A Template for Developing a Web-Enhanced Course

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Abstract

Many web-based learning environments are currently available. Each of these environments provides a unique suite of tools consisting of some combination of course and grade management functions, instructional postings, chat rooms, e-mail accounts, bulletin boards, forums, on-line presentation capabilities, and interactive on-line assignments. Learning to use these tools can be a challenging task. However, determining how to incorporate these tools as an effective part of a course may be even more difficult. This paper presents a template which may be used to construct web-enhancements to a course. This template has been used to enhance a course with classroom contact but could be employed, with few modifications, to implement a completely on-line course. An example lesson covering Bernoulli’s Equation and the Energy Equation is presented.

Introduction

The use of the internet to enhance student learning has become very popular. Originally, the use of the internet consisted mainly of providing lecture notes and links to related web-sites. Today, many web-based learning environments are available. Each of these environments provides a unique suite of tools consisting of some combination of course and grade management functions, instructional postings, chat rooms, e-mail accounts, bulletin boards, forums, on-line presentation capabilities, and interactive on-line assignments. Learning to use these tools can be a challenging task. However, determining how to incorporate these tools as an effective part of a course may be even more difficult. Many of the tools which are technologically exciting, may not be very effective teaching tools and the temptation to use all of the bells and whistles in a particular environment may result in both the teacher and student losing focus and wasting time.

This paper presents a template which may be used to construct web-enhancements to a course. The template has been used in a senior level engineering course on solid waste management. This course was originally taught with two 75 minute weekly sessions in the traditional lecture and chalkboard format. The class progressed over six semesters to become a web-enhanced course which met once per week for 75 minutes. The course uses the Web CT environment and includes three primary on-line components: lesson plans, quizzes, and homeworks. During the six semesters of developing internet content, many mistakes were made, lessons learned, teaching packages evaluated, tangential paths followed and ultimately, the approach and template presented in this paper for enhancing future courses was identified.

Lesson Template

A lesson consists of five main components; required readings, an on-line lesson, an on-line quiz, classroom content, and homework assignments. A student’s view of a typical lesson is shown in Table 1.

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Table 1. Student View of a Typical Lesson.

1. Complete required reading.
2. Complete on-line lesson.
3. Complete the on-line lesson quiz.
4. Classroom activities (lectures, Q&A sessions, problem solving sessions, etc).
5. Complete an on-line homework assignment.
6. Rework homework problems missed during the on-line submission and submit a hard copy.

The five lesson components and the student view of a lesson will change little regardless of the length of the topic to be covered. For instance, in the Solid Waste Management Course, waste properties are covered with one on-line lesson, one lecture, and one homework assignment while landfill design is covered using multiple on-line lessons, quizzes, and homework assignments.

**Developing a Lesson**

The development of any lesson follows a simple seven-step procedure. These steps are presented and discussed in the following sections.

**Step One**

The first step in developing a lesson is to identify the lesson topic. This can range from a single simple topic (ex. detention time, enthalpy, etc.) to the complex (ex. landfill design, finite element analysis, etc.). Complex lessons can be approached with either a single large lesson or multiple lesson modules.

**Step Two**

Write down the lesson objectives and goals. Writing the objectives and goals will help focus the development of the lesson material and focus the students on the important topics. Objectives are general while goals are very specific and preferably measurable outcomes. The objectives and goals used for the waste quantity lesson are shown in Table 2.

Table 2. Goals and objectives for the waste quantity lesson.

**Objective:** To quantify MSW generation in the US and Florida

**Goals:**
- Determine why quantification is important
- Understand the methodology used to quantify MSW
- Become aware of differences among global production rates
- Understand factors affecting waste generation rates
- Become familiar with per capita generation rates

**Step Three**

Identify the lesson content and separate this material into independent and in-class categories. This can be as simple as taking existing lecture notes and marking them up or as involved as identifying pertinent websites, collecting articles for additional reading, or even creating video files. It is very important not to go overboard in this step. Start simple, use what you already have and are familiar with, and then build from there.
Material which students can study independently typically includes reading assignments, comparing and contrasting data, reviewing graphs and figures while looking for specific details, and re-working example problems. The re-working of example problems with new numbers and a posted solution is a particularly useful technique. It ensures student familiarity with basic problems and solution techniques.

In-class material includes the presentation of unpublished material, traditionally difficult material, real world experiences, open discussion of topics from the independent lesson, problem solving sessions, and collaborative learning exercises.

**Step Four**

Develop the on-line lesson for the independent material. The on-line lesson plans consists of

1. a statement of lesson objectives and goals,
2. primary reading assignments from the text and supplemental sources, and
3. an interactive lesson to be completed after the primary readings.

The interactive lesson presents the high points from the primary readings and supplementary material including pictures, graphs, links to other sites, and additional readings. The interactive lesson also includes “What if” and compare/contrast questions, example problems, and solutions for variations on example problems. The variations on example problems have been particularly successful in that they force the students to plug in different numbers and follow through the example problem which ensures some level of understanding and familiarity with basic problems and solution techniques.

The interactive lesson can be developed by first outlining the important points from the reading materials. Once these outlines have been completed, comparisons and contrasts between different articles, figures, and tables can be pointed out. The interactive lesson should direct the student focus to these topics.

**Step Five**

Develop a quiz for the students to take once the independent material has been completed. Ideally, this quiz will be completed prior to presentation of the in-class material. The quiz content should be aimed at ensuring that the student completed the independent material and should have a time limit to ensure that the student studied the material prior to the quiz. Rudimentary material from the reading assignments and outline as well as variations to example problems presented in the lesson plan should be covered in the quiz. In my classes, the quiz may be completed twice and the average score is recorded. This approach encourages students to review the material they missed.

**Step Six**

The material designated for classroom presentation should be organized and in-class lessons developed. Basic material covered in the on-line lesson need not be reiterated in the classroom lesson plan. However, important or complex topics can be emphasized or clarified in the classroom lesson. Collaborative learning exercises rather than lectures are generally best when addressing materials already covered in the on-line lesson.

A qualitative benefit of the on-line lesson plan and quizzes has been significantly more dynamic and interactive lectures. In some cases, the prepared lecture materials were covered in a question and answer session driven by the students. The very topics that were not covered sufficiently in the independent material were what the students had questions about.
Step Seven

Develop a homework set which covers the on-line and independent material in greater depth and complexity. The homework should have both an on-line and hard copy submittal grading component. The initial grading of the homework is done on-line. Students are given an unlimited time to work these problems and initially submit them on-line at which time the problems are automatically graded and the correct answers are provided. If a student does not get a question right, they may submit the problem reworked correctly at the next class meeting for full credit. Thus, the students take a very active part in learning to work problems. This approach also has a positive impact on student time management and a professor’s office hours. Once this technique was employed, it was observed that students came to get help with the class material on a regular basis throughout the semester rather than the day before an exam.

Additional Comments

When developing the quiz and homework sets, some mechanism must be used to ensure that the work submitted on-line represents a student’s personal effort. With some creativity, techniques can be developed which encourage collaborative learning while ensuring individual mastery of the material.

A simple method of ensuring independent work on the quizzes is to randomly order the questions on each student’s quiz. Each student will receive the same questions but in a completely different order. Most software packages have a built in mechanism to randomize the question order. Homeworks can be approached by making several versions of the same question. The only difference between questions will be variations in the numbers used to solve the problems. This approach enables students to work together since the solution approach will be the same but ensures that all of the students understand the solution process.

Observed Benefits

The incorporation of web-based teaching technologies and particularly the implementation of the lesson template presented in this paper have provided the following benefits.

- Students arrive at class better prepared for the material to be presented.
- The textbook can become an active part of the learning process.
- Many lectures drive themselves with the lesson content being presented through an interactive question and answer session.
- Students are forced to keep pace with the class and receive instant feedback on what their deficiencies are.
- Student focus can be directed at the important topics. They know what they are expected to know.
- Open-ended ‘compare and contrast’ and ‘what if’ questions can be presented in the lesson and then discussed in class.
- Groundwork can be laid for classroom collaborative learning exercises.

In addition, students have commented that they have little preparation to do immediately prior to an exam. They have also expressed that they know what is expected of them and which specific topics they must review to ready themselves for the examination.
Web-Enhancement Example

On-line Lesson

Bernoulli’s Equation and the Energy Equation

Objective: Present Bernoulli’s Equation and the Energy Equation and applications

Goals:

- Memorize Bernoulli’s Equation and the Energy Equation,
- Explain the significance of the various terms in the equation,
- Compare and contrast Bernoulli’s Equation and the Energy Equation, and
- Use these equations to solve problems

Read: Text, pp. ## to ##

Both Bernoulli’s Equation and the Energy Equation were developed by performing an energy balance between two sections of pipe. Bernoulli’s equation was developed assuming no energy losses between the two sections whereas the Energy Equation was developed from Bernoulli’s Equation with the additional and realistic assumption that some amount of energy is lost between the two sections.

The energy balance for Bernoulli’s Equation is:

\[
\{ \rho g Q \partial (h_1 - h_2) \} + \{ P_1 Q \partial t - P_2 Q \partial t \} = \left\{ \frac{1}{2} \rho Q \partial t (V_2^2 - V_1^2) \right\}
\]

\{change in potential energy\} + \{change in pressure energy\} = \{change in kinetic energy\}

This can be simplified and expressed in terms of the pressure head, elevation head, and velocity head all of which have units of length as shown below

\[
z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g}
\]

Bernoulli’s Equation

If energy is lost between sections 1 and 2 then the summation of the energy heads at 2 will be less than the energy heads at 1. We now introduce the head loss term \( h_L \), also with units of length, which accounts for the energy lost between section 1 and 2. When this term is added to Bernoulli’s it is called the Energy Equation and has the form shown below:

\[
z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_L
\]

Energy Equation
**Example Problem:**

Determine the flow rate through the gradually tapered pipe shown in the figure below

![Diagram of gradually tapered pipe](image)

Section 1:  
D = 30 cm  
P = 10 m

Section 2:  
D = 10 cm  
P = 2 m

Pipe slope = 2%

Head loss = 3m

We will apply the Energy Equation to solve this problem. The centerline of the pipe at section 2 will be used as the datum. Thus, \( z_2 = 0 \) and \( z_1 = \frac{(2\%)}{100} \times (1 \text{ mile}) \times (5280 \text{ ft/ mile}) \times (1 \text{m/3.28 ft}) = 32.2 \text{ m} \). The cross-section pipe flow areas are \( A_1 = 0.071 \text{ m}^2 \) and \( A_2 = 0.008 \text{ m}^2 \). The energy equation can then be rewritten:

\[
\frac{z_1 + P_1}{\gamma} + \frac{Q_1^2}{2gA_1} = \frac{z_2 + P_2}{\gamma} + \frac{Q_2^2}{2gA_2} + h_L
\]

Since \( Q_1 = Q_2 = Q \) this equation can be rearranged to

\[
\frac{Q^2}{2g} \left( \frac{1}{A_1^2} - \frac{1}{A_2^2} \right) = \left( z_2 - z_1 \right) + \left( \frac{P_2 - P_1}{\gamma} \right) + h_L
\]

By plugging in known values and solving we find that \( Q = 270 \text{ liters/sec} \).

**Think:** How would this problem change if we applied Bernoulli’s equation instead of the Energy Equation? Would the flow rate go up or down?

**Rework:** Rework the example problem above assuming a pipe slope of 3%, \( D_1 = 40 \text{ cm} \), and \( D_2 = 15 \text{ cm} \).

You should get \( Q = 350 \text{ l/sec} \).

**Think:** What would happen if the pipe was not tapered (i.e. \( D_1 = D_2 \))?  

**Think:** What would happen if the tapering were reversed (i.e. \( D_2 > D_1 \))?
On-line Quiz

1) Match the equation with its description

   a) \[ z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_L \] ___Bernoulli's Equation

   b) \[ z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} \] ___Energy Equation

2) Rework the Example Problem in the on-line lesson using D_1 = 15 cm and D_2 = 5 cm.

3) The units on the term V^2/2g in the Bernoulli and Energy Equations are:
   a) Time
   b) Force
   c) Momentum
   d) Pressure
   e) Length

Classroom Material

1) Present the use of hydraulic and energy grade lines (HGL and EGL) to visualize Bernoulli’s Equation and the Energy Equation.

2) Brief presentation on using Bernoulli’s and the Energy Equations between multiple points in a system.

3) Collaborative learning exercise

4) Question and answer session on approach to problems

Homework

1. Determine the pressure at section 2 of the horizontal pipe shown below using Bernoulli’s equation. The pressure at Section 1 is 10 psi and the volumetric flow rate through the pipe is 40 gpm. Give your answer in psi and feet. Watch your units.
2. Determine the pressure at section 2 of the horizontal pipe shown in Problem 1 using the Energy Equation and a head loss of 4 psi.

3. Determine the volumetric flow rate through the pipe system shown. Assume a head loss of 5 m between the inlet and outlet. The inlet (large pipe) has a diameter of 50 cm while the outlet (small pipe) has a diameter of 20 cm. Calculate the velocity in the large and small pipes. **Think:** Could you solve this problem if the inlet and outlet pipes had the same diameter?

4. Determine the elevation of the downstream reservoir in the figure below if the volumetric flow rate is 10 cfs and there is a head loss of 7 ft between the two reservoirs. The pipe connecting the 2 reservoirs has a diameter of 1 ft. **Think:** How do the HGL and EGL concepts apply to this problem.
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Dr. McCreanor has over eight years of experience in the solid and hazardous waste management field. He is currently employed as an Assistant Professor in the School of Engineering at Mercer University. His teaching interests include solid waste management, hydraulics, mathematical modeling, and groundwater hydrology. His research interests include bioreactor landfills, modeling the hydrodynamics of leachate recirculation systems, evaluation of landfill leachate collection systems, unsaturated groundwater flow, and remote/automated sensing. He is the current chairman of the Association of Environmental Engineering and Science Professor's (AEESP) Electronic Communication and Education Committee (ECEC).