

# **Application of Technology in Engineering Education**

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## **Abstract**

This paper focuses on introducing the faculty to a collection of powerful software tools and technologies that can be used effectively in a teaching and learning environment. This presentation additionally illustrates some of the techniques that can be employed in conjunction with using these tools and technologies to further enhance the teaching effectiveness of the faculty and promote student learning. Sample tools utilized in this study include WebCT, Adobe Acrobat, Microsoft EXCEL, Macromedia FLASH, MATLAB, LabVIEW, as well as, a series of other utility tools such as image capturing and screen recording software. The discussed tools and techniques enable the faculty to achieve goals that are unattainable through utilizing traditional teaching approaches. Included in this presentation will be several examples of course related material produced for teaching engineering topics and concepts. These examples clearly establish the great power, valuable utilities, and important advantages of these tools in teaching. Among presented examples are a few sample course modules selected from recent publications and presentations of the author in several national educational conferences, as well as, in an international colloquium. This paper does a comparison study between the tools and procedures utilized in these papers and discusses some of the advantages and disadvantages that these tools offer.

## **I. Introduction**

The submitted paper discusses the application of some of the tools and techniques which can be utilized in an educational setting to enhance the delivery of instruction and to elevate student course comprehension. The paper first focuses on some of the more important advantages of WebCT and illustrates the utility and capabilities of several valuable tools within this software. The paper then proceeds to introduce the utility of other more specialized software tools which can be used in conjunction with WebCT to further aid in improving the educational experience of students. Sample course modules and programs developed in earlier work of the author are used in the paper to clarify and support the points made. This paper further illustrates the manner in which the discussed tools can be utilized to create a richer teaching and learning environment for the students and faculty.

Suitability and effectiveness of utilizing any tool, technology, or strategy in delivery of a course is mostly dependent upon the nature of the course, and the topics discussed in that course. The paper provides an opportunity for the faculty to view some of the valuable capabilities and applications of a range of powerful tools and possibly find a tool which is ideally suited for their classroom use.

## **II. Utilization of WebCT and Other Utility Software Tools**

The use of WebCT in the delivery of engineering instructions has been explored by many engineering educators in various publications in recent years. The WebCT environment offers a variety of communication, evaluation, as well as, other tools that can effectively be utilized in enhancing the delivery of a course. The communication tools such as the electronic mail, discussions, chat, and electronic white board can play a valuable role in promoting the student-instructor interactions. The utilization and advantages of the WebCT tools such as the ones mentioned above were discussed in an earlier paper of the author<sup>1</sup> presented and published in the 2001 ASEE Annual Conference and Exposition in Albuquerque, New Mexico.

One of the more valuable and significant advantages offered by WebCT is the ease and convenience with which a variety of electronic course related material can be offered to and accessed by the students. This material can be course lecture notes, example files, assignment solutions, exam study guides, exam solutions, as well as other helpful documents. The provided electronic files relieve the students from taking extensive notes in the classroom and allow them to pay careful attention to the discussed topics. The offered material can also be accessed and effectively utilized by the instructor during the lecture period to deliver the course topics using a computer projection system. Using these files the instructor can cover more material during the lectures and explain the topics in a manner that students can easily absorb. The author has consistently and effectively been using WebCT in delivery of a computing course at Georgia Southern University in the last few years. Quality of the submitted lab assignments and performance of students in the exams have indicated that the use of WebCT have significantly improved the student comprehension of the course topics. Also, comments from students on the student evaluation have consistently indicated that a great number of students find this method of delivery of instruction very beneficial.

For a majority of cases, the usual general purpose programs such as Word, EXCEL, PowerPoint, Access, etc. offer sufficient capabilities for the instructor to prepare effective course related documents for placement on the course WebCT site. When preparing these documents the “comment tools” and/or “drawing tools” in the above mentioned software can be utilized to create more effective instructional guides. These tools are especially useful for explaining more complicated topics, method of solutions, or for providing additional instructions for the novice student. The utility of several of these tools in teaching a freshman level computing course at Georgia Southern University in the fall semester of 2004 is illustrated in Figure 1.

### **Adobe Acrobat Software**

When making documents available for students through the course WebCT site, it may be more advantageous to convert all these documents to PDF files (Portable Document Format files) using the Adobe Acrobat software. A summary of some of the more attractive features of “PDF” files and the benefits they offer are outlined and briefly discussed below.

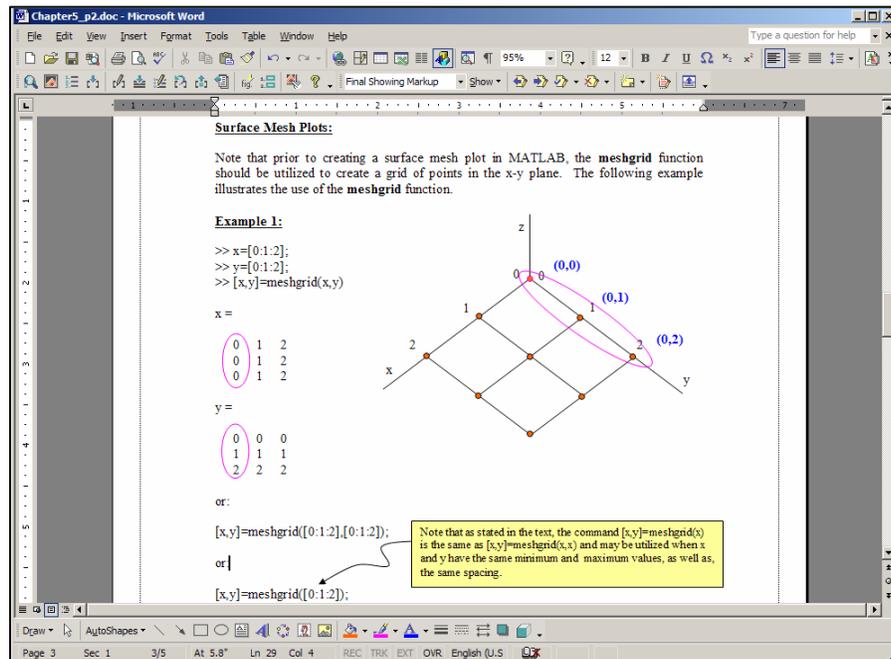
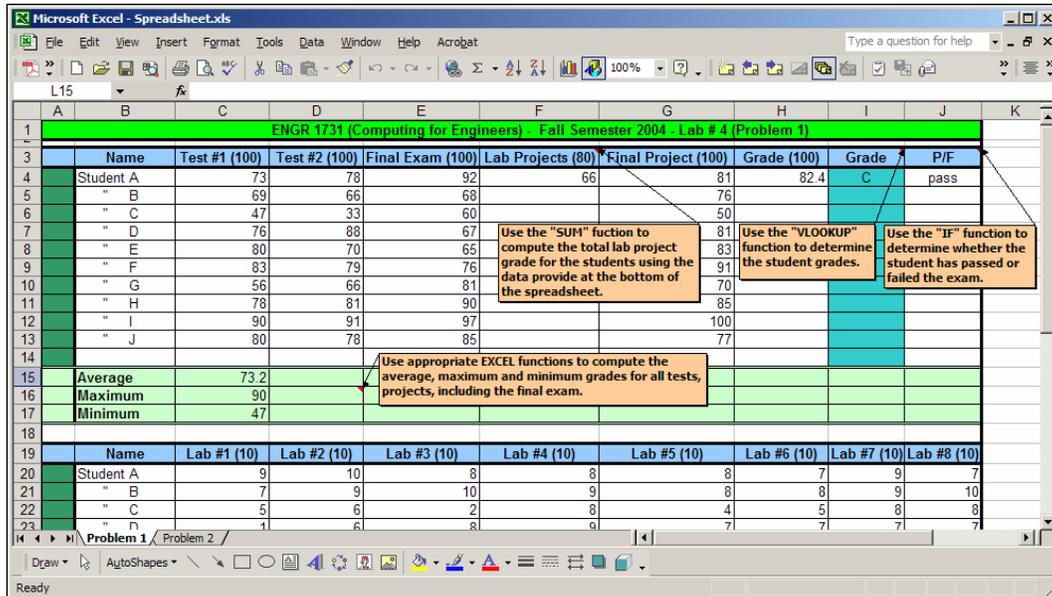


Figure 1. Sample Instructional Material Created Using EXCEL and Word for a Freshman Level Computing Course

- (a) Consistent general look/interface for the presented documents on WebCT regardless of the software used in creating the original files.
- (b) Convenient and easy to use navigational buttons that enable the students to browse through the presented material with more ease in a variety of forms.
- (c) Convenient and easy to use zooming tool for the viewers enabling them to clearly see the finer details in the presented documents.

- (d) Convenient and easy to use search capability to find a word or a phrase in a course related document. Using this feature the students can more efficiently locate information on any specific topic discussed within the posted document. It should additionally be stated that another useful feature of Adobe Acrobat enables the instructors to create electronic "bookmarks" in the files. These bookmarks can further assist the students in locating specific information in produced documents.
- (e) The ease with which the security can be built into the produced PDF files. Using a special tool of the Adobe Acrobat software a variety of "password-protected" files can be created. Two of the most useful password-protected formats are discussed in this section. The first format is used to simply enable the viewer to open the documents. One possible application for this type of password is to encourage the students not to skip classes, by providing the course document passwords only to students that do attend classes. The other type of password is one that prevents students from being able to select, modify, or copy any portion of the posted document on WebCT. The author of the paper has used this type of password in teaching a freshman level computing course at Georgia Southern University. In this course, the password-protected documents prevented the students from copying a guide that was provided for them to complete one of their lab assignments.
- (f) The Portable Document Format files (PDF files) created using Adobe Acrobat are smaller in size and therefore can be uploaded and/or downloaded faster with more ease.

### **Image Capturing and Video Capturing Software**

When preparing instructional related material for placement on the course web site, the utility of other important tools such as image capturing and screen recording software should not be overlooked. These tools can play a valuable role in effective delivery of instruction especially in courses that are inherently linked to use of computers, such as in a computing course or in an Engineering Graphics course. Using these tools, the created screen captures or video captures can clearly illustrate the steps involved in performing specific course related tasks. Two sample screen captures and two snapshots from frames of a video file created for teaching an Engineering Graphics course at Georgia Southern University is presented in Figures 2 and 3. The sample screen captures shown in Figure 2 were created using an image capturing software called "Snagit". These screen captures illustrate the initial steps needed for placing points at measured intervals along the edges of an isometric sketch in an AutoCAD drawing. The still snapshots in Figure 3 were created using a screen recording software called "Camtasia". The video file was essentially created to clearly show the students how to set up the units in an architectural AutoCAD drawing. This task was accomplished in this video file by capturing the movement of the pointer on the screen when selecting the appropriate menu and submenus, and recording the needed text commands. For added clarification, when producing this type of video files, the instructor can also record his/her voice explaining the process as the steps are performed. Course related documents prepared using image capturing and video capturing software can enormously contribute to the students' course comprehension of many course topics.

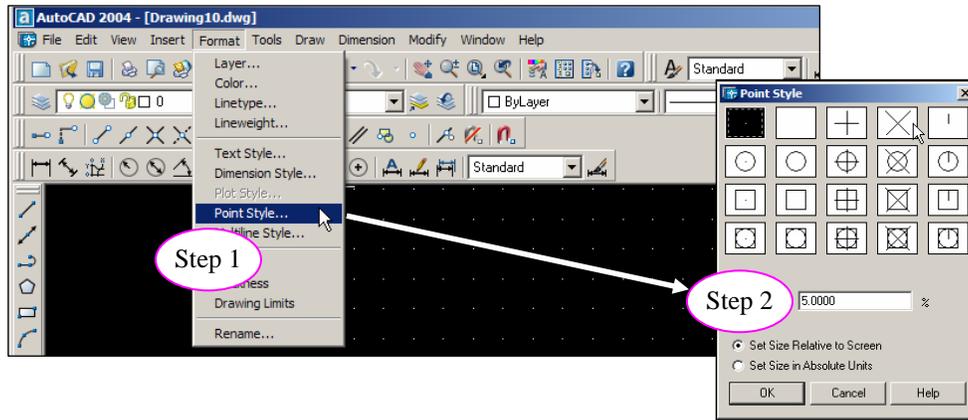


Figure 2. Two Sample Screen Captures produced using the Snagit Software

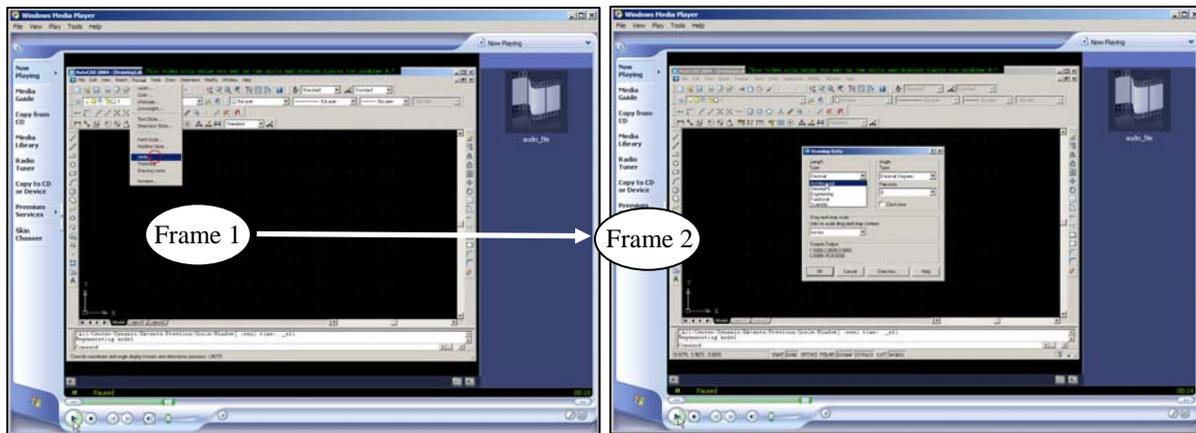


Figure 3. Two Frames of a Video File Created Using the Camtasia Software

### Assignment Tool in WebCT

One of the other useful features of WebCT which is not very well recognized and therefore not utilized by many WebCT users is the "assignment tool". Using this tool the instructor can post assignments on the course WebCT site, and the students can submit their completed electronic copy of their work for grading. Use of the assignment tool in WebCT offers a number of attractive and useful advantages as will be discussed below.

When posting assignments on WebCT, the instructor could select the date and time of availability of assignments to students. The instructor also has an option for choosing a deadline for the electronic submission of the assignments. After the deadline is passed, the assignment will not be available to the students and no assignments can be submitted. A sample snapshot of a WebCT site showing a listing of the lab projects assigned during the fall semester of 2004 in an Engineering Graphics course at Georgia Southern University is shown in Figure 4.

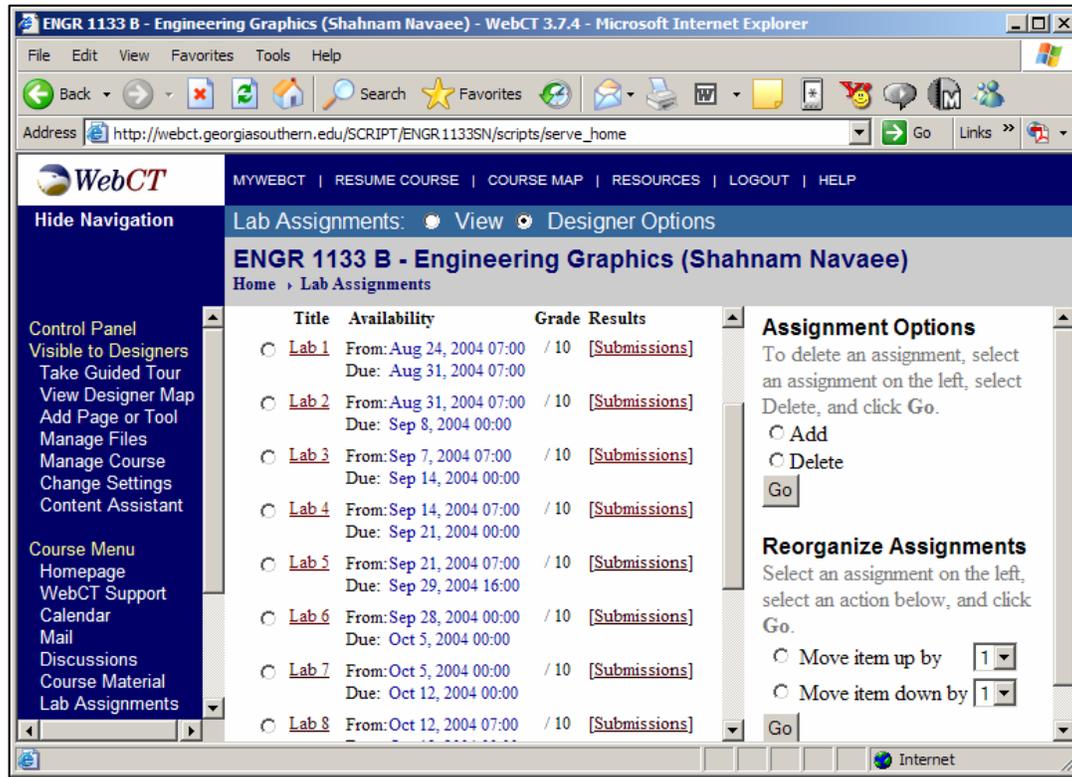


Figure 4. Sample Lab Assignments Window in a Course WebCT Site

By selecting any posted assignment listed in a window such as the one illustrated in Figure 4, the students can access and utilize the provided instructions, and submit their assignment electronically for grading. In WebCT, the assignment submission can easily be set up in a fashion that when an assignment is successfully submitted, an e-mail confirmation is sent back to the student. This helps students detect any possible problems associated with their submissions and take corrective measures. Once the assignments are evaluated by the instructor, the grades can electronically be sent back to the students quickly with ease in a confidential way, so that the students can keep track of their records. Graded assignments are also conveniently archived in WebCT for possible future referrals. Access to the electronic copies of the student projects provides the instructor with an opportunity to take a closer look at the submitted projects and grade them with greater accuracy. In the discussed Engineering Graphics course, the instructor was able to zoom-in to different parts of the submitted AutoCAD drawings and use various measuring electronic tools to determine if the assignments were completed properly.

Once the assignments are electronically graded, a record of the grades is automatically generated in a table format within WebCT as shown in Figure 5. At the end of the semester, this table can easily be downloaded and imported into a spreadsheet program to allow the instructor to compute the students' final course grades.

The screenshot shows a WebCT interface for the course ENGR 1133 B - Engineering Graphics (Shahnam Navaee). The main content area displays a table of lab assignment grades. The table has columns for 'First Name', 'Lab 1', 'Lab 2', 'Lab 3', 'Lab 4', 'Lab 5', 'Lab 6', 'Lab 7', 'Lab 8', 'Lab 9', and 'Lab 10'. Each cell in the table contains a score or a link to 'Sort', 'Submissions', or 'Graph'. The scores are as follows:

First Name	Lab 1	Lab 2	Lab 3	Lab 4	Lab 5	Lab 6	Lab 7	Lab 8	Lab 9	Lab 10
John	10.0	10.0	0.0	9.0	---	5.0	8.0	9.4	6.0	
Parker	10.0	10.0	10.0	9.7	9.7	10.0	9.5	9.2	10.0	
Jeremy	10.0	10.0	9.1	9.7	9.4	10.0	10.0	9.7	10.0	
Jason	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.7	10.0	
Ryan	10.0	---	9.1	---	0.0	9.0	7.5	9.4	4.5	
Tamfu	10.0	10.0	10.0	9.0	10.0	5.0	---	---	---	
Tiffany	10.0	10.0	10.0	9.0	9.4	5.0	7.5	8.5	6.3	
Robert	10.0	9.5	10.0	10.0	10.0	5.0	8.5	8.7	3.5	

Figure 5. Snapshot of the Window Showing the Lab Assignment Grades in a Course WebCT Site

### III. Utilization of Other Specialized Software Tools

There are a number of other more specialized educational tools that can efficiently be used in addition to or in conjunction with WebCT to further enhance the productivity of instructors. These tools effectively contribute to creating an active teaching and learning environment in which the interaction between the instructor and students is greatly enhanced. In the last few years the author has investigated the specific utility of various software tools such as FLASH, MATLAB, EXCEL, and LabVIEW as an educational instrument in the classroom environment. A summary of some of more important utilities of these tools is outlined below.

- (a) Using a computer projection system, the instructor can effectively utilize the modules created by these tools to complement their teaching and to enhance the student comprehension of the course topics. One of ways by which this can be accomplished is through running the developed programs to create the results corresponding to variety of conditions or scenarios. For example, in a module created for teaching a Structural Analysis course, the value and location of the applied loads acting on the structure can be altered to examine the effect on the internal reactions and displacements. Obtaining the solution for many engineering problems is quite involved and without the developed

programs/modules, quick and easy determination of the final results within the class time period is not possible. The created scenarios can serve as a great platform for promoting in-class discussions, and for providing students with different perspectives.

- (b) The developed modules/programs can also be made accessible to the students by placing them on the course WebCT site. The students can utilize these files at any time and from any location which has an Internet connection for as many times as necessary to fully master the topics covered.
- (c) The students can also use the developed programs to perform a check on the validity and accurateness of their developed hand solutions.
- (d) The students can also modify the developed programs themselves to obtain the solutions for other similar problems and gain more from this experience.

## **FLASH Software**

FLASH is a software which is developed by the Macromedia Corporation mainly for producing multimedia documents for the web. Inclusion of various components such as the audio, video, and animations in the instructional modules produced using FLASH can effectively contribute to enhancing the educational experience of students. Incorporation of some of these components in the modules using other presentation software tools such as PowerPoint can be more difficult and in some cases impossible.

In a paper published by the author<sup>2</sup>, the utility of this software for creating educational modules for teaching a Structural Analysis course was discussed. Sample screen-shots from two frames of a multimedia module created for this study is provided in Figure 6. The objective of the module was to analyze the shear and moments in the floor beam of the bridge beam subjected to the moving loads of a truck. The created movie (analogous to an elaborate multimedia slide presentation) outlined the detailed steps needed in solving the problem in a clear, organized, and easy-to-understand manner. In producing this movie, audio, video, and animations were employed to further enhance the created module. Inserted short digital video clips in the movies, captured from real situations, helped the students take notice of the importance of the real life nature of the problem, and appreciate the utility of the proposed method of analysis. The short audio clips inserted in the module aided the instructor in emphasizing the more significant points and steps involved in the problem. Created animations in the module were used to help the students with the visualization and comprehension of the problem.

One of the objectives of the presented module was to illustrate the procedure by which the maximum moment on the bridge due to a series of moving loads can be computed. This solution calls for the successive placement of each of the applied forces at specified locations on the beam using a procedure described in the literature<sup>3</sup> and computing the moment for each of these cases. In the discussed module, animations were used to place each of the applied forces at the proper locations to develop and compute the maximum live moment on the beam needed for each case.

Once the FLASH movies similar to the one described above are produced, they can then be saved as executable files (.exe files). The executable files can be played on any computer with or without the FLASH software installed. These files can be made available to the students to further enhance their understanding of course topics. Using another useful tool in FLASH, the instructor also has an option to convert the produced FLASH files into “html” files before placing them on the course web site. The students may alternatively elect to experiment with this version of the files instead.

The sample FLASH movie presented in this paper has been provided to a faculty member in the Civil Engineering Technology Program at Georgia Southern University who is regularly assigned to teach the Structural Analysis course.

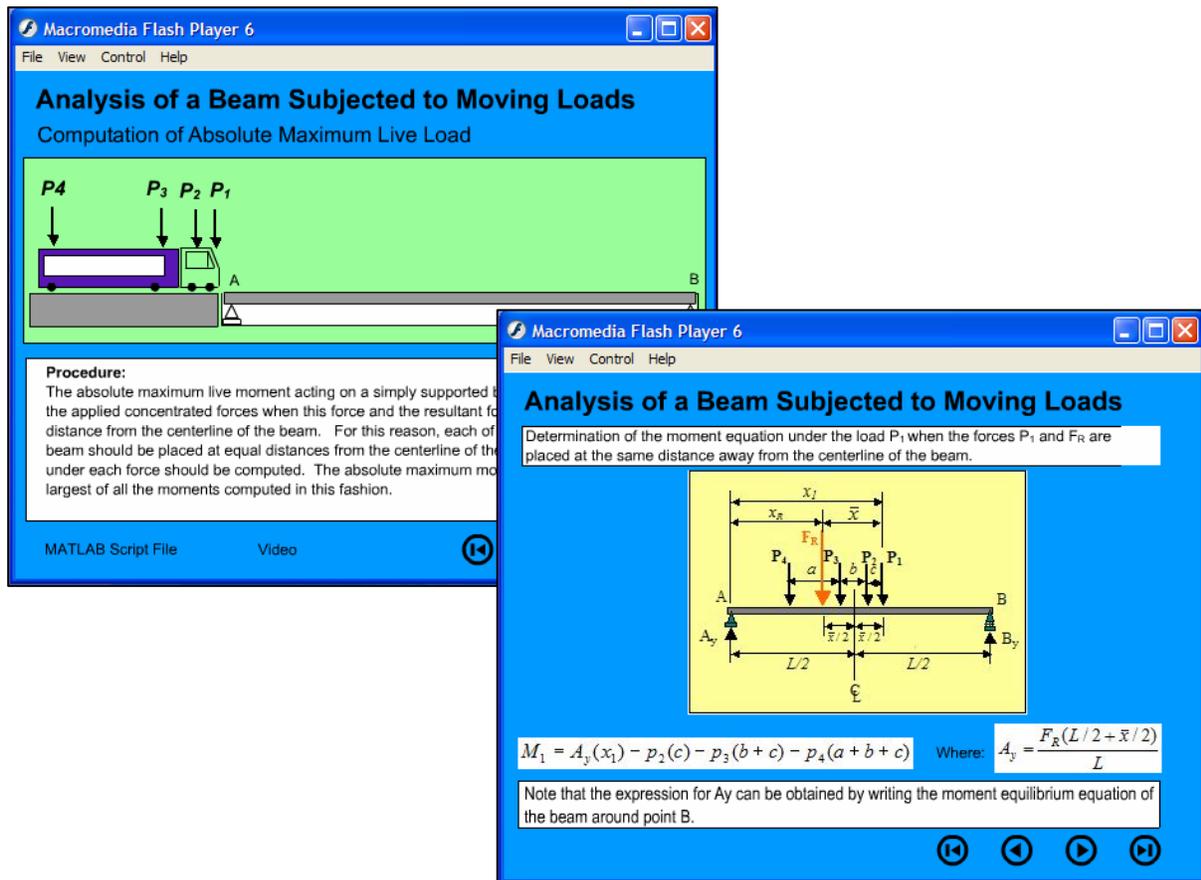


Figure 6. Sample Screen-shots of two Frames of an Instructional Module Produced with FLASH

## MATLAB Software

This popular computing software developed by the MathWorks Corporation is commonly used in various educational institutions for solving engineering and math related problems. The powerful computing environment of MATLAB along with availability of a large number of helpful MATLAB built-in functions has made this software the popular tool of choice for many

engineering educators. Using the interactive MATLAB environment, the desired computations can be performed to yield the needed output in any desired format. The utilization of MATLAB for solving structural engineering problems was discussed in two previous publications of the author<sup>2,4</sup>. One of these publications was associated with the FLASH module described in the previous section. In this module, once the concepts and procedures related to the "Moving Load" problem were mastered using FLASH, MATLAB was introduced as an added measure to further extend the students' comprehension of the course concepts. The purpose of the MATLAB component was basically to provide the students with additional insight into understanding the problem.

Unquestionably, MATLAB is a great computing tool which is extremely powerful and effective in solving many complicated engineering problems. But when considering the utility of this software as an instructional tool, the following issues should also be considered: (a) Possible lack of availability of this software on campus facilities, (b) Possible lack of familiarity of the students taking the course with MATLAB, (c) Alternate utility of other available software packages that are easier to use and provide a more user-friendly interface. A discussion on the utility of two such tools is included in the following sections.

### **EXCEL Software**

This relatively inexpensive software is a component of the Microsoft Office suite which is already pre-installed in many computers when purchased, and is already available in many educational institutions through a site-license. A great advantage of EXCEL is the relative ease with which the features of this software can be utilized in formulating the solution of a variety of routine engineering problems. The other important advantage is that most students already have a working knowledge of the basics of EXCEL, and feel comfortable using this familiar software. Utilization of EXCEL circumvents the shortcomings of the MATLAB software indicated in the previous section.

In an earlier publication of the author, the utilization of EXCEL in analyzing structures was discussed<sup>5</sup>. A sample spreadsheet for the determination of the shear force, bending moment, slope, and deflection of a beam subjected to a combination of a concentrated and a distributed load is shown in Figure 7. The parameters listed at the bottom of this spreadsheet; E, I, L, a, W, and P are respectively, the modulus of elasticity, moment of inertia, length of the beam between the supports, length of the overhanging part of the beam, distributed load, and the concentrated load. By modifying the values of the beam and loading parameters in the appropriate cells in the spreadsheet; the corresponding values of shear, moment, slope, and deflection are immediately updated in columns B through E. This modification also automatically updates the plots on the right side of the spreadsheet. To further aid in the readability and documentation of the problem, various other EXCEL formatting and drawing tools can be utilized to sketch the beam and loading and to place gridlines and shading on the spreadsheet. Producing a document which collectively displays the problem sketch, problem input, numerical output, and the plots in the attractive format as illustrated in Figure 7 is not easily possible using MATLAB.

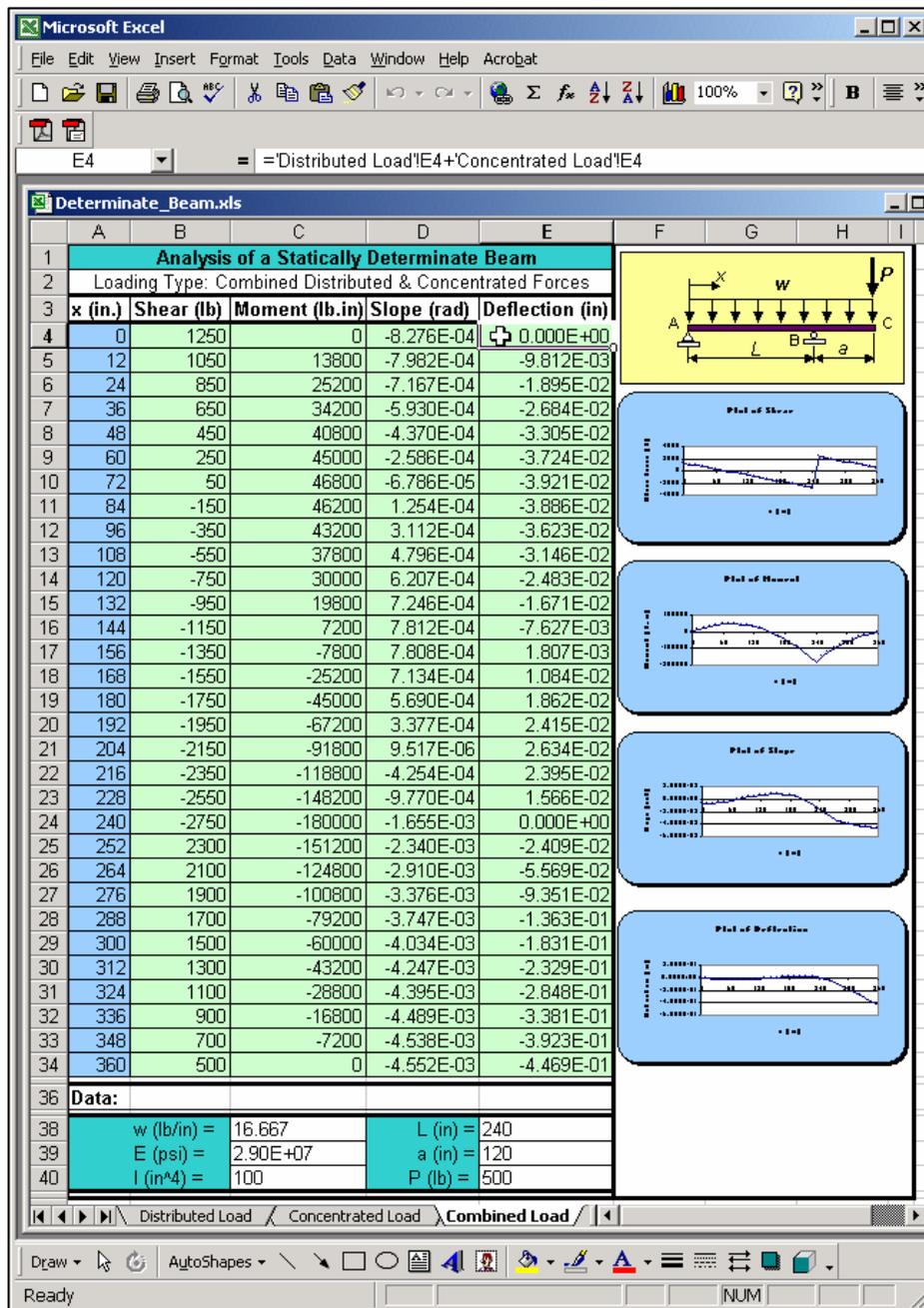


Figure 7. An EXCEL Workbook Developed for Analyzing a Beam Subjected to a Combined Load

## LabVIEW Software

LabVIEW, acronym for “Laboratory Virtual Instrument Engineering Workbench”, is a powerful and robust graphical programming language developed by National Instruments, Inc. for use in

various engineering and scientific related fields. At the present time, this software tool is most commonly utilized in the industrial, governmental, and educational venues to aid the investigators in conducting laboratory experimentations, and in collection and analysis of experimental data. In an earlier publication of the author<sup>6</sup> an unconventional and interesting approach for analyzing structures utilizing LabVIEW was discussed. The submitted paper specifically focused on the programming capabilities of LabVIEW rather than the utility of this tool in data acquisition and laboratory measurements.

A brief introduction to a few main components of LabVIEW follows. The LabVIEW programs also referred to as virtual instruments (VIs) have two main components, the front panel and the block diagram. The front panel basically serves as an interface between the user and the VI. This easy-to-operate and user friendly interface is one of the most attractive features of LabVIEW which is unavailable in many other software/programming environments including in the software pieces previously discussed. Through using LabVIEW's front panel, the input and output of the VIs can be controlled and displayed in any desired fashion using various visual controls and indicators available in LabVIEW. Several sample controls and indicators can be seen in a sample front panel of a VI presented in Figure 8. The computations within the VIs are performed via the instructions provided in the block diagram. In this diagram, a series of programming nodes are placed and wired together to perform the needed operations. The front panel and block diagram of one sample developed VI for analyzing a beam subjected to a combined concentrated and a distributed load is presented in Figures 8 and 9. This is the same beam which was investigated in the previous section using EXCEL.

To run the program the user only needs to interact with the front panel without directly using the block diagram. Through using the front panel presented in Figure 8, the user can interactively and conveniently modify the beam and loading parameters to generate the corresponding values of the shear, moment, slope and deflections along the beam. This action automatically and immediately updates the distribution plots presented on the right side of the front panel shown.

From all the software pieces available on the market including the ones discussed earlier in this paper, LabVIEW probably has the most attractive, convenient, and user-friendly environment. Among other more important advantages of LabVIEW are: (a) The ease with which data and programs from other software packages such as EXCEL and MATLAB can be imported and used in this environment, and (b) the ease with which the data generated from using LabVIEW can be exported to other file formats to possibly be used with other applications.

The LabVIEW tool is ideally suited for in-class presentations of instructors and for computing and displaying the results of engineering problems in an appealing fashion. The author has created several LabVIEW programs for analyzing beams and trusses, and for problems dealing with transformation of stresses. These programs are expected to be used in complementing lectures in a Mechanics of Materials course and a Statics course in the spring semester of 2005 at Georgia Southern University. One drawback to utilizing this software as an instructional tool may be the lack of availability of this software on campus facilities. But this may not pose a serious problem since using the Professional version of LabVIEW, stand-alone executable files

can be created that can run on any computer with or without LabVIEW installed. To run the developed files, the users only need to have the "LabVIEW Run-Time Engine". This engine can be downloaded free of charge from the National Instruments web site (<http://www.ni.com>).

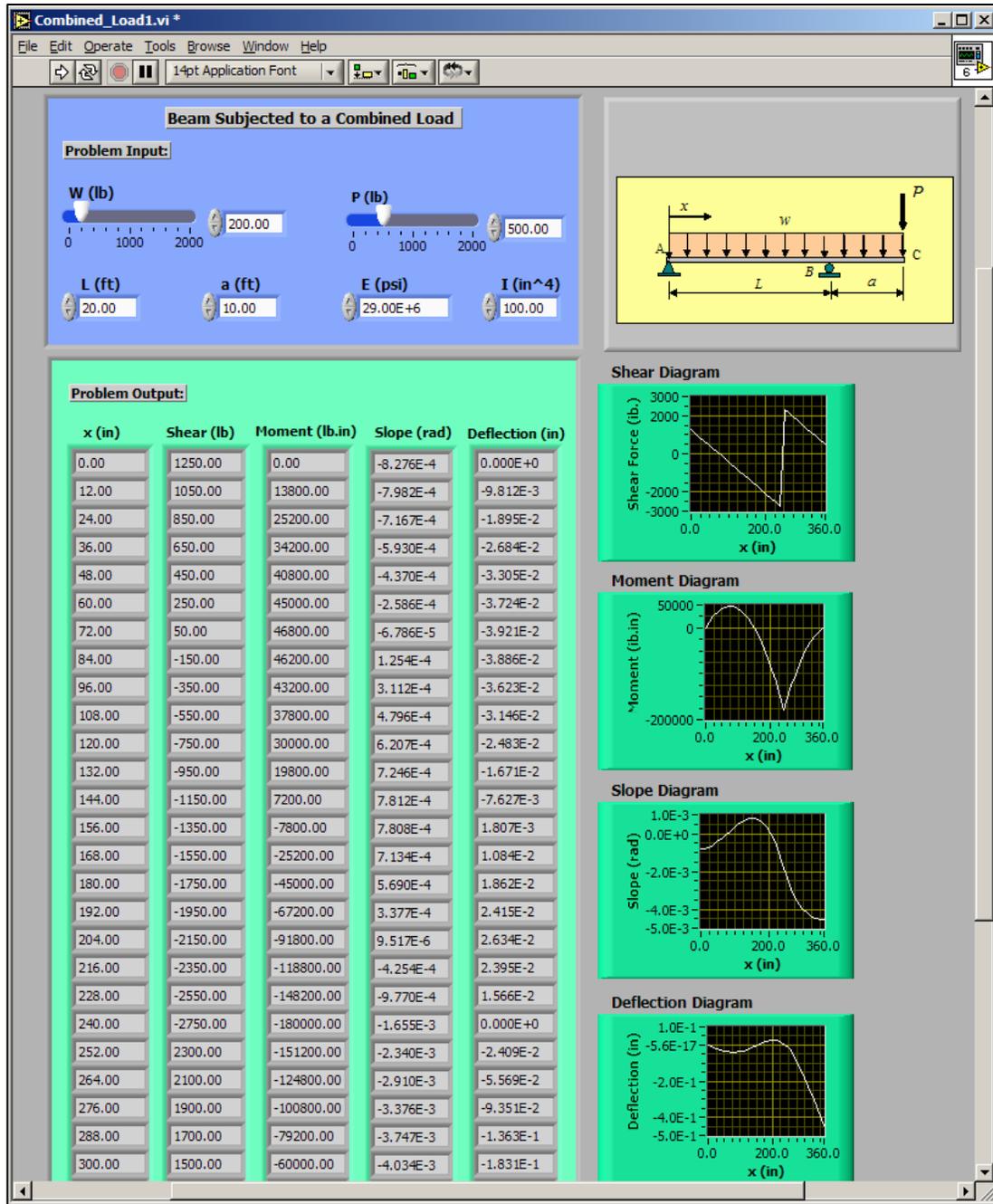


Figure 8. Front Panel of a VI Created for Analyzing a Beam Subjected to a Combined Load

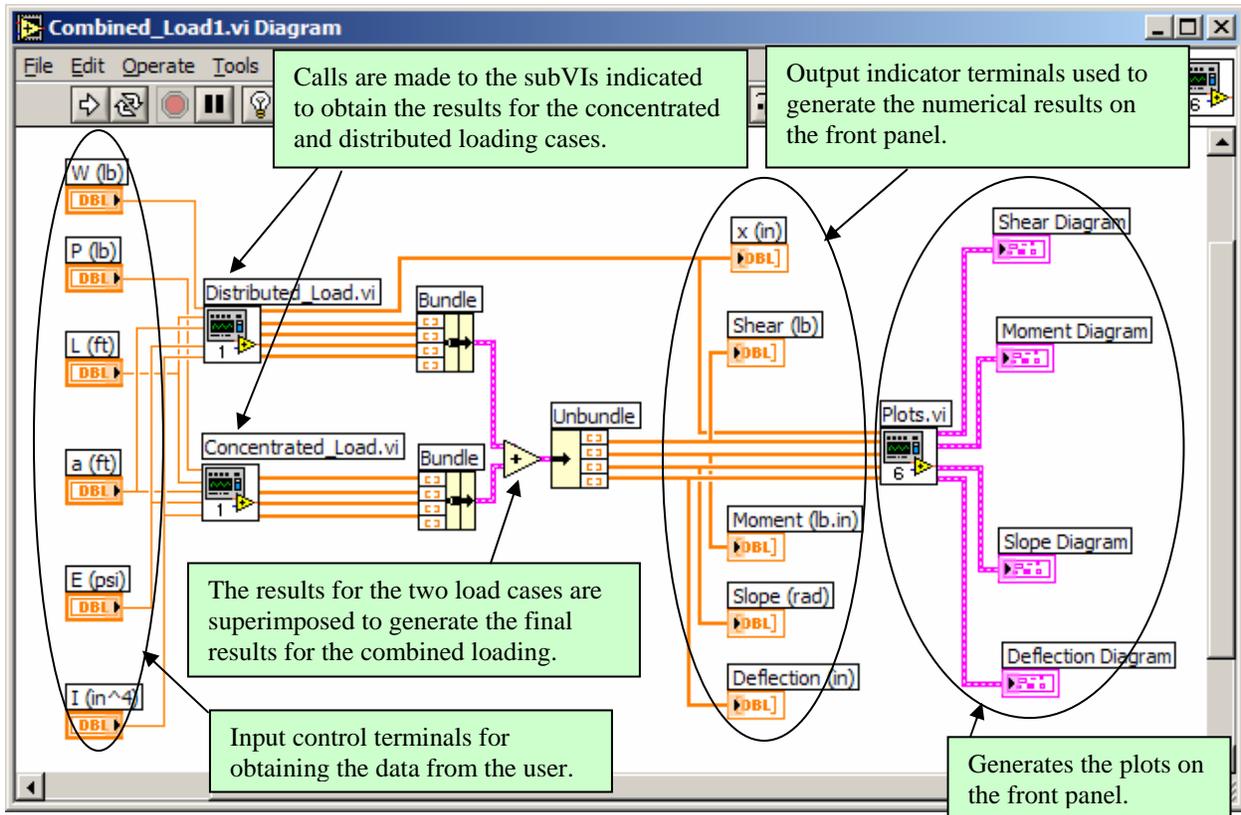


Figure 9. Block Diagram of a VI Created for Analyzing a Beam Subjected to a Combined Load

#### IV. Summary & Conclusion

In the presented paper the utility of a collection of tools and techniques for enhancement of delivery of instruction and promotion of students' course comprehension were offered. These tools and techniques can effectively contribute to creating a richer educational environment through which the interaction between the faculty and students is more enhanced. The paper provides an opportunity for the faculty to learn more about some of the capabilities and advantages offered by the discussed tools and possibly find a tool which is suited for their instructional use. Technology adds a new dimension to the delivery of instruction, a dimension that is missing in conventional approaches to teaching. When used along with the conventional techniques, technology serves as an invaluable tool for complementing the course and achieving certain goals in terms of students' academic development and course comprehension. Some of these goals are more difficult to attain solely through the utilizing of the conventional approaches.

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## **Biographical Information**

SHAHNAM NAVAE is currently a Professor in the Engineering Studies Program at Georgia Southern University where his primary responsibility is teaching freshman and sophomore level courses. Dr. Navaee received his B.S. and M.S. degrees in Civil Engineering from Louisiana State University in 1980 and 1983 and his Ph.D. degree from the Department of Civil Engineering at Clemson University in 1989.