

## Development and evaluation of an introductory course in sustainable food and bioenergy systems

Kate Malone,<sup>a</sup> Alison H. Harmon,<sup>b\*</sup> William E. Dyer,<sup>c</sup> and Bruce D. Maxwell<sup>d</sup>  
Montana State University

Catherine A. Perillo<sup>e</sup>  
Washington State University

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### Abstract

The purpose of this paper is to describe the development, instruction, and evaluation of the undergraduate pilot course, Introduction to

Sustainable Food and Bioenergy Systems (SFBS), at Montana State University. Introduction to SFBS is an interdisciplinary, team-taught, experiential education course designed to introduce students to broad array of SFBS-related topics, expose students to career opportunities in these fields, and enable them to establish relationships with food, agriculture, and energy stakeholders. Students completed baseline and follow-up surveys in which they reported information about their backgrounds, values, and knowledge of SFBS-related topics. The surveys also tracked students' learning and allowed them to provide feedback on course methods. According to the follow-up survey, over the course of the semester students demonstrated development of course vocabulary and concepts. Students' experiences in the course prompted changes in their school- and career-related goals. Additionally, the team-teaching approach was highly valued. Students also indicated that teaching should be more solutions-focused. Evaluation of

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<sup>a</sup> Department of Health and Human Development, Montana State University, 121 PE Complex, Bozeman, Montana 59717 USA. Current affiliation: Portland Community College, +1-406-570-2744; [nutritionistkate@gmail.com](mailto:nutritionistkate@gmail.com)

<sup>b\*</sup> *Corresponding author.* Alison Harmon, Department of Health and Human Development, Montana State University, 121 PE Complex, Bozeman, Montana 59717 USA; +1-406-994-6338; [harmon@montana.edu](mailto:harmon@montana.edu)

<sup>c</sup> Department of Plant Sciences and Plant Pathology, Montana State University, Bozeman, Montana 59717 USA; [wdyer@montana.edu](mailto:wdyer@montana.edu)

<sup>d</sup> Department of Land Resources and Environmental Sciences, Montana State University, Complex, Bozeman, Montana 59717 USA; [bmaxwell@montana.edu](mailto:bmaxwell@montana.edu)

<sup>e</sup> Department of Crop and Soil Sciences, Washington State University, Pullman, Washington 99164-6420 USA; [cperillo@wsu.edu](mailto:cperillo@wsu.edu)

students' backgrounds and learning is an important tool for the future evolution of this course and the development of others like it. The survey tool was in its first iteration; it will require revision as the course evolves. Introduction to SFBS can serve as a model for curricula related to sustainable agriculture, food, and energy. Courses like this can prepare students to become informed, innovative, critical thinkers capable of excelling in a multitude of food, agriculture, and energy-related careers. This course will continue to be monitored and evaluated as the curriculum evolves.

### **Keywords**

course assessment, education, Higher Education Challenge Grant, interdisciplinary education, sustainability, sustainable food systems

### **Introduction**

In response to the growing demand for innovation, problem-solving, and comprehensively trained professionals in the food, agriculture, and bioenergy industries, Montana State University recently implemented a novel undergraduate degree program, Sustainable Food and Bioenergy Systems (SFBS). The SFBS program is a nationally unique, interdisciplinary degree program that combines classroom and field-based education to address the production, distribution, and utilization of food and bioenergy. Led by the Montana State University (MSU) SFBS Degree Program Curriculum Development Team, the program currently represents a multidepartment, multicollege collaboration between the departments of Land Resources and Environmental Sciences, Plant Sciences and Plant Pathology, and Animal and Range Sciences in the College of Agriculture and the Department of Health and Human Development in the College of Education, Health and Human Development. The U.S. Department of Agriculture's Higher Education Challenge Grant Program has funded a multi-institution learning community that includes MSU, Washington State University, and the University of Idaho. The purpose of the learning community includes collaborative course development and assessment. The assessment described in this paper is the first piece

of that collaboration; it is the baseline assessment in an evaluation protocol that also includes field-based learning assessments, capstone course assessments, exit interviews, and post-graduation follow-up surveys.

The SFBS program's freshman-level, single-semester pilot course, Introduction to Sustainable Food and Bioenergy Systems, was developed and taught in 2009 by the first author. Course themes, goals, and topics were chosen with considerable input from SFBS faculty members and other MSU faculty advisors. Additionally, several food, agriculture and energy stakeholders in Montana were surveyed for recommendations. Course themes included systems thinking, experiential learning, and multidisciplinary teaching. The primary teaching and learning goals of the course were to (1) create a "systems" model of learning by introducing students from diverse backgrounds to a variety of academic topics related to food and bioenergy; (2) expose students to SFBS-related service and employment opportunities; (3) help students establish meaningful relationships with key SFBS stakeholders at the university and in Montana communities; and (4) provide students with opportunities to experience food, agriculture, and energy first-hand through experiential projects and field trips. Topics included agroecology, soil and plant sciences, integrated pest management (IPM), biofuels, climate change, community and public health nutrition, corporate regulation, and public policy.

To assess student's backgrounds, knowledge, and values regarding food and agriculture, students completed an online baseline (pre) survey during the first week of the course and an in-class follow-up (post) survey during the final week of the course. Several of the survey questions were also designed to provide information regarding the level of student learning due to the course, and at entry into the SFBS major, for eventual use in overall program assessment.

The objectives of this paper are to:

1. Share the course design and lessons learned from the pilot offering of Introduction to SFBS, and

2. Present the profile of course participants, and changes in this profile resulting from the course.

### Review of Related Literature

Student and faculty demand for interdisciplinary, sustainability-centered education in the university setting is growing. In the United States and internationally, several universities offer multidiscipline, systems-oriented and experiential learning-based sustainable agriculture curricula (Borsari & Vidrine, 2005; Clark, Byker, Niewolny, & Helms, 2013; Delate, 2006; Furgeson, Lamb, & Swisher, 2006; Jacobsen et al., 2012; Keating, Bhavsar, Strobel, Grabau, Mullen, & Williams, 2010; Lieblein, Brelan, Salomonsson, Srisankarajah, & Francis, 2008; Parr, Trexler, Khanna, & Battisti, 2007; Parr & Van Horn, 2006). According to Francis et al. (2003), there is both an opportunity and a responsibility to evaluate food systems in novel ways, balance the system with existing resources, and acknowledge the moral obligation to manage system outputs equitably. Further, land-grant universities are uniquely qualified to train agricultural scientists, natural resource managers, farmers, and agribusiness leaders (Francis et al., 2003; Jacobsen et al., 2012; Schroeder, Creamer, Linker, Mueller, & Rzewnicki, 2006).

Future professionals will influence how social, cultural, and environmental resources are utilized (Sibbel, 2009). Additionally, professionals must be capable of engaging in critical discourse in situations where stakeholders hold widely varying and conflicting world views (Galt, Clark, & Parr, 2012; Jordan, Bawden, & Bergmann, 2008). Interdisciplinary engagement and experiential learning educational styles encourage students to adopt a broad world view, facilitate a richer understanding of individual disciplines, enhance critical thinking, and provide students with the tools to develop solution-focused problem-solving skills (Holley, 2009; Ivanitskaya, Clark, Montgomery, & Primeau, 2002). Further, McArthur and Sachs (2009) noted that interdisciplinary programs are needed at the collegiate level to generate problem-solvers who are capable of developing and managing innovative and sustainable energy, food, and water resources. Similarly, sustainability-centered university

curricula train students to become informed professionals who understand agricultural, environmental, and social issues (Clark et al., 2013).

Discipline-specific learning, hands-on experiences, and communication skill development are vital components of interdisciplinary programs. Graduates of an interdisciplinary agroecology degree program and their employers have reported that problem-solving skills, proficiency in oral and written communication, and practical field experience are highly valued in their professions (Karsten & Risius, 2004). Additionally, agroecology courses can help students address the numerous challenges facing sustainable agriculture (Francis & Altieri, 1992). For example, Pennsylvania State University's Agroecosystem Science major emphasizes experiential learning, problem-solving, learning to work in groups, and developing oral and written communication skills through field trips, guest speakers, case studies, and oral and written reports (Karsten & Risius, 2004). Further, coursework in sustainable food systems prepares students to better understand how their food choices affect the natural resources that sustain food system, how consumer health is related to conditions for farm laborers, and how animal production methods are intertwined with other methods of food production (Harmon, 2002). Though still in its infancy, bioenergy curricula are expanding in Europe and new programs are emerging in the United States.<sup>1</sup> Currently, however, there is a literature gap in bioenergy curriculum evaluation.

The effectiveness of interdisciplinary courses is enhanced when diverse faculty and stakeholders are intimately involved in curriculum development and instruction. Team-teaching methods that emphasize a systemic learning and discovery process facilitate problem-solving in complex situations, enhance communication skills, and

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<sup>1</sup> For example, see these resources: Oregon Tech's Renewable Energy Engineering program at <http://www.oit.edu/academics/degrees/renewable-energy-engineering>; University of Tennessee Knoxville's Bioenergy Concentration at <http://www.utk.edu/academics/programs/09/casnr/plant-sciences-bioenergy.html>; and the University of Illinois at Urbana-Champaign's Bioenergy Professional Science Master's program at <http://www.bioenergy.uiuc.edu/education/major.html>

encourage life-long learning (Stonehouse, 1996). Additionally, food, agriculture, and academic stakeholders can provide invaluable suggestions for pertinent curriculum topics (Parr et al., 2007; Trexler, Parr, & Khanna, 2006).

Because of their interdisciplinary nature, such courses often attract students from a wide range of backgrounds. It is common for instructors to provide a quiz or survey near the start of the class in order to better understand the composition of each year's cohort (Karsten & O'Connor, 2002). For example, Karsten and O'Connor (2002) included several questions about bioregionalism in their survey, one of the major themes of the course. They administered the same questions at the end of the course and found a statistical increase ( $p < 0.05$ ) in the proportion of students answering correctly compared to the proportion answering correctly at the start of the course. In this case, the "survey" included both indirect and direct measures of student knowledge that can be used in overall assessment of student learning resulting from the course.

For many years, evaluation of student learning in higher education has focused on exam and assignment scores. Recently, there has been a shift in interest toward assessing student learning outcomes and understanding what students can accomplish as a result of taking a specific course or program of study. One approach to assessment is to survey students on their learning outcomes (an *indirect* measure); this provides the students' perceptions of their learning. A stronger approach is to use *direct* measures through external evaluation of student work. Cook, Wiedenhoef, Polito, Gibson, Pogranichniy, and Mullen (2006) demonstrate the use of an outcomes-assessment approach within an agronomy course, with the dual purpose of assessing student outcomes with respect to the learning outcomes the course is supposed to meet, as well improving teaching practices within the course. They describe a course-embedded performance measure that provides a direct measure of student progress toward a stated course outcome. Galt, Parr, and Jagannath (2013) use students' reflective essays as an indirect measure of student learning, and demonstrate how learning competencies can be addressed and

assessed in a sustainable agriculture curriculum (Galt, Parr, & Jagannath, 2013).

## Methods

### *Course Development and Design*

Introduction to SFBS was designed to enhance students' critical and creative thinking capabilities, provide hands-on experiential learning opportunities, introduce students to a variety of SFBS stakeholders, and encourage students to be inquisitive and conscious consumers. The course was also created to give students considering SFBS as a major the opportunity to explore a diverse array of topics.

The SFBS development team, other Montana State University faculty and staff, and stakeholders from Montana provided substantial input for course development through an open-ended survey. Stakeholders included farmers, ranchers, food processors, food retailers, nonprofit managers, policy planners and county extension agents. Instruction combined guest lecturers from a variety of departments and research laboratories on campus, speakers from community organizations, panel discussions, hands-on projects, and field-based learning experiences. The course was divided into three modules: agroecology, sustainable crop production, and sustainable food systems. Specific course topics are listed in figure 1.

It was useful to begin the course by asking small groups of students to create a definition of sustainability based on their previous experiences and current knowledge. Student and scholarly interpretations were then woven by the class to create a general course definition of sustainability: the "ability to last," preserve natural resources, prevent harm, and provide for present and future generations (American Dietetic Association [ADA] Sustainable Food Systems Task Force, 2007; World Commission on Environment and Development, 1987; Dahlberg, 1993). Throughout the course, ways in which individuals can apply the concepts of sustainability and food and energy systems as conscious consumers capable of critically thinking about their choices were discussed. Definitions of sustainable food systems and sustainable energy systems were similarly constructed (ADA

## Figure 1. Introduction to Sustainable Food and Bioenergy Systems Course Topics

### Module 1. Agroecology

- Sustainability: Framework and Definitions
- Sustainability at Montana State University
- Agriculture in Context: World and Montana Agricultural History
- Ecological Concepts in Agriculture
- Agroecology on a Small Scale
- Agroecology on a Large Scale

### Module 2. Sustainable Crop Production

- Nuts and Bolts of Conventional Crop Production
- Nuts and Bolts of Organic Crop Production
- Integrated Pest Management
- Food, Agriculture and Energy Policy, Regulations and Advocacy
- Bioenergy: Overview
- Bioenergy: Camelina in Montana

### Module 3. Sustainable Food Systems

- Food Systems Thinking and Modeling: Overview
- Food Systems Thinking and Modeling: The Montana Food System
- Community Food Security
- Community Food Security: Gallatin Valley Food Bank
- Food Justice
- Montana State University Food Service
- Ecological Eating

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Sustainable Food Systems Task Force, 2007; Gleissman, 1998). Students completed a variety of course projects designed to engage them in food and energy systems (see figure 2). Projects and course activities were designed to support the course teaching and learning goals described above (see figure 3).

Evaluation of student learning and course methodology was integral to this introductory class. Evaluation instruments and procedures were approved by the MSU Institutional Review Board. Students had the opportunity to complete a pre-survey during the second week of the course using the online course management tool. The purpose of the presurvey was to gather data on students' demographics, backgrounds, and prior experience with food, fiber, and bioenergy production, and to assess understanding of course definitions, themes, and topics; food selection preferences; and academic and career goals. For example, students

## Figure 2. Introduction to Sustainable Food and Bioenergy Systems Course Projects

### 1. Personal Experience Project

Students completed one of two experiences:

- **Eat Montana Project:** Students consumed only Montana-produced and processed food and beverage products for a 24-hour period. Participants documented what they consumed and answered a series of reflection questions about their experiences. Students considered their purchasing, food preparation, and consumption strategies; challenges; lessons learned; and if or how the project would modify their behavior related to food procurement, preparation, and/or consumption.
- **Farm Tours:** In a large group, students toured three Bozeman area farms and ranches. Participants answered reflection questions about their visits.

### 2. Organization Report and Presentation

In pairs, students gave a brief written report and presentation about an SFBS-related organization. Organizations included Slow Food International, International Sustainable Energy Organization, Farm to School, Alternative Energy Resources Organization, Patagonia, Feeding America, and the Marine Stewardship Council.

### 3. Book Project

Students read one of three suggested popular books about an SFBS-related topic and completed a guided reflection paper.

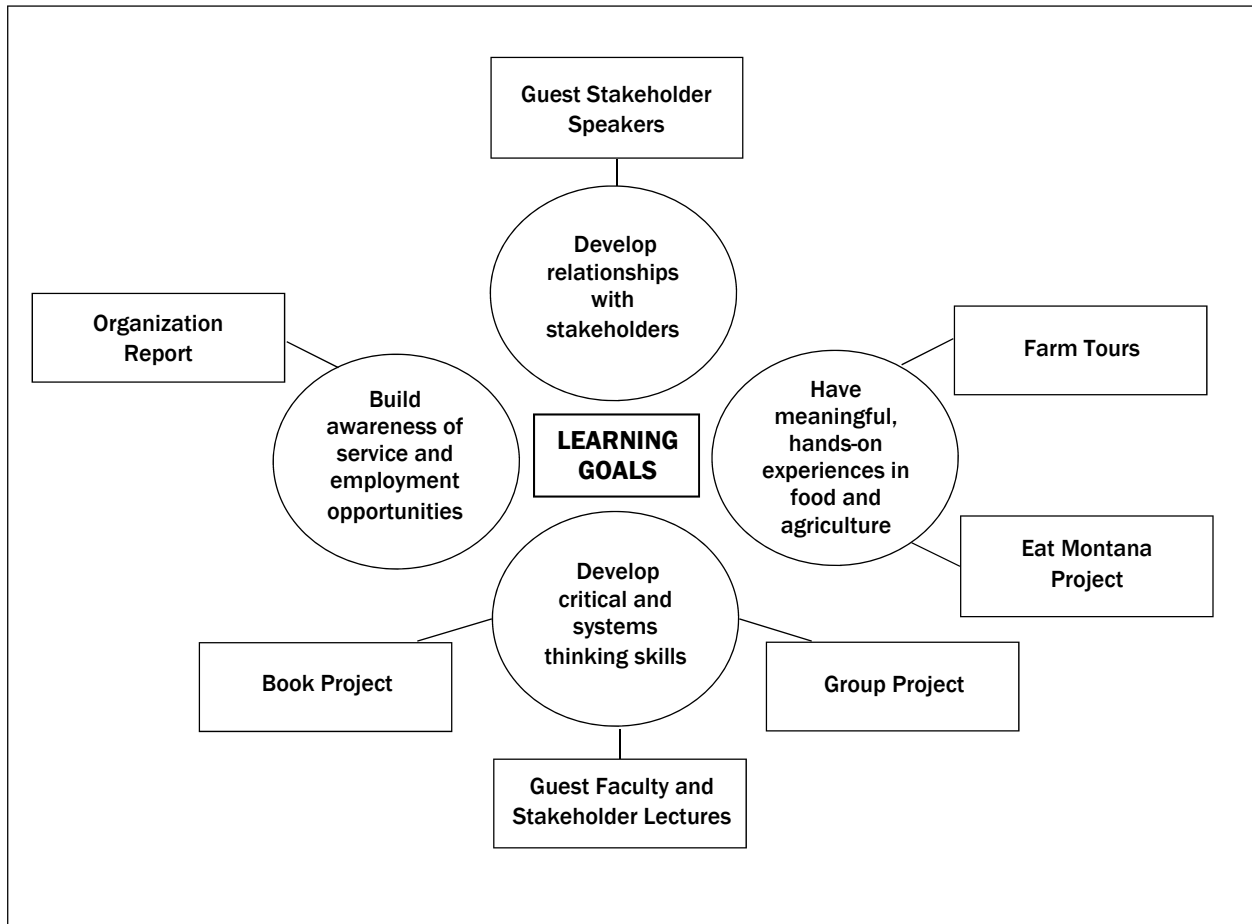
### 4. Final Project

In small groups, students researched and presented on a SFBS-related topic of their choice. Topics included organic certification, vertical farming and hydroponics, animal production, terrestrial carbon sequestration, sustainable ranching, urban agriculture, coffee production, and genetically modified organisms.

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were asked to describe the meanings of sustainability, food system, bioenergy, and systems thinker. Students were then asked to select factors (from a list) that are important to them personally when deciding what to eat. They were asked to describe what they hoped to learn in the course, the value they placed on interdisciplinary coursework, and what they hoped to do in the future. Finally, students were asked to describe what they thought were the most important food and energy issues on local, state, regional, and global scales. The post-

**Figure 3. Learning Outcomes Supported by Course Projects and Activities**



survey was designed to assess changes in these measures. Additionally, the postsurvey asked students to provide feedback on course methods and offer suggestions for future course topics. The postsurvey was completed on paper in class, in an effort to encourage more students to participate. Twenty-five students completed the presurvey and 33 completed the postsurvey.

Surveys were analyzed as aggregate data to assess the impact of the course on the class as a whole rather than tracking change in individuals. Demographic, background, and food preference results could be tabulated and expressed using descriptive statistics, but most survey questions were open-ended, requiring manual analysis and coding. Common answers and themes were identified for each question. The authors were looking specifically for changes in language from

the pre- to postsurvey that would indicate an improvement in literacy in Cardwell's terms (2005).

## Results

### *Student Profiles*

Thirty-eight students enrolled in the course. Of the 25 students who completed the presurvey, 84 percent were Caucasian/White non-Hispanic, 8 percent were Hispanic, and 4 percent were Native American. Fifty-two percent were male (48 percent female) and the median age was 20. Thirty-six percent of students were raised in Montana. Additionally, students had completed an average of two years of university-level coursework. Students' current or intended majors included agricultural economics, animal science, biology, civil engineering, education, environmental science, fine arts,

food and nutrition, liberal studies, nursing, political science, sustainable food and bioenergy systems, and university studies.

Twenty-four percent of students had no experience with food, fiber, or bioenergy production; 60 percent had gardening experience; 28 percent had on-farm experience; and 20 percent had ranching experience. Approximately three-fourths (76 percent) of students were motivated to enroll in the course due to personal interest, about half (44 percent) were interested in the SFBS major, 20 percent enrolled because the course was recommended, and 16 percent were required to take the course for the SFBS major.

When asked what they hoped to achieve and/or learn in the course, 36 percent of students reported that they wanted to develop their understanding of sustainability or learn how to be sustainable, while 12 percent aspired to learn about food systems. Students also expressed an interest in learning about bioenergy, Montana's food system and environment, and SFBS-related academic and career opportunities. Fifty-two percent of respondents intended to work in fields related to food systems and the environment.

### *Student Learning*

In both the pre- and postsurveys, students were asked a series of open-ended questions in which they were prompted to define several terms related to sustainable food and bioenergy systems, including sustainability, food systems, systems thinker, and bioenergy (see table 1). Table 1 includes exact quotations from student surveys that are representative of the pool of responses received in order to illustrate the changes that took place over the course of the semester in students' thinking about these terms. When asked to define sustainability, students initially focused on the environment and the future. Generally, they described sustainability as minimizing future damage indefinitely by using practices that are environmentally sound, conserving and replenishing natural resources, and promoting energy balance. Students' postsurvey interpretations of sustainability were more comprehensive. At the end of the course, students included economics, social justice, animal health, and use of non-fossil fuel sources in their definitions.

Students' initial definitions of food system varied widely and included references to "groups of food" and food security. In the postsurvey, 80 percent of respondents demonstrated that they were approaching an understanding of the concept of a food system and described it as including the processes that food undergoes from production to consumption, or from "farm to table."

When defining systems thinker in the presurvey, 56 percent of students indicated that a systems thinker considers the whole rather than only individual parts. Presurvey definitions also indicated a bias towards *food* systems. According to the postsurvey, 70 percent of students believed that a systems thinker was one who thought "holistically," approached problems in a holistic manner, or considered broader consequences and how different parts affect the whole.

In both surveys, students defined bioenergy as renewable, alternative, and derived from biological sources. In the postsurvey, respondents expanded their definitions. Specifically, 40 percent of students stated that bioenergy is also environmentally safe, low-impact, and intrinsically sustainable. In addition to defining terms, students also answered open-ended questions about local and state food systems issues.

Students most frequently cited agricultural land use as an important issue facing the local food system in both the pre- and postsurveys. At the end of the course, students cited agricultural land use, lack of in-state processing, and lack of consumer education as the top three issues facing the local food system. When asked to consider the most important issues facing the Montana food system, students initially suggested that the top three issues were localizing the food system, in-state processing, and support for producers. In the postsurvey, 64 percent of respondents listed in-state processing as an important issue and 21 percent mentioned localizing the food system. Transportation and crop diversity were each reported as important by 12 percent of respondents in the postsurvey.

Many students communicated the importance of interdisciplinary coursework and experiences to their education. In both the pre- and postsurveys, approximately 85 percent of respondents openly

**Table 1. Changes in Student Qualitative Definitions for Key Terms from Presurvey to Postsurvey**

Presurvey Representative Responses	Key Term	Postsurvey Representative Responses
It means to continue forever.  Ultimately keeping the planet as green as possible, caring of what you are putting in and taking out of the earth, and how much you waste.  A system of agriculture that puts the same amount of energy back into the land that is taken out.	<b>Sustainability</b>	Something, specifically food, that can be maintained indefinitely without harming the environment, available to all, does not harm or do injustice to others in the process.  Production that is economically, environmentally, and socially proactive.  Developing a system that supports the production and processing of local agricultural products in order to become more self-reliant.
Energy from natural sources such as plants.  Chemical energy.  Renewable energy from water, wind, solar power etc.	<b>Bioenergy</b>	Renewable energy not from fossil fuels that can be produced in an ecologically safe and sustainable manner.  Energy that is derived from natural or biological means.
A network of growers/sellers who together produce a variety of crops.  All the stages food takes from being put in the ground to being put on your table.  The food system involves everything from planting the seed to eating the product.	<b>Food Systems</b>	A collection of people, capital, and infrastructure leading to the production and consumption of food.  A food system is a form of production and consumption. A food system consists of producers, transformers, distributors, and consumers. Each depend on the other in order for the system to last. Each component also has to be sustainable in order for the system to be sustainable.
To think more broadly.  Looking at the big picture the whole time rather than focusing on the little things.  To think about how everything fits together.	<b>Systems Thinker</b>	Thinking in terms of each small part affecting the whole.  A systems thinker is educated on all the aspects of a systems and understands the interactions.  Seeing the big picture and how everything is connected.

reported that they were extremely important, very important, vital, or the basis of their education.

Students were prompted to choose from a list of factors that were most important to them personally in deciding what to eat, and invited to check all that applied. In both the pre- and post-survey “like the taste” was the most often checked. Between the beginning and end of the course, the importance of “locally grown” increased from 48 percent to 79 percent students (a 31 percent

increase), “sustainably grown” grew from 40 percent to 67 percent (a 27 percent increase), and “pesticide-free” increased from 28 percent to 45 percent (a 17 percent increase) (see table 2).

Students were also asked to freely report the ways, if any, in which what they learned in the class changed their attitudes and/or behaviors related to food and energy. Fifty-five percent of respondents stated that their awareness of SFBS-related issues increased. Specifically, 21 percent of students



**Table 2. Factors Important to Students in Deciding What To Eat**

	Presurvey (% students)	Postsurvey (% students)	Change Factor (+/-)
Like the Taste	88	80	-8
Price Is Right	68	70	+2
Safety of Food	60	70	+10
Minimally Processed	52	64	+12
Locally Grown	48	79	+31
Sustainably Grown	40	67	+27
Who Produced It	32	33	+1
Pesticide-Free	28	45	+17
Certified Organic	24	24	-
Pre-Prepared Convenience	12	9	-3

mentioned that their awareness of local food issues increased. Eighteen percent of students reported that they will seek out and purchase more local foods. One student mentioned that the knowledge he had gained in the course made him more concerned about future production on his family farm. Fifty-eight percent of respondents also reported that the course prompted a change in their academic and/or career goals, and 45 percent specifically mentioned that the change(s) would include incorporating some aspect of the course in their plans. Four students (12 percent) changed their major to SBFS as a result of their experiences in the course. In addition, 56 percent of students had stayed or intended to stay in touch with one or more of the guest speakers.

### *Student Feedback*

When asked to provide feedback on course topics, 40 percent of students listed bioenergy or biofuels as the most interesting course topic. Respondents also suggested that future course topics should emphasize local food, slow food, climate change, measuring and/or tracking sustainability, animal production, and urban agriculture. Students would have preferred more information on the farm bill, genetically modified organisms, and bioenergy. Several also indicated that future courses should focus more on solutions. Students reported that

farm tours, guest lectures from MSU faculty and staff, the “Eat Montana” project, and guest speakers from outside of MSU were the most valuable course components.

### **Discussion**

The course, Introduction to Sustainable Food and Bioenergy Systems, represents a novel approach to teaching and learning in interdisciplinary curricula focused on sustainable food and energy. Throughout the semester-long class, students were introduced to a broad array of topics through guest lectures, hands-on projects, and field experiences. Course themes included sustainability, systems thinking, interdisciplinary and experiential learning, critical thinking, conscious consumerism, and mentoring relationships between students and stakeholders in the food, agriculture, and energy systems.

Shroeder et al. (2006) affirmed the need to clearly explain and define key course concepts in sustainable agriculture courses. Similarly, several surveyed Montana stakeholders urged instructors to clarify the definition of sustainability in particular. Key terms and concepts such as sustainability, food system, and bioenergy were introduced to students early in the course and revisited regularly.

Shroeder et al. (2006) also urged instructors to provide students with ample opportunities to interact with and learn from each other. Having students with diverse backgrounds enabled constructive debate as well as opportunities to share and understand varied perspectives on a variety of SFBS issues. Moreover, facilitating open classroom discussion and project debriefing sessions as well as permitting students to complete projects on topics with which they had personal and/or professional experience created a more intimate learning environment.

Survey responses at the start and end of the course indicated that the course affected students in myriad ways. Coming into the class, students wanted to learn about food systems, develop their

understanding of sustainability, and learn how to develop sustainable practices. Over the course of the semester, students demonstrated development of course vocabulary. Similar to experiences described by Lourdel et al. (2007) following a survey of students in a sustainable development course, Introduction to SFBS students showed a more comprehensive understanding of sustainability by the course's conclusion. Similarly, their definitions of food systems, systems thinking, and bioenergy broadened. In Cardwell's (2005) terms, students seemed to advance from nominal food and bioenergy system literacy to functional, cultural, and in some cases multidimensional literacy. With regard to food purchasing habits, students viewed sustainable production methods, locally grown status, and who produced their food considerably as more important at the end of the course compared to the start of the semester (Farenga & Ness, 2010).

More than half of the students reported that the course affected choices related to their future studies and career goals. Similarly, more than 50 percent indicated that they intended to work in fields related to food systems and the environment. Several students became SFBS majors during the semester. Students also indicated that interdisciplinary coursework and experiences are important to their education. Further, many students formed lasting relationships with SFBS stakeholders.

Overall, students found the farm tours and guest lectures to be the most valuable course components. This finding is similar to Karsten and Risius (2004), who reported that hands-on work, farm visits, and guest speaker series were highly rated by students in a sustainable development course. Though formal class discussion about bioenergy was limited to two lectures, nearly half of the students reported that it was their favorite course topic. Bioenergy will likely play a critical role in Montana's future economy and therefore warrants expansion in the curriculum (Bradley et al., 2007).

### **Implications**

Courses like Introduction to SFBS should challenge students and educators to think more critically, creatively, broadly, and collaboratively.

The execution of this pilot course reflected long-term planning, reliance on interdisciplinary partnerships, highly invested and diverse instructors and stakeholders, motivated students, and pertinent field experiences. The future of the course will depend largely on the factors that serve as its foundation: student and faculty driven initiatives; technological advances related to food, agriculture, and energy; political and economic policy; and socio-cultural influences.


The interdisciplinary nature of this course presented numerous challenges for development and teaching. One specific challenge is determining how to best connect with a class of students that varied in year, background, and academic preparation for study in sustainable food and bioenergy systems. Unlike more disciplinary courses, this course experience did not fit neatly into a logical progression of content. Students arrived from different places in their academic experiences, and the challenge for the instructor was how to make the material interesting and meaningful for each individual — encouraging each to grow and develop on his or her own path. Most of the learning goals for the course transcend content. For example, building relationships with stakeholders, developing critical thinking and systems thinking skills, improving awareness of service and employment opportunities, and engaging in hands-on learning may be novel for students at any level in their university program and effective for encouraging professional development in this interdisciplinary field.

As evidenced by survey responses regarding food purchasing priorities, career and academic goals, and lifestyle adjustments, courses like this provide opportunities for students to consciously adjust their priorities and behaviors as consumers and community members. Both the etiology and consequences of these changes may warrant further in-class discussion.

Students suggested that future courses should incorporate more discussion about local food, urban agriculture, animal production, and methods for measuring and tracking sustainability. Instructors may also consider integrating a lecture on water access, quality, and policy. Moreover, several students noted their desire for a more solutions-

based learning environment. Incorporating more case studies and providing more opportunities for students and stakeholders to interact directly and address problems together may facilitate development of solutions.

Future courses would be enhanced by inviting input from a wider array of professionals, recruiting more non-White students, and creating more space for small-group sharing. Further, we recommend implementing a course fee and seeking grants for off-campus field trips. Finally, there is a need for additional collaboration with Animal Sciences and the College of Engineering to address the demand for the inclusion of animal production and more discussion about bioenergy. On the community and state level, it is clear that students recognize that agricultural land use and lack of in-state food processing are critical issues facing the local and Montana food systems, respectively. One additional lesson learned is that in courses where students are exposed to multiple perspectives through guest faculty and stakeholder presentations, they will need some time with a consistent instructor to process, question, and reconcile contradictions in what they have heard. This would be beneficial in increasing competence in systems thinking. *Learning* what a systems thinker is differs from *becoming* a systems thinker, which will likely require many courses beyond this one, additional hands-on experiences, and more opportunities to address systems problems.

The future of food and bioenergy systems depends considerably on actions and achievements at universities. The SFBS curriculum will continue to use embedded assessment as recommended by Cook et al. (2006) to help instructors facilitate students' development of multidimensional literacy in food, agriculture, and bioenergy systems education (Cardwell 2005). In conclusion, Introduction to SFBS and the degree program for which it is the foundation will continue to be improved and assessed over time, striving to promote the advancement of sustainability and interdisciplinary education and influence the future of food and bioenergy systems. 

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