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INTRODUCING PROBLEM-BASED LEARNING TECHNIQUES INTO THE NATURAL RESOURCE MANAGEMENT CURRICULUM AT THE UNIVERSITY OF DELAWARE

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ABSTRACT: Natural Resource Management is a relatively new interdisciplinary major in the College of Agriculture and Natural Resources at the University of Delaware. This paper describes the efforts of faculty to incorporate problem-based learning techniques into several courses in the Natural Resource Management major. It includes a brief history of the major; an overview of problem-based learning programs and initiatives at the University of Delaware; a discussion of problem-based learning techniques recently introduced into courses in statistics, community economic development, environmental law, and a senior capstone course; and observations by faculty and students on the problems and benefits of problem-based learning techniques.

INTRODUCTION

Natural Resource Management (NRM) is a relatively new interdisciplinary major in the College of Agriculture and Natural Resources at the University of Delaware. The major is co-sponsored by three Departments within the College: Entomology and Applied Ecology, Food and Resource Economics, and Plant and Soil Sciences. The program has attracted very high-quality students both as freshmen and transfers from other majors within the university. In response to increased awareness of the benefits of problem-based learning techniques, many

faculty have incorporated problem-based learning techniques into several required and optional courses in the NRM major.

BRIEF HISTORY OF THE NRM MAJOR

The College of Agriculture and Natural Resources at the University of Delaware offers a variety of traditional, discipline-specific undergraduate majors in five academic departments. Beginning in 1994, a faculty committee worked for more than two years to formulate a new interdisciplinary major. The first freshmen students were admitted to the NRM major in the fall of 1997 (Hastings and Anuinas, 1998).

The need for the new major arose from two sources. First, a need to coordinate existing course offerings in the college into an interdisciplinary major that transcended traditional departmental majors (e.g., Wildlife Conservation, Environmental Soils Science, and Agricultural Economics). Second, the college had many requests from prospective students for a major focused on natural resources and the environment. These requests originated from an incorporation of environmental topics into high school biology, chemistry, and agriculture curricula, as well as intensifying local and global issues focusing on the environment

NRM was designed to fill the void for students who sought to have a solid training in the physical sciences but also have an understanding of economics, ethics, and public policy. As articulated by the faculty committee that formulated the major, the purpose of the curriculum was to produce graduates with: (1) an understanding of the social, physical, economic, legal, and political problems of managing the use and perpetuation of natural resources in the twenty-first century and (2) the skills and capabilities to address those problems in both public or private forums.

The curriculum was designed to ensure that characteristics of graduates would include

- the skills required to solve "real-world" problems;
- the ability to write and speak effectively;
- a solid understanding of natural sciences, mathematics, statistics, economics, and public policy;
- a sound knowledge of the world's biodiversity;
- a competence in using computers to manage information and solve problems;
- a broad interdisciplinary education in the arts, humanities, and social sciences; and
- an awareness of the ethical issues in natural resource use and management.

The curriculum relies heavily on courses already offered by the sponsoring departments within the college, (Entomology and Applied Ecology, Food and Resource Economics, and Plant and Soil Sciences), together with courses offered in other colleges across the university.

In the Spring 2002 semester, NRM has 28 majors. Many have done internships with a variety of state and local agencies including the Delaware Water Resources Center, the Delaware Water Resources Agency, the Delaware Emergency Management Agency, the U. S. Army Corps of Engineers, and the Delaware Nature Society. Thus far, the program has produced 14 graduates; seven more will graduate in May 2002. The graduates have been successful in finding jobs in both the private and public sectors as well as attending graduate and law school. Employers of recent graduates are Clayton Group Services (national environmental consulting firm), Environmental Alliance (regional consulting firm), Maryland Environmental Services, the Kent County (Delaware) Conservation District, Horne Engineering Services, and the Department of Natural Resources and Environmental Control (Delaware).

PROBLEM-BASED LEARNING INITIATIVES AT THE UNIVERSITY OF DELAWARE

The introduction of problem-based learning into courses and curricula at the University of Delaware began in 1992 (Duch et al., 2001). Since then, the University of Delaware has become a national and international leader

in the use, training, and development of problem-based learning. Dr. George H. Watson, Professor of Physics and Astronomy, and a leader of campus problem-based learning activities, summarized (via e-mail, January 2002) recent and future activities at the university as follows:

- training faculty in active learning and instructional technology via the Institute for Transforming Undergraduate Education (ITUE), week-long faculty training sessions which began in 1997;
- received funding from both the National Science Foundation and the Pew Charitable Trusts to support problem-based learning education and development;
- developed (and hosting) the Problem-Based Learning Clearinghouse, a peer-reviewed online repository of problem-based learning problems;
- in 2001, offered a bilingual ITUE session for a group of visiting engineering deans from France; and
- in June 2002, will be hosting PBL 2002: “A Pathway to Better Learning,” an international conference on problem-based learning.

PROBLEM-BASED LEARNING IN THE NRM CURRICULUM

Duch et al. (2001), citing Boud and Feletti, outline the problem-based learning process as follows: Students are presented with a problem; working in groups the students identify “learning issues” or aspects of the problem they do not understand; issues are ranked and assigned to be investigated by the group or individually; and, then, the issues are explored and new learning issues developed as the process continues. While numerous operational models exist for this process, most include a problem to be solved/explored, students working in groups, independent exploration by the students, and discussion and/or presentation of findings.

At the University of Delaware, faculty use a variety of problem-based learning techniques in a variety of courses. A text by Duch et al. (2001) provides eleven case studies of different faculty’s problem-based learning experiences in subject-matter areas ranging from agriculture to physics. Some use problem-based learning exclusively; other mix problem-based learning techniques and more traditional lecture-based approaches.

Several faculty that teach required and recommended courses in the NRM major have incorporated problem-based learning approaches into their courses. The following sections describe the approaches used, and student and faculty reactions to them.

FREC 408: “Research Methods I”

FREC 408: “Research Methods I” is designed for juniors and seniors, within the College of Agricultural Sciences and Natural Resources, to provide skills and insight into research methodologies. FREC 408 emphasizes elementary statistics from description of data through an introduction to regression. It generally has an enrollment of 50 students from a diverse set of majors (Animal Science, Agribusiness, Plant Sciences, Natural Resources, Wildlife Conservation, and Entomology). FREC 408 is considered a substitute for a statistics course for these majors and is generally viewed as a requirement of the majors. The course is designed to give the students an appreciation and understanding of the use of descriptive and inferential statistics in the agricultural sciences. The course does not assume that the students have any prior exposure to statistics. Students use spreadsheets and hand calculations to apply statistical techniques to real data.

FREC 408 has historically been taught with elements of problem solving and student projects. However, it was primarily a lecture-based course with students working individually on assignments. In Fall 2000, the structure of FREC 408 was revised to incorporate key components of problem-based learning. Nine group assignments were introduced into the course. One, of three, classes per week, students were assigned one or two problems that reflected course material and were given class time to complete the assignments. The instructor and a graduate student circulated among the groups to answer questions and assist students as they worked. This format

allowed for students to work through statistical applications with the support of their fellow group members. Students signed an answer sheet and turned in their results.

The group assignments were designed to push the students beyond the lecture material. They use interesting examples to demonstrate techniques and strategies of statistical analysis in an interesting format. Answers to the problems were provided via the Web site and at times in the next class.

At the end of the class, students completed a short evaluation that addressed the modifications of the course. The first part of the evaluation used a five-item scale: 1 (Very Useful), 2 (Useful), 3 (Slightly Useful), 4 (Not Useful), 5 (Not at All Useful). Of the 52 students in the class, 44 voluntarily completed the evaluation form (85% response rate).

Students responded positively about the changes to the class. The group assignments were rated as Very Useful or Useful by more than 80% of the students. Over half rated the group assignments as Very Useful. A follow-up question focused on the effectiveness of the group assignments in helping the student understand the material. On a scale from 1-10 (with 10 being Very Effective), the average rating was 7.7 (the median and mode were 8). Only one student gave a rating of one, while nearly 2/3 (63.6%) gave a rating of 8 or higher.

Overall, the use of group assignments in FREC 408 was beneficial. The assignments broke up the monotony of lectures; provided useful exercises to challenge the students; and gave the students an opportunity to work together on problems. As an active participant in the group exercises, the instructor gained a sense of what material needed to be reviewed or emphasized.

No problems were experienced with the make-up of groups or group dynamics. Students did not have to meet or work on the group assignments outside of class. Managing assignments outside of class would have posed more group-dynamic problems. Grading issues were avoided by giving each group all the points for the exercise provided that they were present and completed the work.

There were several “lessons learned” about the use of group work. First, allow enough time to complete the exercises. Second, the group work must be balanced and coordinated with the class lectures. Third, it is important for the instructor and a graduate student to serve as a resource for the groups. Finally, many students wanted to see the correct answer to the problem—post the answers at the end of the exercise or provide the answers on a Web page.

FREC 429: “Community Economic Development”

FREC 429 is not a required course for any major in the department. It is a group option—offering breadth—for majors in Natural Resource Management and Resource Economics. The course objectives are to introduce students to the practice and principles of community economic development in the United States, and to enhance students’ ability to recognize, understand and respond to local, regional, and national economic development issues. Students are exposed to course topics via mini-lectures by the instructor and presentations by other students. Each student is required to read, outline, and present articles from the reading list to the class as a whole.

In addition to individual assignments and exams, major components of the course are two group assignments. For these assignments, teams of 3-4 students are required to function as “economic consultants.” Each team selects (adopts) a county of their choice and is asked to address various economic growth and development issues about the county. Teams organize themselves and assign roles (recorder, task master, etc.) and responsibilities for each of the projects. Students are led through the process of conducting an economic study of their county that includes identifying socioeconomic conditions; identifying an economic issue and how economic theory can contribute to the solution of the issue, applying appropriate analytical techniques and possible policy remedies.

Class time is a must for team discussions, review of work, and assignment of responsibilities. Team reports are presented in a written format and are also presented to the class. Most teams use presentation software and prepare very impressive presentations. For credit, students are asked to specify their role on the team and the extent of their contribution to the report. They also rate other team members' contributions to the project.

In formal course evaluations, student commented that the strengths of the course included the group work and that the course material was applicable to the "real world." They thought that they could apply what they learned in class to local development issues. Overall, it is clear that students enjoy the team approach to address current economic development issues.

From the instructor's perspective, there are several "operational" issues with this approach to the course. One is unequal effort by team members. In some instances, the team members regulate this internally. In some cases, the instructor must intervene. In small classes, it is obvious which students are not participating fully, and if not, other team members will gladly tell you. A second issue is class time allocated to teamwork. If you have used the traditional lecture format, it is difficult initially to relinquish "lecture" time for teamwork. It is naïve, however, to think that team members will find time outside of class to meet on a regular basis. A final, and perhaps the most difficult, issue is assigning credit and grades for team activities.

FREC 450: "Topics in Environmental Law"

The problem-based learning component of the undergraduate seminar, FREC 480: "Topics in Environmental Law," has been increasing since 1998. The course is taught yearly to fifteen to twenty students. The syllabus acts as an extensive course contract, specifying expectations about student effort, active-learning exercises, and group activities. Students are divided into five permanent groups on the first day of class, and each class meeting involves active-learning exercises such as 50-minute problems, role-playing advocacy, group reflection, and peer review. Content objectives center on learning the institutions and processes of environmental conflict resolution in the United States. As important, however, is the course objective to improve the analytical skills of the students. To achieve the latter objective, the course has been redesigned to include a semester-long problem focusing on student analysis and the assimilation of peer and instructor reviews.

Students select an actual environmental conflict to study at the beginning of the semester by searching Lexis-Nexis, using topics of interest to them. The problem then is to identify the fundamental conflict of interests among stakeholders and to assess the relative performance of conflict-resolution processes. Although ultimate student achievement has generally been outstanding in the past, a great deal of resistance (or lack of confidence) from students remained because of the burdens of what was seen as a 25-page research paper. To attenuate this resistance, the active-learning components of this problem were emphasized by the construction of a Web-based interface for peer review.

The interface was designed so students could submit six assignments using a Web-based form over the course of a semester. These assignments, collectively, constitute the semester-long paper. Using the Web, however, the assignments are available to all students for peer review. Group members are required to review four of the six assignments of their peers and submit at least three substantive comments for each using the Web interface. In total, each student posts six assignments on the Web and receives four Web-based critiques from each group member. The instructor also graded and commented on each assignment. At the end of the semester, a revision of the problem is due, which requires students to assimilate between 14 and 18 separate documents of peer and instructor feedback. The technological challenges in designing and maintaining a secure, private interface were substantial (see Duke and Whisler, 2002).

Student comments were positive about the problem-based learning modifications. The comments included the following: "the individual project spanning the semester was very useful"; "the Web site aspect of the course was useful"; "I really enjoyed the class; I definitely have a new view and way of thinking about environmental problems."

The effect of the problem-based learning activities on student learning was positive. The student groups functioned well, and the students treated one another with respect. The class had few disruptions, and the students were consistently engaged. The Web-based interface encouraged the students to complete much more work out of the classroom. In addition, students tended to take more ownership of their projects, improved their level of argumentation, and seemed more accountable for the quality of their work. These quality improvements are likely due to the effect of peer pressure; when all of the students' problem analyses and peer reviews are posted for all the class to see, the incentive to produce a higher-quality product is quite strong. The students actively collaborated in discussing and solving difficulties they were having in completing their problems. A shortcoming of the problem-based learning revision is that the group structure created a vehicle for organized dissent during the particularly difficult times during the semester. Overall, however, the instructor believes the students learned more, spent more time learning, enjoyed class more, and produced higher-quality projects. The higher-quality work was especially evident among the lower-performing students.

ENTO 467: "Capstone: Interdisciplinary Natural Resource Management"

This course was developed to be an interdisciplinary capstone course for Wildlife Conservation, Natural Resources Management, and Environmental Soil Science majors in the College of Agriculture and Natural Resources. Prior to this initiative, no capstone course existed for these majors. The course materials were developed during the Summer and Fall 2000 and the course was offered in Spring. Eight students (WC and NRM majors) enrolled in the course and completed all the requirements.

The course was designed to be a problem-based learning experience. Course content focused on an interdisciplinary approach to examining the White Clay Creek Watershed with special emphasis on the White Clay Preserve (PA), White Clay Creek State Park (DE), and the collaborative effort that led to the watershed being designated a Wild and Scenic River.

The instructor and other experts introduced issues and assignments via mini-lectures. The course involved a mix of group and individual assignments. Course materials were provided in both printed and Web format. Students presented individual and group assignments to the class. The three major assignments focused on (1) biodiversity in the White Clay Creek Watershed, (2) water resources of the White Clay Creek Watershed, and (3) legal protection of the resources of the White Clay Creek Watershed. The theme of all the assignments was using collaboration to solve natural resource management problems. Students used the course text, a variety of government reports and studies, and numerous Web resources to complete the assignments.

Students gained skill in finding relevant resources for problems, sharpened group-activity skills, and improved oral/written communications using "real-world" problems. The focus was on collaboration and providing students with opportunities to practice critical thinking and improve problem-solving skills.

Two evaluations of the course were conducted during the last week of class. One focused on the problem-based learning components of the course. The students found the group assignments, individual assignments, and guest speakers to be very useful aspects of the course. Reactions were more mixed to the readings and the text. The group work was deemed to be very effective (8.65 on a 10-point scale) in helping understand the course material. Aspects of the group work that students liked best were dividing up work and hearing alternative ideas and views. The aspect liked least was finding time to meet outside of class (students were actually given ample time in class to do assignments).

All three of the group assignments in the class involved the White Clay Creek Watershed. Students thought three assignments were appropriate. In retrospect, it might have been better to vary the topics. This was supported by 87% of the students. Overall, the students had positive comments about the course. The small class size was noted as a plus. A suggestion to be considered for the future was a field trip.

In addition to the problem-based learning survey, the regular College of Agriculture and Natural Resources course evaluation was conducted. Overall, the comments about the course and instructor were positive. The students commented that the strengths of the course were “teamwork,” “real-life problems,” and applying what they had learned.

SUMMARY

Since 1992, the University of Delaware has evolved into a national and international leader in the use, training, and development of problem-based learning. Natural Resource Management is a relatively new interdisciplinary major at the university. In response to increased awareness of the benefits of problem-based learning techniques, many faculty who teach required and optional courses in the NRM major have incorporated problem-based learning techniques into their courses. Collectively, the changes are viewed as positive by both the students and the instructors. The changes have added new dimensions to students’ learning processes. The use of these problem-based learning techniques helps produce NRM graduates with many desired skills, including the ability to solve "real-world" problems, the ability to write and speak effectively, the use of technology to manage information, and an interdisciplinary understanding of the world around them.

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