Enhancing Instruction in Civil Engineering Courses with Use of Video-Streamed Tutorials

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Abstract

The importance of incorporating software into the curriculum is widely recognized, but allocating sufficient class time to provide training can be difficult. Some courses taught at the Civil and Environmental Engineering (CEE) department at Worcester Polytechnic Institute (WPI) have made use of video-streamed tutorials to address this challenge. The goal was to enhance training of young engineers and illustrate abstract concepts related to course material.

This paper describes the advantages and challenges associated with the use of these tutorials in three case studies, which include integration of Finite Element Analysis (FEA) software in a graduate impact crashworthiness course and Geographical Information System (GIS) software into four undergraduate environmental planning courses. For each course, short tutorials were developed using the Camtasia Studio Software Package, which captures parts of the screen defined by the user and records any action occurring in that area along with audio instructions. The tutorials helped the students gain experience and confidence in software use, with the goal of increasing the students' interest, motivation and comprehension of course material.

Introduction

Incorporating software packages in the undergraduate curriculum represents a significant teaching challenge for educators. Proficiency in the use of specific software is often an important qualification for students looking to join the work force in their area of interest. To effectively make use of these packages, however, time and often training is needed. Given the increasing breadth of topics that must be covered in our undergraduate curriculum, it is becoming increasingly difficult to allot the time needed to provide this background. The development of effective techniques for incorporating these software packages into the undergraduate curriculum remains as a critical need.

This paper describes the use of video-streamed tutorials for facilitating software use in undergraduate and graduate classes in civil and environmental engineering. The scope of the paper includes software associated with Finite Element Analysis (FEA) and Geographical Information Systems (GIS), two classes of software that illustrate the challenge and importance of integrating software into the curriculum. Both of these classes of software are extremely important in civil and environmental engineering.

FEA is considered to be an asset for technology incorporation in engineering classes. Nowadays FEA software has developed remarkably and it offers a variety of tools for visualizing, understanding and solving problems in various areas. In civil engineering, an important application of FEA is in the area of structural analysis design, where static and dynamic load conditions need to be taken into account to solve for forces and displacements in a given structure.

GIS software is a critical tool for civil engineers, community planners and environmental analysts. It combines a visualization workspace with an analytic and modeling framework, based in the science of geography [1]. GIS is the platform for spatial data, which is information linked to a particular location on a map. Examples include parcel, zoning and land use data; information about rivers, lakes, and other waterbodies; performance data for transportation infrastructure; demographics; aerial photography; etc. All of this information is used to analyze environmental conditions, measure development impacts, and ultimately, make decisions about how to best manage natural resources and the built environment in a sustainable way.

Methods

The video streamed tutorials for incorporating these packages into the classes were developed using the Camtasia Studio software package. Camtasia Studio is a screen video capture program which captures parts of the screen defined by the user and records any action occurring in that area. It is generally used to produce interactive training and support videos by recording interaction with software applications and websites or capturing power point presentations as videos and audio as depicted in Fig. 1 [2]. Especially in the educational field, pre-recorded videos can be employed for demonstrating visual and technical subjects. Instructors can record live presentations and make content accessible as popular video format, enabling the students to learn according their own pace, or to simply to make-up absence in class. Also, these recorded videos allow the students to follow step-by-step operations during software demonstrations, which is sometimes hectic with use of paper tutorials. The Camtasia tutorials were used in a set of undergraduate courses in the urban and environmental planning area. and also in a graduate course in the area of impact crashworthiness.

For the undergraduate courses in urban and environmental planning and environmental analysis, a set of Camtasia tutorials was developed to support instruction on the use of ESRI's ArcMap, the GIS software. These courses used GIS to demonstrate the utilization of spatial databases in the public decision-making process and to assist with the analysis of land use and development impacts on the environment. The on-line tutorials served as an important learning resource to help students utilize the software packages to complete assignments or projects. The tutorials are also being used to provide some additional support for GIS use in a graduate course in water quality protection, but this application is not discussed here since the course is on-going,

For the graduate impact crashworthiness course, Camtasia was employed to formulate lessons in the use of the LS-DYNA/LsPrePost FE package [3, 4]. The finite element programs and postprocessor software were applied for visualization of wave propagation concepts taught within the course. More detailed descriptions of the undergraduate and graduate courses are included in the following paragraphs.

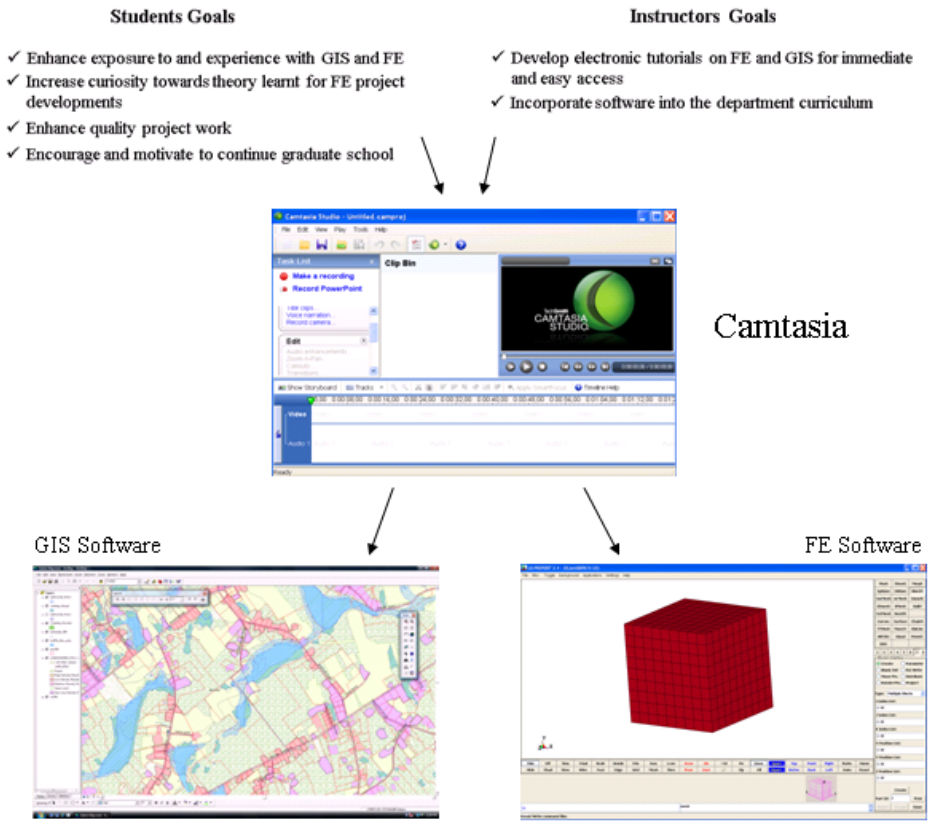

Figure 1. Camtasia Studio employment to enhance instruction of GIS and FE software.

❖ Undergraduate Courses in Urban and Environmental Planning

Four courses offered within WPI's CEE undergraduate program present analyses that professionals would be hard pressed to conduct without the use of GIS. These include: CE 3070 "Urban and Environmental Planning", CE 3074 "Environmental Analysis", CE 4061 "Hydrology" and CE 4071 "Land Use Development and Controls". WPI's undergraduate courses are offered in seven-week terms per academic year, with students enrolling in 3 courses in each term. The time constraints in the rigorous schedule further complicate the ability to utilize and teach software within the existing curriculum. Consequently, an integrated approach was used to incorporate GIS into all of these courses. Technical considerations included the time required to obtain (clip) data, ensure that it is properly scaled, and ensure that it provides the level of accuracy appropriate for the intended use – which may not be feasible for students within the 7-week course timeframe.

To incorporate the use of GIS, a course website and server-based data storage area was developed to provide online instruction and pre-packaged data sets for use in term projects and/or homework assignments. The website includes modules and video streamed tutorials introducing the use of GIS software. The server-based data storage area includes some sets of GIS data and case studies that may be accessed by all students. When students enroll in each of the classes, they are simultaneously enrolled in the course website and are given access to the data server. In this manner, the site and server provide a resource for students working in this

area, and can be accessible for work beyond the identified courses, such as for independent projects.

During the 2009-2010 academic year, three of these courses were modified slightly to provide the means for students to utilize the GIS software (ESRI ArcView) in their course and project work. The fourth, which is offered every other year, will incorporate GIS when it is next offered in the fall of 2010. Summaries of the courses and relevant course topics/assignments are as follows.

- **CE 3070 "Urban and Environmental Planning".**
  This course provides an introduction to urban and environmental planning and focuses on sustainability and the inter-relationship of various planning disciplines. Two homework assignments were redesigned to incorporate the use of GIS. One involved basic software skills to make a map identifying Environmental Justice neighborhoods. The second involved an added GIS skill of creating new layers and editing attribute tables to display population data and projections. Base data for use in these assignments was provided to the students to ensure that the assignments could be completed within the 7-week course timeframe.

- **CE 3074 "Environmental Analysis".**
  This course introduces the concepts and techniques required to evaluate the suitability of natural land areas for sustainable urban and resource-based uses. Homework assignments address population, landscape characterization, and the use of environmental assessment to define the impacts of humans on the landscape. GIS utilization included 2 assignments along with a one-week team project. The assignments were set up to help students learn the basics of GIS, such as importing data layers, and creating and effectively presenting a map. The project involved the analysis of potential environmental impacts resulting from residential development. Topics included map development, calculation of land areas and defining the effects of land use on water quality.

- **CE 4061 "Hydrology".**
  CE 4061 (Hydrology) is a fourth-year undergraduate course that covers the basic principles governing the distribution and transport of water in the environment as well as the techniques used to quantify these processes. Topics include the hydrologic cycle, probability and statistics in hydrology, precipitation, evaporation, infiltration, groundwater flow, runoff, stream flow, lakes and reservoirs, and design of hydrologic systems. CE 4061 typically includes a two 1 to 2 week project modules intended to introduce students into open ended projects involving hydrologic analysis and modeling. The GIS serves as a tool for the students to characterize the watershed and understand how watershed characteristics affect runoff and water quality of receiving waters. The tutorials (which have not been used previous offerings of this class) will be introduced in the next course offering in Fall of 2010.

- **CE 4071 "Land Use Development and Controls".**
  This course presents the regulatory framework, mechanics, and implications of land use and development. It is expected that students will be able to identify and analyze regulatory, environmental, economical, and social constraints to development by the time

they have completed the course. To assess this, a homework assignment was given at the end of the course which required the students to identify a suitable parcel of land for a residential subdivision. GIS was used as the means to display zoning districts, existing land use, transportation networks, and water features within the community. Again, these base layers were provided to the students ahead of time. Students were also asked to identify additional GIS data pertaining to other development constraints, such as soil types or the presence of steep slopes, which would have improved their ability to complete the assignment. The course also requires the completion of an individual student project in which development constraints are identified for a current development project of the student's choice, an argument is made for highest and best use of the land in question, and regulatory (zoning) language is written or revised to encourage said use. Some students who took the course as part of the 5-Year BS/MA program offered at WPI opted to incorporate the use of GIS in this term project as the "additional work" requirement to justify the graduate credit. Interestingly, these were not students who had previously been exposed to GIS in CE 3070 or CE 3074.

- **Graduate Course in Impact and Crashworthiness**

The graduate class CE 527 "Impact Strength of Materials and Structural Crashworthiness" offered at the CEE department at WPI was taught during the fall semester 2009, for a total period of 14 weeks, with an enrollment of 12 master students. It had duration of three hours, one day per week, to accommodate the needs of part-time master students who were commuting to WPI after their regular full-time daily job. Summary of the relevant course topics/assignments is as follows.

- **CE 527 "Impact Strength of Materials and Structural Crashworthiness".**
  This course provides the students with a basic understanding of the mechanics of impact and contact as well as the behavior of materials subjected to dynamic loadings. Topics include elastic and plastic stress wave theory for rods, including longitudinal, torsional, flexure and shock waves. FE programs and postprocessor software were employed to allow for visualization of wave propagation concepts taught through the course, as well as to enhance training of young engineers to illustrate concepts that have abstract nature. Students were requested to organize small groups of three people each and decide of a practical problem of impact nature which could have been investigated computationally, numerically and/or experimentally. A software system can offer an easy but appropriate functionality to support the formation of problem representations by requiring precise specification of a problem in a highly constrained formal specification language. The majority of the students did not possess any knowledge on usage of FE software. Thus, a basic but efficient training on such topic was required. Teaching how to effectively use an FE program in a few hours of class requires a lot of effort due to the necessity, at the same time, of being concise and ranging on various steps and commands. Also, it is expected that students can acquaint themselves with a software usage only through experience, which is gained with time and repetitive use of the program. With the intent of helping the students during this learning process, the Camtasia software was introduced and utilized for development of mini-courses on use of FE solver LS-DYNA and LsPrePost post-processor.

❖ Tutorials

Tutorials were developed to assist with the instruction on use of the software incorporated in the undergraduate and graduate classes described in the previous paragraphs. Following is a more detailed explanation on how these tutorials were formulated and employed in each course.

➢ Undergraduate Classes

Camtasia was utilized to produce short (10-15 minutes) tutorials demonstrating the use of ESRI's ArcMap program as it pertained to each course. The tutorials were comprised of screen capture of the instructor's computer as well as audio capture of verbal instructions. The first course offered during the academic year was CE 3070 "Urban and Environmental Planning." Seven individual tutorials were developed to instruct the student on some of the basic functions of the software, using the homework assignment as an example. Some of these tutorials also demonstrated techniques that were somewhat more advanced. During the next course, CE 3074 "Environmental Analysis," students were instructed to view the existing tutorials, while the instructor posted an additional tutorial to the course website to demonstrate one of the more advanced techniques as it pertained to that course's student project assignment. During the third course, "Land Use Development & Controls," one additional tutorial was provided, again relying on the students to view the earlier tutorials to learn about the basic functions.

➢ Graduate Classes

Camtasia was employed for formulation of small tutorials on LS-DYNA/LsPrePost usage and consequently electronically uploaded on the information portal available for members of the WPI community. These video-streamed tutorials were no longer than ten minutes and focused on showing a detailed capacity of the FE program. All steps of each lesson demonstration were carried out accurately, revised and cut and/or pasted with other different parts, as needed. As an additional feature, voice was recorded and overlaid as well, resulting in complete and efficient presentations, as those that are typical of class teaching.

In addition, students were required to follow the same methodology with Camtasia to record and show the steps of FE program use for their group project. In addition to a written report for their project, students were asked to employ Camtasia software to verbally and visually explain the choices and the results of their modeling part of their assignment.

Results and Discussion

Use of Camtasia software required the student to go beyond the information presented during the course and to interactively become acquainted with the domain concepts. Since this program allows the generated video stream to be exported to common video formats which can be read by most computers, even those where Camtasia software is not installed, the students had class lessons available at any moment. This helped in gaining practice and confidence for use of the

software programs and increased the student's interest, motivation and comprehension towards the subject. Student feedback from the use of video-streamed tutorials for the classes was primarily very positive and considered these recorded videos as an easy, handy and powerful source to be used also for other classes incorporating that specific software use. However, many students noted that they still relied on the course instructor and in some cases other students more heavily than on the tutorials.

Preparation of GIS and FEA tutorials and their recording was not a difficult and time costly task for the instructor, since the tutorials were designed to be short and focused on a specific task. Their availability on the information portal accessible to the WPI community facilitated the instructors supporting the student understanding and practice of the software any moment, as well as helped saving class time for more complex theoretical concepts related to the course subject.

In the graduate impact course, students welcomed very positively the request from the instructor about using Camtasia and recording the preparation of the final FE modeling project. This was considered an enjoyable and relatively quick way for demonstration to the instructor of the acquired capabilities with the FE software. Moreover, during its preparation, it turned out to be also a learning process for the students towards complete acquisition of main steps for the FE software use.

Conclusions and Future Improvements

The Camtasia Studio Software Package was found to be a useful tool for developing tutorials to facilitate the incorporation of FEA and GIS software into undergraduate and graduate classes in the Civil and Environmental Engineering Department at WPI. The use of the tutorials provided the ability to enhance the students' exposure and experience with FE and GIS software. It also was found that the approach increased the students' curiosity towards the abstract concepts taught in class and enhanced the quality of their project work. The method was welcomed and supported by the students who were also challenged, in certain classes, to use the same approach for developing and presenting their final course project.

Future improvements could address the need to create additional tutorials to cover more advanced software functions and replace, in certain cases, some assignments-specific tutorials with improved instruction from a more generic perspective in order to broaden the audience of future students. Moreover, well-developed projects accomplished by students during the current year could be considered as further examples and employed in class in the following years to provide more detailed explanation of specific software use. Providing additional references and documentation in the common GIS website could serve to enhance the effectiveness of the tutorials. In addition, the use of common project themes for different classes could provide an opportunity to reinforce concepts developed through the use of tutorials in previous classes. The tutorials described in this paper provide the basis for these additional efforts to incorporate software into the curriculum.

References

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Biographies

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