Problem-based learning and e-learning approach to teaching introductory soil science course

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Abstract
In most faculties of agriculture, the Introduction to Soil Science course is traditionally taught using a combination of lecture and laboratory formats. To promote engagement, improve comprehension, and enhance retention of content by students, Introduction to Soil Science was developed and delivered on-line using Blackboard® and Moodle® (Course Management Platforms), and employing a problem-based learning (PBL) approach to teaching the course. Delivering the course using PBL shifts the focus to student-centered learning by assigning student teams to work and report on a number of current soil science themes. Teams of students are responsible for problem investigation and definition, for identifying and obtaining the information and skills they will need for development of a satisfactory solution. Each of the problems undertaken by student teams concludes with student presentations and the preparation and submission of a professional quality work product. Teams work semi-competitively on the same problems so that students can learn from the experience of other students that are reflected in the oral reports. The construction approach of this online course is presented, including new teaching approaches, assessment tools and mapping of course outcomes to program outcomes.

Key Words
Active learning, student-center learning, project-oriented, team-based learning

Introduction

The Introduction to Soil Science course has a lecture and laboratory component. The main expected outcome of the course is problem-solving skills, which make student (1) be able in individual and team/group settings to use the scientific method to solve problems related to soil resource management; (2) be able to identify and treat problem causes, rather than effects; (3) be able to see the whole of a problem, including the social and economic aspects, along with the soil resource management aspects; (4) be able to make logical decisions based on available information and (5) be able, when appropriate, to include the personal values of those involved in decision-making. Problem-based learning (PBL) is an instructional method that challenges students to "learn to learn," working cooperatively in groups to seek solutions to real world problems. These problems are used to engage students' curiosity and initiate learning the subject matter. PBL prepares students to think critically and analytically, and to find and use appropriate learning resources (Duch 1996; James 1998; Duch, *et al.* 2001).

Introduction to Soil Science course is well suited for development and delivery employing PBL. PBL has shown promising results in achieving course objectives and positive outcomes in soil science courses overseas (Smiles *et al.* 2000; Amador and Görres 2004). Previously, Introduction to Soil Science course was delivered as a traditional teacher-centered, lecture based course. The developed course has been designed for delivery in a studio style that models the project-oriented, team-based approach used universally by soil science professionals (Smiles *et al.* 2000; Amador and Görres 2004; Kelley 2004). Delivering the course using PBL shifts the focus to student-centered learning by assigning student teams to work and report on a number of current soil science themes. Teams of students are responsible for problem investigation and definition, for identifying and obtaining the information and skills they will need for development of a satisfactory solution. Each of the problems undertaken by student teams concludes with student presentations and the preparation and submission of a professional quality work product. Teams work semi-competitively on the same problems so that students can learn from the experience of other students that are reflected in the oral reports.

Course Design

Introduction to Soil Science course was developed around four learning modules employing the Problem-Based Learning and active learning methodology, supported by Blackboard or Moodle and computer technologies. Each learning module is of four weeks' duration. Each module is structured as a short project

in which students work to understand, explore, and recommend contributions to soil science goals. Table 1 shows an example of the structure of Module 1.

The course learning modules are:
1. Module 1 – Soil Genesis
2. Module 2 – Soil physics
3. Module 3 – Soil Mineralogy, Chemistry and Fertility
4. Module 4 – Soil Survey and Classification

Table 1. The Structure of Module 1 - Soil Genesis.

Week-1	Week-2	Week-3	Week-4
Meeting 1	**Meeting 2**	**Meeting 3**	**Meeting 4**
Session-1	**Session-1**	**Session-1**	**Session-1**
Course Introduction	***Problem Exploration 1***	***Problem Solving 1***	***Outcomes & Solutions***
1. Introductions **2. Distribute outlines** **3. Mini-lecture:** Introducing Problem-Based Learning **4. Assign PBL readings**	**Team work and consultations**	**1. Mini-Lecture:** Soil Development, Chapter 4 **2. Team work and Consultations**	**1. Team Meetings** **2. Student Presentations & Report submission**
Session-2	**Session-2**	**Session-2**	**Session-2**
Team formation and Problem Assignment **1. Mini-Lecture:** Introduction, Ecological Functions, Rocks and Minerals, Chapter 1, 2 and hand out 2. **Team formation** **3. Problem Assignment** 4. **Team work session**	***Problem Exploration 2*** **1. Mini-Lecture:** Soil Formation, Chapter 4 **2.Team work and Consultations**	***Problem Solving 2*** **Team work and consultations**	***Module Test:*** **Chapters 1, 2, 4**
Lab -1	**Lab -2**	**Lab -3**	**Lab -4**

Use of technology
Blackboard or Moodle and computer technology have been employed in all class session. Many additional linls to technologies, activities and resources links have been added to provide depth for student exploration and use following graduation. Additional technologies, activities and links include (1) educational videos, (2) internet sites & links and browse documents, (3) communication/interaction between faculty/students & student/student (using e-mail, new groups, white board and broadcast), (4) online quizzes. Students gain access to a large database of high quality questions and answers covering a broad range of topics. The answers and explanations will enable student to learn more about the topic as well as related material), (5) online laboratory skills virtual resources and hands-on experience during the laboratory time, (6) Net.OP (class management software) for monitor student activity in class, (7) PowerPoint for basis of course and student presentations, and (8) Chime Plug-In for 3-D silicates minerals visualization.

Restructuring lectures (learning activities - integrating lectures and hands-on)
The class time is 100 min. The lecture is divided into two sessions, 50 min. each. Based on the activities in each session, the distribution of session time (different from one class to another, see Table 1) is as follow: (1) 20 min. mini-lecture or team work, (2) 15 -20 min. consultation or watching educational videos or/and accessing web sites searching for specific information, (3) 5-10 min. taking online quizzes, (4) 5 min. homework/assignment, (5) interacting with instructors or classmate, e-mail, new groups and browse documents, anytime, and (6) doing Lab exercises (hands-on experience) during the laboratory time.

Delivery Method
Synchronous and asynchronous e-learning deliveries have been incorporated into Introduction to Soil Science course. The synchronous delivery method includes (1) mini lectures, (2) in-class discussion and

analysis, (3) face- to- face student teams meetings in class, (4) student oral report presentation, and (5) online laboratory skills virtual resources and hands-on experience during the laboratory time. The asynchronous delivery method includes (1) E-mail & digital drop box and (2) browsable documents on Blackboard or Moodle. Table 2 shows the mapping of Intended Learning Outcomes (ILO's) of Introduction to Soil Science course to Soil Science Program.

Table 2. Mapping of Course ILO's to Program ILO's.

Learning objective	Program ILO's	Code	Course ILO's
Knowledge and Understanding	A.1. Understand the theoretical basis of different soil properties	A.1.1	Identify the nature, origin and function of soils.
		A.1.2	Describe the soil texture, structure, porosity and color.
		A.1.3	Define the soil CEC and pH.
		A.1.4	Explain the concept of soil fertility.
	A.2. Explain the concepts, principles and theories of soil–water–plant relationship	A.2.1	Define soil water content, classification, potential and availability
	A.3. Outline basics of soil formation, survey and classification	A.3.1	Describe elementary aspects of soil formation
		A.3.2	Name different horizons in soil profile
		A3.3	Identify 12 soil orders in the USA Soil Classification System.
Intellectual Skills	B.1. Obtain and use information and ideas from both on- and off-line sources	B.1.1	Solve problem assignments of each course module using on and off-line collected information
		B.1.2	Calculate soil bulk density, porosity and water content.
	B.2. Transfer and integrate appropriate knowledge and methods from one topic within the subject to another.	B.2.1	Relate soil physical, chemical and biological properties with nutrient availability and different agricultural practices.
Professional and Practical Skills	C.1. Analyze soil, water and plant efficiently	C.1.1	Analyze soil for texture, color, water content, CEC and pH.
	C.2. Identify and assess of different types of soil problems (i.e. salinity, alkalinity, compaction, pollution, … etc.) in the field and suggesting solutions.	C.2.1	Demonstrate the ability to apply the knowledge learned in the course during lab and field internship.
		C2.2	Identify soil problems by soil analysis and field examination and suggesting solution.
General and Transferable Skills	D.1. Communicate scientific ideas in written and oral form.	D.1.1	Communicate and present soil and water idea, principles and theories through written, oral and visual means.
		D.1.2	Evaluate approaches to problem-solving related to soil and water.
	D.3. Work as part of a team	D.3.1	Develop skills in lab and communicating tasks within a group setting, take part in group discussions and co-operative learning.

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