A Decentralized and Onsite Wastewater Management Course: Bringing Together Global Concerns and Practical Pedagogy

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INTRODUCTION
The lack of adequate sanitation for 2.6 billion individuals worldwide is a global concern (World Health Organization 2004). Solutions will require professionals who can learn from an international exchange of ideas, and have the background, and perspective to fully understand and implement appropriate management of water resources and environmental systems. Leaders in industry and academia must accept this as a training and education challenge and prepare to foster the necessary knowledge and skill set development for both practicing and future professionals. To address this challenge at the University of Washington we designed a senior-level engineering course – *Onsite and Decentralized Wastewater Management and Reuse – Technology, Ecology, Policy and Appropriate Solutions* – that provided students with fundamentals of onsite and decentralized wastewater treatment and experience with real-world applications. This team-taught course employed problem-based learning (PBL) (Gijbels et al., 2005) and team-based methods (Michaelsen and Knight, 2004) within a course framework built around six primary learning objectives (see Table 1).

Table 1. Learning Objectives

As a result of this course students will be able to:
1. Identify, define and be familiar with testing and reporting methods for: key wastewater characteristics; environmental impacts of wastewater; public health concerns associated with wastewater; current treatment technologies; and different wastewater streams.
2. Locate and interpret existing policies and regulations for onsite and decentralized wastewater treatment. Distinguish important aspects of policies and regulations relative to designing and operating an onsite or decentralized system.
3. Explain basic elements of a site evaluation that are critical for onsite and decentralized wastewater treatment systems.
4. Provide details of basic elements, design criteria and mechanisms of removal for different onsite and decentralized treatment and conveyance processes.
5. Determine suitable operational management and maintenance schemes for onsite and decentralized wastewater treatment based on needs.
6. Determine key design issues and factors that are important for the successful implementation of onsite and decentralized treatment technologies based on client needs and the desired effluent treatment level and effluent recycle method. Compare and select the most appropriate technologies to meet treatment needs for a given situation.

PBL and other active collaborative teamwork methods were chosen because they have proven to be effective teaching and learning methods and are also more reflective of real-world applications (Halpern and Hakel, 2003). Learning is enhanced when students solve open-ended problems, like those faced by practicing professionals. These activities help students deepen their knowledge and develop design skills that are transferable to professional circumstances and enables them to solve problems on their own (Dym et al., 2005). The course was taught for the first time spring quarter

2007. This paper highlights the main components of the course, the learning outcomes relevant for knowledge transfer of onsite and decentralized wastewater management, and the lessons learned from implementing such a course.

METHODS

We approached the development of this course as a rational design process using Fink's (2003) "backward design" method. The 1st step was to identify our learning objectives (see Table 1), and the next was to determine what the best evidence would be that students had effectively mastered the objectives. We then designed the learning activities applying the principles of *authentic learning assessment*, wherein the learning activities in which students are engaged result in demonstrations (evidence) of the learning they have achieved. This type of assessment is considered an essential component of PBL (Gijbels et al., 2005). Learning activities included applying a hands-on method for ribbon testing soil texture, designing a drainfield, discussing ecological effects of wastewater constituents in small groups, discussing policy as a large group, interacting with professionals in the field, and during the final four weeks of the quarter, engaging in group application projects focused on real-world, global problems.

The course began by building students' knowledge of onsite and decentralized technologies, ecological impacts, and regulatory policies; helping them to create a discrete knowledge framework to then apply it in an engineering design. Six homework assignments and a midterm were used to foster learning and evaluate how well students were achieving learning objectives one through five. Students then applied that knowledge in a four week long group project to achieve objective six. Important aspects of the course included: (a) a web site, in which students could access all information for the course including assignments, readings and supplemental information (http://courses.washington.edu/onsite/); (b) bi-weekly guest speakers from a variety of professional backgrounds; and (c) team-teaching, wherein instructors worked closely together on all aspects of the course development and facilitation.

One of the basic components of the course was a series of pre-class preparation assignments, due at the beginning of each class period. These were authentic assessment activities, designed to serve several purposes. The first was to assist students to learn directly from the readings by helping them identify important points and then to complete a short reflective writing exercise. The pre-class preparation also helped students focus on what was important for the associated course period, giving them a head start in the cognitive learning process of attention, comprehension, and integration (National Research Council 2000; Halpern and Hakel, 2003; Svinicki, 2004). These activities promoted a level of comprehension of the essential information, so that during class time we could introduce case studies and have discussions wherein further structuring and elaboration could take place.

We employed several classroom assessment techniques (Angelo and Cross, 1993) to determine how various aspects of the course were working and whether adjustments needed to be made. Midway through the course, an outside evaluator conducted a small group instructional diagnosis (SGID), as well as a follow-up last class interview (LCI) at the end of the quarter. At the end of the quarter data was also collected through the university's instructional assessment system (IAS).

RESULTS AND DISCUSSION

Mid-term analysis of the learning assessment data and SGID results suggested that the overall course design was working as planned. Students' were developing the intended knowledge of course material and significant gains were being made in how they approached open-ended, real-world onsite and decentralized application problems. However, early data also indicated that several bugs still needed to be worked out. Adjustments were made and by the end of the quarter evidence provided by the LCI, IAS and other metrics suggested that problems with course design were alleviated. Important aspects of this course are discussed in the larger paper.

CONCLUSIONS

In implementing this course we knew that consideration for how students learn to think about and solve problems is essential if we are to going to successfully manage the worlds' water resources and environmental systems. We need a cadre of management professionals with the current knowledge and broad perspectives required to integrate and implement each of the technologies discussed at this conference. Our course is one model for the kind of teaching and learning necessary to build that professional cadre. Based on our experience, here are some recommendations to help ensure that this occurs:

- Course design. Employ a logical approach to course design. The backward design method ensures that learning evaluation is tied directly to the learning objectives.
- Pre-class preparation. Preparing students for class time helps students focus and reflect on their reading. Benefits include increased cognitive development, motivation to complete reading assignments, and a method for ongoing assessment of student learning.
- Limit content. Focus on key fundamentals providing students with a knowledge base ensuring they are later able to access and build information on their own. Covering material in class is not equivalent to student learning.
- Formative evaluation. Evaluate teaching effectiveness and alignment with student-based learning principles. Implement evaluations with adequate time remaining in the course to modify or address any necessary changes.
- Appropriate tools. Instruct students how to effectively work in groups prior to asking them to work on group assignments. Teach students what design means and how to approach it before asking them to work on a design project.
- Teams. Form diverse design teams to increase learning from group members with complementary skill sets and aid in development of real-life design project skills. Promote accountability of individual group members.
- Course expectations. Clarify expectations early and often throughout the course. If students understand how what they are learning fits into the progression of the course and relevance to learning objectives, it will enrich the potential for them to fully understand concepts.

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