TEACHING EMERGING COMPUTER TECHNOLOGY TO ENGINEERS: A PROBLEM SOLVING APPROACH

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ABSTRACT

Due to the impressive progress in computing ability that the world has witnessed over the last couple of decades, the coverage of emerging computer technology in most engineering courses is no longer a matter of choice. Coming to this realization, many engineering departments and colleges have been increasingly integrating computer technology in their curricula by either modifying the coverage of certain courses or the creation of complete new courses. The Department of Civil Engineering and Construction at Bradley University adopted the latter approach a few years ago, and students must now take a course titled "Emerging Technology in Civil Engineering and Construction" in order to fulfill the requirements of graduation with a Bachelor's degree in civil engineering or construction. Although the introduction of a new course presents advantages such as 1) not having to add coverage to other courses that may already be overloaded and 2) avoiding the repetition of the coverage of the same material in different courses, it does have it own challenges. One of these challenges is how to teach students to use a certain software package to solve a variety of engineering problems, some (if not most) of which they have not even been exposed to. This paper discusses these challenges and presents some of the solutions that this author adopted to ensure that students not only learn how to use a computer tool, but rather how to use a computer tool to solve a given engineering problem.

KEY WORDS

teaching technology, computer technology, problem solving, emerging technology, teaching software

INTRODUCTION

Engineering problem solving is all about understanding the nature of a given problem, considering solution strategies, evaluating possible solutions based on some feasibility, acceptability, and economical criteria, adopting and finalizing the most viable solution, and finally reporting the details of the adopted solution to other parties for follow-up action. Because of the relative complexity of this process, an effective use of emerging computer technology can expedite it and greatly enhance its outcome. Consequently, the civil engineering and construction professionals of today are a lot more dependent on computer technology than their even recent predecessors ever were. As Dewey (1998) put it, "the common first course in the engineering curriculum has evolved from drafting/graphics to one

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in computer applications." This evolution reflects the changing expectations of the industry towards new graduates, whom are now supposed to be proficient in using a good number of computer tools and applications as soon as they start their professional career. For this reason, it has become imperative that students learn early on during their education how to use these tools.

This requirement, however, presents a couple of problems that need to be addressed before any computer technology related material can be efficiently incorporated in an existing engineering program. The first problem has to do with the logistics of squeezing in more instructional material in an already packed program, at a time when a pressure exists on engineering departments to keep their graduation requirements at a competitive level. The second problem has to do with the timing of introduction of this material: should it be taught to students during their freshman year so they can benefit from it during their later classes, or should it only be introduced when students have had an opportunity to develop some engineering problem solving skills so they can grasp the material and apply it in a more efficient way? This paper addresses these issues and tries to shed some light on ways they can be tackled.

COMPUTER TECHNOLOGY AND PROBLEM SOLVING SKILLS

Over the last couple of decades, the personal computer has invaded schools, businesses, and homes at every level. Consequently, most students are quite computer-literate by the time they make it to engineering school. However, and by simply interacting with these students, it would not take a very long time for one to find out that this literacy is very limited in nature and in scope. Moreover, these students, for the most part, do not really know how to use the computer knowledge that they have to solve problems. This is probably what prompted researchers, such as LeBlanc (1998), to argue that problem solving is an acquired skill that must be incorporated in an engineering curriculum. Maul and Gillard (1996) emphasized the importance of class and team make-up during the learning process, pointing out that problem solving skills are best learned by doing. Nix (2004), who used information technology to teach problem solving skills, describes how tools that are learned in the process can be extrapolated for solving general problems. The effectiveness of this technique was further echoed by Hoff et al. (2002) and Harrison and Deanes (2005) who also used some aspects of information technology to enhance problem solving and critical thinking skills in their students.

The literature is full of many other examples of the successful use of computer and information technology tools for teaching, or at least enhancing the teaching of, problem solving skills in a variety of engineering and scientific fields. These tools were reported to have been introduced at different levels of the education process, and were found to be useful at all these levels. The next section describes the approach that was adopted by the Bradley University Department of Civil Engineering and Construction to introduce emerging computer and information technology into the civil engineering and construction curricula. This is followed by concrete examples of class assignments that were used to motivate students to be proactive learners while broadening their understanding of information technology and enhancing their problem solving skills.

COURSE DESCRIPTION AND PYDAGOGIC APPROACH

A few years ago while carrying out a program evaluation and revision, and driven by a desire to enhance the learning experience of their students, the faculty at the Bradley University Department of Civil Engineering and Construction (CEC) came to the conclusion that the introduction of a viable information technology component in their curriculum was the best way to go. Consequently, the civil engineering and construction programs where modified to incorporate a required emerging technologies course, which was offered for the first time during the spring semester of 2003. Figure 1 depicts the description of the course as it appears in the most recent Bradley University Undergraduate Catalog.

CE 124 Emerging Technologies in CEC 2 hrs.
Examination of emerging computer technologies and their relevancy to Civil Engineering and Construction. Introduction to common software including spreadsheet, word processing, databases, graphics and presentation. Exposure to multimedia tools such as text, image, sound video and animation. Introduction to E-mail and Web page development. Cross-listed as CON 124.

Figure 1: Bradley University Catalog Entry for the CEC Emerging Technologies Course (Bradley University 2005-2006)

The main objective of the course was to introduce civil engineering and construction students to useful computer technology early on during their program of study. The two credit-hours class was therefore set to be offered to students during their second semester in college. This would give them a chance to start using the new skills and knowledge they are acquiring to solve problems in higher level classes while still having adequate guidance from their instructors. This guidance is critical to the proper development of problem solving skills in the different areas of civil engineering and construction, and it would clearly not be available if the course is otherwise offered closer to the time of graduation. On the other hand, presenting problem solving tools to students who do not quite understand the types of problems that they would be required to solve in the first place can often present a challenge. It turns out, however, that this challenge can easily be overcome when one considers going back to the basics of engineering problem solving. In fact, a careful examination of any engineering activity will reveal that the process, as depicted in Figure 2, involves three main stages, which are: planning a solution, implementation of the solution strategy, and then finally reaching the target of presentation of the results. From a civil engineering perspective, the planning stage will involve the collection of important project information, i.e. research, and the development of solution alternatives and a feasible plan of action. The implementation stage will involve carrying out the adopted design alternative and ensuring that all the decisions that are necessary for meeting project requirements are taken. And the final stage encompasses the development of all necessary reports and plans and presenting them to the appropriate parties for follow-up action. From the construction point of view, the planning stage would also involve the collection of pertinent project information and the scheduling of the various construction activities and the implementation stage involves the

execution of the plan and the continuous monitoring of adequate and timely progress of the planned activities. The presentation and delivery stage involves the filing of all required documentations and securing the owner's certification that the project has been completed.

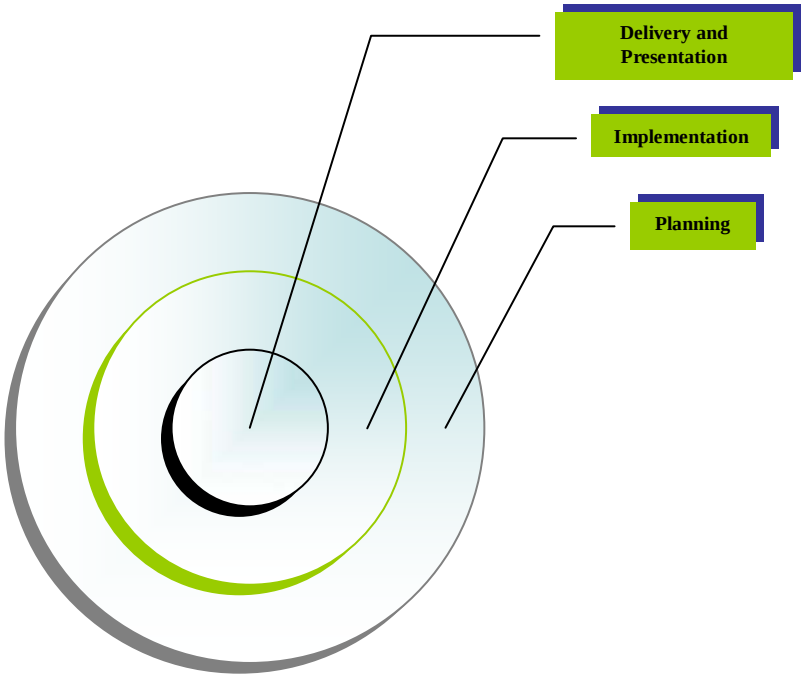


Figure 2: Basic Problem Solving Strategy in Civil Engineering and Construction

The three-stage engineering problem solving approach actually turned out to be quite useful in this course because it was easy to apply in every assigned project. A sampling of the projects that the students had to complete is provided in the next section.

INSTRUCTIONAL EXAMPLES

All of the exercises that the students had to complete to pass the course were selected to broaden their knowledge of information technology and emphasize the Plan-Implement-Present and Deliver theme described in the section above. In the first assignment, the students were asked to identify five different branches of information technology, research them, and come-up with two concrete applications, in each branch, pertaining to civil engineering and construction. They were to report their findings using a chart that they had to produce using the Microsoft drawing program Visio (2002). The only help they had, other than the Visio tutorial, was a modest listing of some examples of IT applications in civil engineering and construction and the general format of the figure they had to come up with. Figure 3 shows a sample of the work that was produced by the students. This simple exercise introduced the 'initially unknown' concept of information technology to the students, made them familiar with part of the technological terminology of the trade, gave them the chance to appreciate the value of research as a problem solving tool, and allowed them to practice

using a new software tool while inciting their creativity and building their confidence in the process.

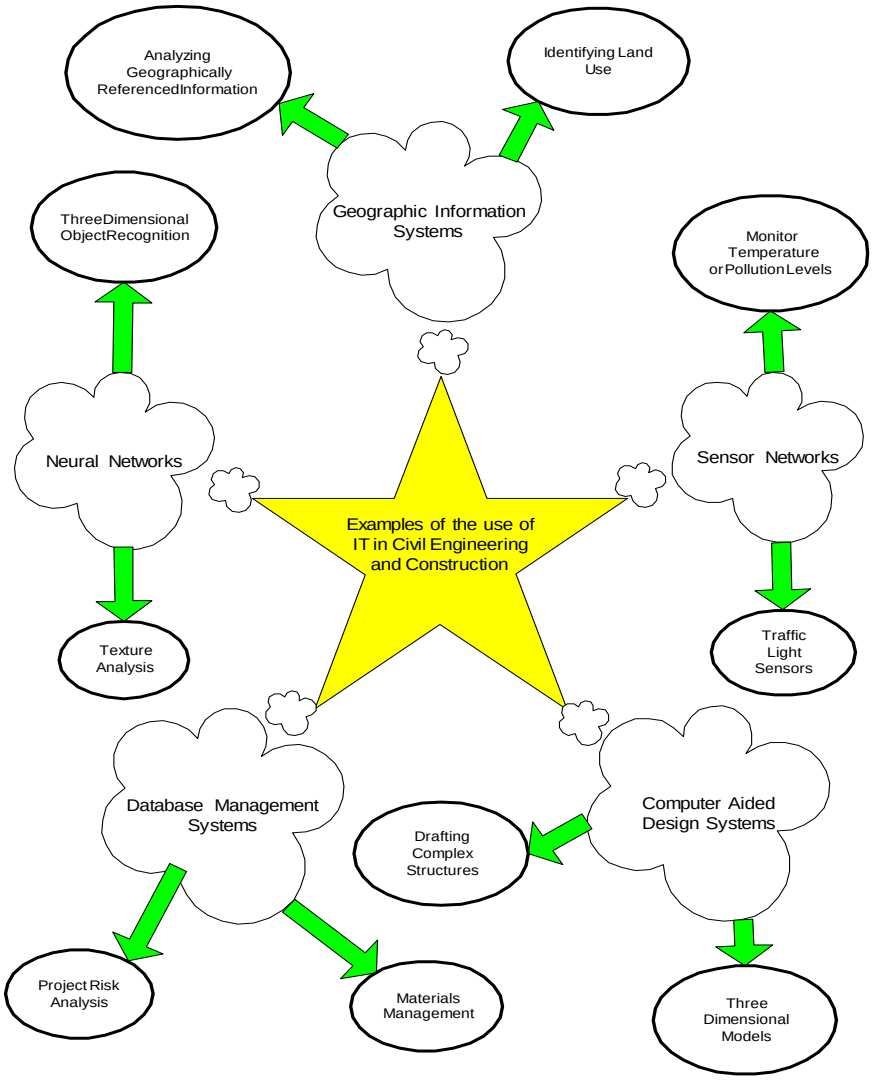


Figure 3: Sample Student Depiction of IT Applications in Civil Engineering and Construction

The second set of exercises in the course was designed to illustrate the importance of artistic presentation and its utility in the civil engineering and construction industry. Students in the class are introduced to the image editing program Photoshop 6.0 (2001) and given examples of how and where it can be used to support the activities of civil engineers and constructors. Although the tutorial that is provided to the students was not designed to make them proficient Photoshop users, it does provide them with basic image editing terminology and techniques to be productive. As an exercise, they are provided with the picture of a structure or scenery and asked to introduce modifications to it to meet their client's requirements.

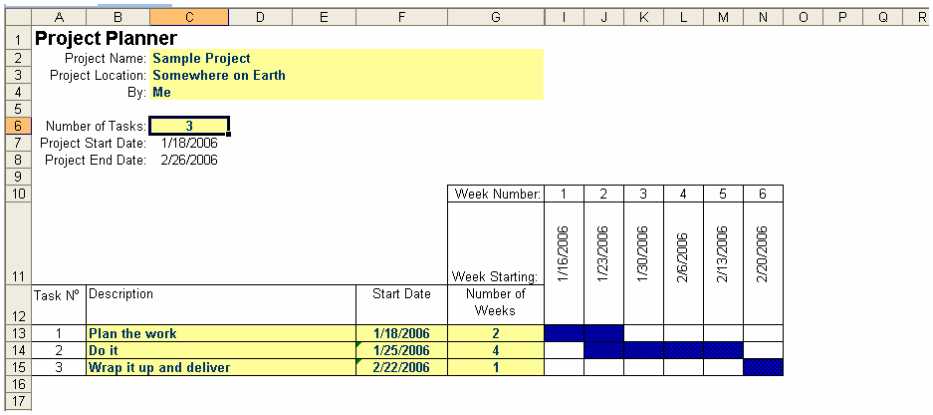
These requirements can be changing the look of a given house from siding to red brick, placing a bridge on a river that initially did not have one and making it look realistic, or placing a given building in an empty lot and make it look as if it has always been there. Figure 4 shows the before, Figure 4(a), and after, Figure 4(b), of such an assignment where students had to show their prospective client what their property might look like with a pedestrian bridge installed in it.

(a) Original Photograph (b) Manipulated Photograph

Figure 4: Sample Photo Manipulation Using Photoshop – Placing a Stone Bridge Across an Existing Creek

The third set of exercises deals with the development of Microsoft Excel (2003) applications to solve a variety of problems. During this portion of the course, students learn how to represent and manipulate tabular data, create different types of graphs and charts and analyze data trends, formulate and solve some simple engineering problems using Excel functions, and create simple form-based applications using macros. One of the most challenging applications that the students are asked to create is a project planning spreadsheet that relies heavily on conditional formatting for its proper operation. As may be seen in Figure 5, the application creates a weekly-based bar-schedule once the user specifies the number of tasks involved and the start date and duration, in weeks, of each task. The program is then supposed to figure out the end dates and lay out the task duration bars automatically. If the number of tasks or the project duration is modified, the program then automatically adjusts the backgrounds and borders of affected cells to reflect the changes.

This exercise was assigned to students taking the class in two consecutive years. During the first year, the students were only shown simple examples on how to use the if-statement and define conditional formats before they were assigned the project. During the second year, however, the students were first exposed to the basic concepts of predicate logic with intermediate level examples, and then shown the if-statement and conditional formatting examples before they were assigned the project. As a result, the rate of success of the second year students in reproducing the application was noticeably better than the one observed for the first year students.



Project Planner

Project Name: **Sample Project**
Project Location: **Somewhere on Earth**
By: **Me**

Number of Tasks: 3
Project Start Date: 1/18/2006
Project End Date: 2/26/2006

				Week Number:	1	2	3	4	5	6
				Week Starting:	1/16/2006	1/23/2006	1/30/2006	2/6/2006	2/13/2006	2/20/2006
Task N°	Description	Start Date	Number of Weeks							
1	**Plan the work**	**1/18/2006**	**2**							
2	**Do it**	**1/25/2006**	**4**							
3	**Wrap it up and deliver**	**2/22/2006**	**1**							

Figure 5: Project Planner Application Screen Shot

Other applications that are also introduced in the course include word processing, computer presentation, web development, and database management. The final requirement of the course is a team project that involves the selection of one specific item relating to information technology and researching its application in civil engineering and construction. Each team is required to write a technical paper about their topic, create a web site to present their findings to the public, create a spreadsheet application to solve a problem relating to their selected topic, and finally make a PowerPoint presentation to the class about their work. Each of the items that they have to produce must follow specific formatting requirements (e.g. document and paragraph styles), have specific characteristics (e.g. form-based input), and include specific items (e.g. animation and 3-D buttons) that are stated in the project assignment.

CONCLUSION

The development of courses to teach emerging computer and information technology has become a necessary ingredient for any engineering program that wants to be successful and remain competitive. These courses would be even more beneficial when they are taught using an approach that emphasizes the development of sound problem solving skills. This paper showed that this is not too difficult to achieve if one is to stick to a simple theme, referred to herein as Plan-Implement-Present and Deliver (or PIP&D), that summarizes the basic steps of engineering problem solving. Using this approach, students are first introduced to a computer tool, given basic information on how to use it and what it can be used for, and then assigned a civil engineering and construction related problem that they have to solve and/or present information about using the tool that they had just learned. Every assignment involves some degree of planning in addition to the implementation and presentation. The course is culminated with a project in which the students must apply the skills that they learned during the semester to research an IT related topic in civil engineering and construction and present their findings using different presentation modes and formats. The most telling achievement of the course is probably the fact that many of the skills and tools that are learned in it can be seen appropriately used by the students, and of their own initiative, in later courses.

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