Lessons Learned from Teaching an Interdisciplinary Undergraduate Course on Sustainable Agriculture Science and Policy

H. D. Karsten* and R. E. O'Connor

ABSTRACT

Interdisciplinary courses that teach both science and policy are rare. In 1999, we developed and began to offer an interdisciplinary undergraduate course in the science and policy of sustainable agriculture to students majoring in political science, agricultural science, and other disciplines. As the theme of the course was both the science and politics of sustainable agriculture, we selected and developed materials that featured both natural and social science domains. We faced challenges tied to the interdisciplinary nature of the course material and to the diverse backgrounds of the students. The major barriers to learning were differences in students' technical backgrounds and levels of motivation to study a discipline outside of their major. After teaching the course three times, we report here approaches helpful to address these challenges: (i) compile a customized set of reading assignments, (ii) address student disciplinary parochialism with interdisciplinary team teaching, (iii) focus on the crucial concepts rather than broader topical coverage, (iv) employ frequent short quizzes and in-class written activities and discussions to identify points that needed to be clarified, and (v) use a variety of educational materials and activities (e.g., articles, videos, field trips, and guest speakers) to address diverse learning styles. There is evidence that these approaches promoted student learning.

We are an agroecologist and a political scientist who developed and taught an undergraduate course entitled Sustainable Agriculture Science and Policy for the general student population at the Pennsylvania State University (Penn State). This general education course is in the natural sciences and is open to the general student population. We chose not to require any previous course preparation in order to reach as many interested students as possible, particularly early in their undergraduate studies.

The purpose of this paper is to share what we have learned from teaching this interdisciplinary course three times. Although interdisciplinary curricula that involve natural and social scientists are increasing, individual courses that teach both science and policy seem uncommon (William et al., 1999). In light of the valuable learning opportunities such courses may provide, we share our experiences in hope that this may encourage others to teach interdisciplinary courses and that, if they teach such courses they may learn from our successes, as well as our mistakes. We describe the course content and teaching approaches before turning to the five most significant lessons learned.

H.D. Karsten, Crop and Soil Sciences Dep., 116 ASI Bldg, Pennsylvania State Univ., University Park, PA 16802-3504; and R.E. O'Connor, Political Science Dep., N160 Burrowes Bldg, Pennsylvania State Univ., University Park, PA 16802. Received 16 Nov. 2001. *Corresponding author (hdk3@psu.edu).

Published in J. Nat. Resour. Life Sci. Educ. 31:111–116 (2002).
http://www.JNRLSE.org

Course Content, Development, and Teaching Approaches

We designed the course to help students understand how both science and policy influence agricultural sustainability. We wanted students to understand how both science and policy determine the sustainability of agriculture, so that they can make informed decisions as consumers, voting citizens, and employed professionals. We were also interested in exposing our undergraduate academic programs to new students. The course content and teaching methods flowed from our three primary educational goals:

- Enhance understanding of the science and policies that influence food production today. By learning how science and policies affect agricultural sustainability, students will identify how to improve agricultural sustainability.
- Stimulate learning about science and policy through the food production system, a topic that is personally relevant and interesting to many students. Students who are neither science nor political science majors might not be intimidated by these disciplines when they are introduced through a substantive course on sustainable agriculture.
- Improve student communication skills and critical thinking capabilities.

Funding Assistance

Both of us wanted to learn more about the subject outside of our area of expertise (policy or science), and about teaching an interdisciplinary course on sustainable agriculture. Mini-grants from the Keystone 21 Kellogg Foundation and The Pennsylvania State University Fund for Excellence in Learning and Teaching provided some financial support that facilitated development of this course. In the beginning, we used the funds to purchase course reference reading materials and to support a graduate assistant to help us identify course materials. For the first teaching semester, the grants supported a teaching assistant as well as the costs of field trips to farms and the Rodale Institute.

Course Outline

Each course lasted 15 wk with three in-class hours per week. We began by introducing the fundamentals and key concepts of agronomy, the policy process, and sustainable agriculture. Then we introduced current high-profile agricultural issues with which students often had familiarity due to media coverage. Each issue was relevant to sustainable agriculture in the northeast and served as a *case study* for learning the fundamentals of both science and policy. Students identified the agricultural science, policy, and sustainability themes and challenges, and possible solutions for each issue. For instance, in fall 2000, we used the following course outline:

1. Introduction and overview of agroecosystems and public policy.

2. Defining sustainable agriculture: Why we are reassessing what is sustainable? Multiple definitions of sustainable agriculture.
3. Soil management and conservation, annual and perennial crops.
4. Industrialization of agriculture.
5. Nutrients: flows and nutrient management on livestock farms in the northeastern USA.
6. Pest management, integrated pest management, and the Food Quality Protection Act.
7. Food genetic resources, genetic resource conservation, and transgenic organisms.
8. Agricultural policy: Do current government policies promote or inhibit sustainable agriculture?
9. Farmland preservation.
10. Bioregionalism.

Interdisciplinary Teaching Approach

Scholars and educators use the term *interdisciplinary* in a myriad of ways (Klein, 1990). For purposes of creating this interdisciplinary course, we were comfortable with a definition that stresses the necessity of working together: "Interdisciplinary is…the work that scholars do together in two or more disciplines, subdisciplines, or professions, by bringing together and…synthesizing their perspectives. Interdisciplinary courses involve efforts…to bring about mutual integration or organizing concepts and methodologies" (David, 1995). Therefore, to integrate agricultural and political sciences in the course, we both attended every class and contributed to discussion of course material each day. Often when introducing fundamental concepts or new material, we took turns individually presenting material from our respective disciplines and contributed comments to the other instructor's presentation. Issues were always discussed from an interdisciplinary perspective. To encourage students to think this way, we asked the students to participate in role-playing, short in-class writing, and discussion activities that required them to consider—individually and in groups—both the science and policy aspects of an issue. After in-class writing and small group discussion activities, we asked the students to contribute their thoughts to class discussions. During these activities, both instructors guided and contributed to the class discussions.

Course Materials

To respond to diverse student learning styles and maintain interest, we utilized a wide range of course materials including readings, videos, guest speakers, field trips, and student and instructor led discussions. These materials provided written, oral, and experiential support of the course themes. In an effort to keep the subject material personally relevant to students, we used many examples from Pennsylvania and the northeastern USA. For some subjects such as world population growth, genetic resources, and the industrialization of agriculture, however, we highlighted international issues and the interconnections of global agroecosystems.

Course reading materials originated from agricultural science and policy college texts, research and extension publications, and news magazines. We updated the reading assignments to keep the information current. To present multiple perspectives on course material and bring course material to life, we asked the class to view and discuss videos, and listen to guest lectures by a soil conservation researcher, a nutrient management scholar, and an agricultural economist.

Field trips supplemented the readings and in-class activities. Short trips included visits to:

- A research farm managed by Penn State's Crop and Soil Science Department to see a conventional and conservation tillage field demonstration, and to hear the agronomy farm manager describe soil conservation policies and their impacts.
- A community-supported agriculture (CSA) farm that produces vegetables, fruit, and some livestock products (e.g., eggs, lamb, and wool) to provide a live example of an integrated commercial farm practicing soil conservation, nutrient management, integrated pest management, and bioregionalism.
- A dairy farm that uses rotational grazing, raises endangered domestic animal breeds, and hosts a summer camp for girls to provide a live example of animal agriculture, soil conservation, genetic conservation, and innovative activities that generate income.

The class also took a day-long trip to the Rodale Research Institute to increase their understanding of sustainable agricultural by observing research.

Student Evaluation

We modified the means that we used to evaluate student learning during the three semesters we taught the course. Only during the first semester did students work on a semester paper and presentation in groups with students from both science and policy majors. We observed that the semester group project enabled students to avoid learning about the disciplines outside their major. Further, one project rather than two shorter projects limited student exposure to multiple issues and the opportunity to improve their work. Therefore, the second and third times we taught the course, we replaced the group project with two short papers in which each student discussed both the science and policy aspects of an issue. We also substituted more short quizzes for the midterm exam to encourage students to read the assignments in a timely manner.

The first two times that we taught the course, students wrote a short paper defining the opinions and positions of interest groups regarding an issue addressed during the course. During class, students then assumed the roles of interest groups participating in the policy process. We asked the students to reach a consensus among the interest groups. Students often had to compromise their original demands to reach a consensus. We evaluated the students based on the short paper and their participation in the role-playing activity in class.

As part of our evaluation of the course in the second year, we learned that some students were not comfortable with the role-playing. Concluding that role-playing was a less effective use of class time than other assignments, we eliminated the role-playing activities and increased the number of other in-class writing and discussion activities.

The third time we taught the course, we employed a student evaluation approach designed to keep students engaged and current with the course material. We gave eight 15-min,

short answer, biweekly quizzes and left out the lowest quiz grade when calculating the final grade. Quizzes accounted for a total of 40% of the grade. In-class writing activities, both individual and group, accounted for 10% of the class participation grade. The instructors' assessment of each student's participation in class discussions and lectures accounted for an additional 5% of the final grade. In addition to these frequent evaluative exercises designed to keep students current with the course material, we required papers and a final examination, which constituted 45% of the final grade.

To help develop their writing skills and enhance their understanding of course materials, students independently wrote two papers on nutrient management and farmland preservation. For each issue, students explained the technical agricultural problems, the interests and likely policy proposals of three different interest groups, and possible policies that could address the interests of multiple interest groups. Each of these papers contributed 10% of the student's grade. Scores for the last 25% of the final grade came from a comprehensive final examination that included multiple choice, matching, and short essay questions.

DATA AND METHODS

This paper does not report results from a controlled experiment, but is based on data we gathered to help improve our interdisciplinary course. We use three sources of information to identify broad themes regarding student learning and the effectiveness of the course. First, as we taught the course each semester, we monitored student performance during in-class activities, as well as written papers, quizzes, and examinations, and we adjusted our teaching approaches and pace in response to performance measures.

Second, we consulted student course evaluation comments. At the end of the course, students anonymously evaluated the course by writing what they liked most and least about the course. In revising the course each semester we considered the students' comments regarding the course.

Third, on the first day of class before the students received the course syllabus, we asked them to fill out a questionnaire that asked their attitudes and opinions regarding food, agriculture, and the environment. We repeated this exercise at the end of the course and used a difference of means *t*-test to compare responses to questions from the pre- and postcourse surveys. We used the Statistical Package for the Social Sciences Version 11.0.1 (SPSS, 2001) and considered differences statistically significant when $p < 0.05$. The lessons that we present in this paper are based on our interpretation and synthesis of these three types of data.

LESSONS LEARNED

We have learned a great deal about students, teaching, and the politics and science of sustainable agriculture and have five lessons to share.

1. Time spent identifying reading materials and creating a course reading packet that featured interdisciplinary readings about local and current issues to maintain student interest was worthwhile. The first year we tried to use a textbook, but it failed to address the basics of science, policy, and local sustainable agriculture issues. Interdisciplinary college texts on agricultural science and policy that feature current northeastern U.S. agricultural science and policy issues were not available. Therefore, we compiled a customized course packet with some chapters from textbooks about agriculture policy and agroecology, and articles from current news magazines and research and extension publications. Barbarick (1992) also reported that selecting current reading material kept an Environmental Issues in Agronomy course relevant and interesting to students from a range of disciplines in Colorado.

2. Many students had a strong initial preference for the natural science or social science aspects of the course related to their academic major. By using an interdisciplinary team teaching approach, we demonstrated to students that both natural and social science perspectives are important to sustainable agriculture. Pintrich and Garcia (1994) found that learners often develop a *self-schema* or *working self-concept* that defines what learners think their cognitive abilities are for learning a particular subject. A person's self-schema can be positive or negative, and accordingly affect motivational behavior and learning. We found that some students' self-schemas and academic interests reduced their motivation and interest to learn course material that was outside their major. The comments below illustrate this parochialism.

Student course evaluation comments about what they did not like included:

> *I would have preferred more emphasis on science.*
>
> *I didn't like the lack of political science discussion.*
>
> *I didn't like the emphasis on agriculture in this course. It's a political science course. I don't need to know in detail how soil works.*

Grades in the course reflect the reluctance of some students to engage the material. Figure 1 shows that students majoring in agriculture performed much better than students in other majors. The poorer grades of political science and business majors reflect in many cases their unwillingness to focus on the science. Some of these students stopped attending class.

Because the course fulfills university general education requirements in the natural sciences, more than half of the graded quiz, examination, and written paper questions dealt with material from the agricultural sciences. Therefore, agricultural students could do relatively well in the course without incorporating politics in their thinking. By contrast, political science students who understood the politics but failed

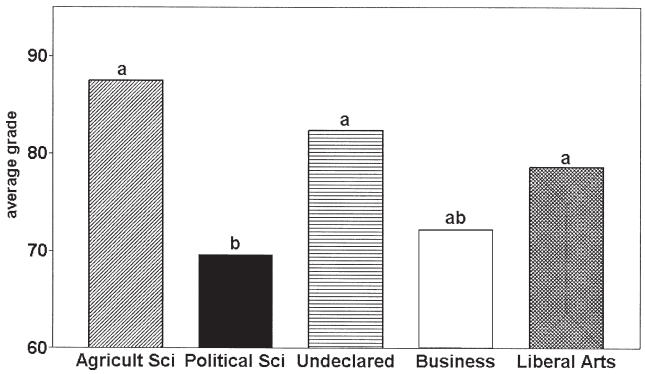

Fig. 1. Average grade by major across all three semesters (1999–2000). *a* and *b* indicate significant differences at $P < 0.05$.

to comprehend the agricultural science did not fare as well as the equally parochial agricultural students.

University policies do not allow political science students to count the course as fulfilling a general education requirement in the natural sciences. For purposes of fulfilling degree requirements, the course counts as a political science course for political science majors. In the course evaluation, some students commented that for this reason, they were not interested in learning about agricultural science, and preferred to focus on politics, perhaps explaining the reluctance of some political science majors in the course to engage the science.

By contrast, many of the liberal arts students who had not yet declared a major or had chosen a liberal arts major outside of political science appeared to be more open to interdisciplinary thinking and learning. As Fig. 1 illustrates, undeclared and liberal arts majors attained grades almost as high as those of the agricultural students.

The course covered economics as well as politics and science. In addition to presenting and discussing economic factors throughout the course, we asked an agricultural economist to give two guest lectures. We integrated the economic concepts presented at several points later in the course. Some students, however, had difficulty understanding that science, politics, and economics all contribute to creating agricultural policies, and ultimately to how agricultural resources are managed and food is produced. Agriculture students often stated that science should be the basis for decision making with considerable attention to economics. Political science students, in contrast, often said the course should emphasize politics and the policy making process. Helping students learn that current policies reflect all of these disciplines and that better policies depend on insights from all of these disciplines was our objective, and our challenge.

Although we are still working to improve the interdisciplinary aspect of the course, we found that *true interdisciplinary team teaching* of sustainable agriculture science and policy enabled us to integrate the disciplines throughout the course. True interdisciplinary team teaching meant that we both were present for classes, and required almost as much class time as teaching an individually taught course. While time spent on grading student assignments and answering independent student questions was reduced, planning the course and adjusting to each semesters' students, however, required extensive, collaborative planning time.

Student course evaluation comments that indicate students valued interdisciplinary teaching:

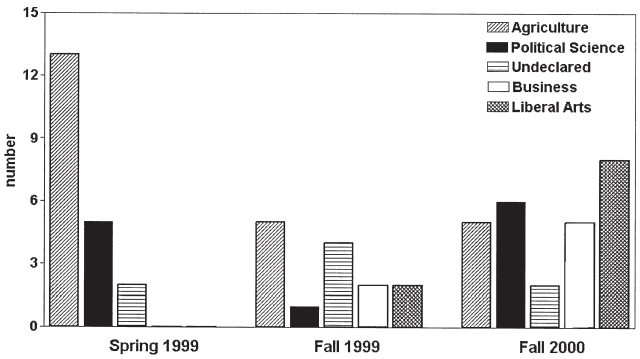

Fig. 2. Number of students by major in each semester course offering (1999–2000).

I liked the integration of agriculture and political science, and the opportunity to apply the material learned in class through discussion.

I liked the broad scope of topics, mixing the policy with Ag to give a view not offered in many other classes.

The course made me think about issues I had never really considered, opening my eyes to many ag. and policy issues. I loved it.

3. Each semester the background of the students, their academic majors, and students' degree of motivation changed. Accordingly we changed how we taught, and focused on key concepts instead of covering many topics. As many students lacked background coursework in or understanding of either agricultural science or political science, we realized that we could not teach the same material and use the same approach each semester. As Fig. 2 demonstrates, in its initial offering most of the students were enrolled in the College of Agricultural Sciences. By the third offering, less than one-quarter of the students were in Agriculture. We learned to cover the crucial concepts in-depth rather than many topics and to adjust the pace, types of evaluation materials, and the way we taught the course to students of different backgrounds each year. For instance, in the last semester offering when students had difficulty with a short paper assignment, we provided feedback and suggestions for improvement. Then, students who had received a below-average grade were permitted to write a new paper that addressed the same question or theme but with different course material. The value of this approach is supported by Light's (1990) survey of Harvard students. Both Light and we found that significant learning occurred when students revised their coursework based on feedback from their instructors. In Light's survey, some students reported that revising work was one of their most memorable learning experiences.

We are still addressing how to teach material to students with weak academic foundations in agricultural science or political science. We are adjusting teaching approaches to students with varied interests and backgrounds as McKeachie (1980), Barbarick (1992), and others recommend. The final course grades indicate that each year students from different majors have successfully learned the course material; however, we still need to address the needs of students with weak study skills, who lack motivation, or who are not natural science majors. We have tried to help these students by encouraging them to work with other students who were performing well. One way to make this happen is to rotate students during in-class activities through groups composed of students from different academic majors.

Student course evaluation comments that support this lesson:

The course was rather difficult for a political science student. At times it seemed like a lot of information was review for the Ag. people.

I found it difficult to follow some lectures without prior knowledge of agricultural terms.

I learned a lot about a subject completely non-related to my major, but vital to society, and I feel that I got a lot out of this course.

4. Frequent in-class writing assignments, discussion, and quizzes improved comprehension over an approach

of just lectures and major exams, and provided important feedback to us. Because students' academic backgrounds and degree of motivation to learn course material varied widely within each class, we gave short quizzes to encourage students to read assignments and review their notes. Frequent in-class activities required students to write and discuss their ideas with classmates and the instructors. In-class discussions clarified student understanding, improved students' self-confidence, and provided important feedback to us about what students did and did not understand. Although in-class activities did require class time, they improved student learning, required students to engage in independent and critical thinking, and kept students engaged in course material. Light (1990) also found that Harvard students reported that frequent evaluation exercises, immediate feedback, and opportunities to revise their coursework significantly improved their learning.

Student course evaluation comments that support this lesson:

> *I liked the frequent quizzes given. This encourages, if not demands, one to read selected materials, which promotes better study habits for all classes.*
>
> *I liked the method of learning and grading. I like the idea of short quizzes and papers instead of multiple choice tests [given] in most classes.*
>
> *I liked the opportunity for group discussions.*

5. Diverse class materials and activities improved student interest and learning. Students benefited from hearing different opinions and perspectives presented in different media, including videos, guest speakers, and field trips. Listening to another person's explanations and perspectives in another context about course materials reinforced crucial information, brought topics to life, and exposed additional aspects that a reading assignment alone could not provide. Guest lecturers were useful, but required efforts on our part to integrate lecture messages into the context of course materials. We often took part of the following class to explain the vocabulary, clarify messages, and discuss the lecture.

Education researchers have found that people learn differently and have described various models of learning styles according to instructional preference models, information processing models, personality models, and social-interaction models (Davis, 1993; Sternberg, 1990; Woolridge, 1995). Therefore, we presented course material with multiple approaches (e.g., field trips, guest lectures, videos, and in-class activities) to respond to different learning styles. Student comments indicated that this approach was effective, and that students appreciated the experiential and human interaction in the course. Many students today are accustomed to using the World Wide Web and to receiving information in many forms that include more than text. These students seemed to respond to videos, field trips, and interpersonal interactions (along with traditional readings and lectures) better than they responded to traditional readings and lectures alone. Barbarick (1992) also found that students thought a variety of educational activities were effective.

Student course evaluation comments that support this lesson:

> *I liked the field trips because it was great to actually be out in the fields.*
>
> *I really enjoyed the field trips, the book, the guest speakers, group presentation assignment. There was a lot of variety and leeway. I also liked that it wasn't a "book course."*
>
> *The guest speakers were excellent, as well as the field trips.*
>
> *I liked the interaction, field trips, group discussion, guest speakers.*

Although we cannot trace learning to any particular teaching method, we can demonstrate that at least some learning did take place during the semester each time we taught the course. The average final student grades (see Fig. 1) are one indication that the majority of students mastered most of the course material. Further, although most of the pre- and postcourse survey questions did not measure knowledge, one item was particularly useful to gauge learning because it measured students' understanding of bioregionalism, one of the major themes of the course. The item asked students if they agreed with the following: "To improve agricultural energy use and nutrient management, regions of the U.S. should specialize in a few agricultural products (as many do), and transport these products to other regions." As regional specialization contributes significantly to both agricultural energy use and regional nutrient imbalances, the correct response is disagreement with the statement. Significantly more students chose the correct answer by disagreeing with the statement at the end of the course (Table 1). These figures were similar for each semester offering: a majority shifted from the wrong answer to the right one. The pre–post surveys also asked if Pennsylvania is "one of the top five states for production" of a number of agricultural products. A statistically significant greater percentage of students understood that Pennsylvania is one of the top five states in both apple and mushroom production at the end of the course (Table 1).

CONCLUSIONS

Teaching an interdisciplinary sustainable agriculture science and policy undergraduate course to students majoring in political science, agricultural science, and other disciplines presents challenges tied to the interdisciplinary nature of the course material and to the diverse backgrounds of the students. The major barriers to learning we identified were differences in students' technical backgrounds and levels of motivation to study a discipline outside of their major. Approaches that

Table 1. Student responses to regional agroecosystem questions before the course began and after the final exam.

Question	Percent of students who answered correctly: Before the course	After the course	Sign
	%		
Pennsylvania ranks as one of the top five states for production of the following agricultural products:			
Apples	41	76	*
Mushrooms	73	93	*
To improve agricultural energy use and nutrient management, regions of the USA should specialize in a few agricultural products (as many do), and transport these products to other regions.	38	70	**

* Significant at $P < 0.05$.
** Significant at $P < 0.001$ for difference of means t-test.

we found helpful to address these challenges and achieve student learning included: (i) compiling a customized set of reading assignments, (ii) addressing student disciplinary parochialism with true interdisciplinary team teaching, (iii) focusing on the crucial concepts rather than broader topical coverage, (iv) employing frequent short quizzes and in-class written activities and discussions to identify points that needed to be clarified, and (v) utilizing a variety of educational materials and activities (e.g., articles, videos, field trips, and guest speakers) to address diverse learning styles.

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