses, this module made positive impacts on students' understanding of the roles agricultural workers play in linking food production to consumption. By discussing the UN and FAO concept of food security, students received a broader understanding of the many components that comprise the concept of sustainability, which they communicated in the assessments. We also identified areas regarding other aspects of agricultural production and consumerism that this module did not cover (per a lack of change in student perception or incorporation of concepts into the exam question or labeling assignment responses), that will be important to include in future iterations of this module or in the design of a larger course.

Faculty and staff continue to integrate sustainability into the curricula of institutions of higher education. Degree programs, discipline-specific applications and cross-disciplinary approaches have all proven successful means to these ends. By using systems thinking and an applied example in the food system, the module of *A World that Works* illuminates the processes and actors integral to the movement of food from production to consumption. This module improved students' understanding of the complexity and expansive nature of sustainability, its relevance to all decisions and actions that bring food to our tables. In exploring rich intersections in history and science, this paper reveals the value of humanities-based and science-driven academic explorations of sustainability.

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