2006-2393: CBT TEACHING TOOLBOX: A MECHANISM FOR COLLABORATIVE DEVELOPMENT OF INTERACTIVE COMPUTER AND WEB-BASED TRAINING

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"CBT" Teaching Toolbox: A Mechanism for Collaborative Development of Interactive Computer and Web-Based Training

Abstract

The "CBT" teaching toolbox is a dynamic forum for the planning, development, and dissemination of interactive computer and web based training. The toolbox web site serves as a resource of development tools, a repository of developed course content, and as a rendezvous for collaboration and interaction. The principle objective of the toolbox is to assist with the development and introduction of new pedagogical methods that allow for the teaching and integration of professional course related software into the engineering curriculum. Interactive computer based training (CBT) is used to accomplish this objective. The teaching toolbox facilitates the promotion of learner-centered, knowledge-centered, assessment-centered, and community-centered learning environments. Application of the toolbox tools has brought to light the importance of desegregating the learning environment to promote a higher level of learning. Each software application requires a significant investment of time for the instructor to teach and for the student to learn and apply. This extra burden on students is minimized through the effective use of CBT tools that can adapt to the student's instructional needs. The introduction of CBT tools into the curriculum brought with it the ability to impact other aspects of the course and student learning. The interactive movies, games, quizzes, virtual world, and other resources offered on the instructional web sites developed for each involved class focused on course fundamentals that are problematic for students. The additional assistance that students receive from these interactive tools can offset the cost of introducing engineering software into the curriculum but more significantly provides needed formative feedback and variety in the instructional environment. The teaching toolbox provides a mechanism for sharing the effort of creating and disseminating instructional content. The course specific content is designed to be adapted in part and in whole by instructors at other institutions who desire to use the developed resources without having to create content. The usefulness of the teaching toolbox as an aid to those, faculty and/or students involved in learning through teaching, who desire to create new content however should not be overlooked.

I. Introduction

Asynchronous interactive computer-based training is a powerful complement to classroom instruction. While the teaching of core engineering principles requires an interpretation and a developed understanding that generally requires classroom discussion between faculty and student, computer based training can be used to instruct students in the use of engineering software and to reinforce students’ interest, knowledge, and engineering judgment. The use of asynchronous delivery allows students to enter the instruction at the appropriate level. Students can select additional instruction in weak areas and skip ahead if they are familiar with the topic. Additionally, students can receive instruction on their own schedule and at their own pace. Finally, the instruction can be repeated and reviewed if students need repetition to grasp and retain instructions. However, the full capacity of asynchronous computer-based instruction is still emerging. The development and use of interactive computer and web-based training (CBT)
tools and a CBT teaching toolbox at The University of Texas - Pan American (UTPA) has brought to light several aspects of the impact of interactive computer and web-based training on the learning and teaching of engineering. The impact of selected elements of an interactive computer and web-based training on the engineering learning environment has been previously reported in the literature including Crown\textsuperscript{2}. CBT promotes learner-centered, knowledge-centered, assessment-centered, and community-centered learning environments\textsuperscript{3,4}. Learner-centered environments help students make connections between their previous knowledge and their current academic tasks. “Learner-centered” refers to environments that pay attention to the knowledge, skills, attitudes, and beliefs that students bring to the educational setting. CBT provides a key tool to address the diversity of students’ backgrounds, experiences, race/ethnicity, gender, physical capabilities, and learning styles through instruction with a diversity of perspective and materials. Knowledge-centered environments help students to develop organized knowledge that is accessible, applied appropriately and that enables learning with understanding during the learning experience. CBT is a practical tool for contextual learning and enhancing the learning process with engineering software. Furthermore, CBT can help students acquire and organize knowledge by, among other things, student learning through teaching. Assessment-centered environments provide students with opportunities to revise and improve the quality of their thinking and understanding. Assessment must reflect the ultimate learning goals, for instance, understanding and applicability of knowledge. CBT is a means to provide immediate feedback and self assessment. CBT is also a practical tool to create public forums for assessment. Finally, community-centered environments promote a sense of community. They encourage students to learn how to use their peer students, teachers, and other members of the community as a resource for their own learning. CBT provides public forums to promote a sense of community. All four of these dimensions of an effective learning environment should be present in effective student learning environments. Obtaining a balance of each dimension is the key to the design of a better learning environment.

A faculty development resource called the “CBT” teaching toolbox has been created to assist in the development of asynchronous interactive computer and web based training (http://crown.panam.edu/toolbox). The teaching toolbox shown in Figure 1 is a website devoted to the dissemination of content and methods developed under a NSF CCLI grant. The toolbox was developed primarily as a resource for faculty who desire to use interactive computer based instruction in their courses. The toolbox is in many ways what its name suggests, a compilation of assistive tools for the creation of CBT materials. Tools are not creative and do not provide direction. They do, however, enable the user to build and create useful structures formed from a carefully designed plan. The toolbox examples provide much insight to the creative possibilities for the tools but should not in any way limit their use. Faculty who desire to make use of the toolbox must invest themselves in the creative and thoughtful process of considering the needs of their particular students and how the developed materials might meet those needs.
II. CBT Teaching Toolbox as a Mechanism for Collaborative Development

The toolbox provides links to the course content developed for four mechanical engineering courses. The links serve as a resource for those who desire to use the developed content in similar courses at other institutions and as examples of what can be accomplished through the use of the tools presented in the toolbox. A database of registered users and a discussion forum facilitates the sharing of newly created content. The course links provide powerful examples of how interactive computer based instruction can impact the pedagogy of engineering education and the tools and methods links show how to create this content.

The audience for which the toolbox was created is threefold. First, there is the basic user who will primarily look through the developed course content and find content that supplements existing courses taught at their institution. The content would then be linked to the basic user’s course web site and support like courses. An example is an instructor at another institution using the tutorial movies developed for AutoCAD to teach his students program basics typically presented in the first half of an introductory text. With the authors permission the movies were downloaded to a local server to speed delivery time. Second, there is the adaptive user who sees an application for the structure of the developed content but applied to teach new concepts. An example is a student under the direction of a UTPA chemistry professor who used the Java applets developed to create over 30 new interactive exercises for an introductory chemistry course. Third, there is the technical user who will use the structure and content as a starting place for the development of new content that builds on the developed materials. An example
being the creation of the toolbox itself by the PIs whose creative work has developed out of countless instructional sites distributed on the internet.

Within the audience for the toolbox is an important target group that is vital to the sustainability of using introducing software into the curriculum with CBT. Collaboration with and among students in the process of developing CBT materials not only distributes the load to a reasonable level but actually enhances the learning environment. This experience is consistent with the design principles of an effective learning environment. Instructional materials developed by students or in collaboration with students will be better connected to their peers interests, skills, and knowledge helping to create a learner centered environment. These authentic student materials have an impact on the student beyond their content and suggest to students that the information is relevant and accessible since it was developed by their peers. This sense of community-centered learning is further enhanced when the student reciprocates in the learning process and develops CBT materials for future students. In the process of organizing their knowledge to develop a specific CBT module students find themselves immersed in an effective knowledge-centered environment. Finally as the materials are used by other students in the class feedback and assessment from their peers provides a rich assessment-centered environment. The teaching toolbox has been effectively used to walk students through the development of CBT materials to the extent that nearly half of the CBT content presented in the engineering graphics course is developed during the class by students as part of the learning process. In the kinematics and dynamics course, students were used to translate the instructional content into Spanish since the local student population is approximately 85% Hispanic.

All of the examples presented in the teaching toolbox have primarily been constructed using three basic toolbox tools. These three basic tools are the computer-based games and quizzes, interactive virtual environments, and screen capture tutorials. A number of supportive tools are needed to effectively use the basic tools including image editing, dynamic databases, and faculty web pages. Tutorials for using specific software tools, helpful utilities, and examples are provided in the teaching toolbox to aid in the development of new CBT materials. The toolbox is dynamic in the sense that it is the working resource used by the developers to disseminate content and provide training and is constantly adapting to meet those needs.

A. Games and Quizzes

The games and quizzes sections of the toolbox provide tools for the use and development of interactive web based activities to teach and assess specific learning objectives. The quizzes provide a simple mechanism for testing knowledge through multiple choice or true/false questions. The interactive games provide a mechanism for the presentation of visual content in an engaging “game like” environment that can be used to balance some of the text based non-interactive content on an instructional web site. The games and quizzes may be used as an optional learning activity or as a formal means of assessment for a particular course concept. Furthermore, the collaborative development of games by students involved in a teaching through learning exercise builds a stronger learning environment.

The toolbox quiz is built upon a JavaScript form that allows for the posting of multiple choice and true/false questions. Upon submitting the form the student is given a score and the
opportunity to review the quiz and make corrections. The quiz can be used as a personal assessment tool for the student or, with simple modification, for grade assessment where the results are posted to the student’s record in a database. A sample quiz as shown in Figure 2 below can be downloaded from the teaching toolbox web site. Simple online instructions for modifying a sample quiz have enabled students to successfully generate study quizzes for other students in the class. Images can easily be included and referred to in the quiz to accommodate and assess graphical content. The graded quizzes provide a necessary component to interactive computer based training in that they give immediate feedback to the student about their progress on expected learning outcomes. This immediate feedback both reinforces what was accurately learned and gives the student the opportunity to review problem areas while the subject is still fresh in their thinking.

The toolbox games are divided into three categories based on the programming language that they are built upon. The three platforms used to create the games are Java, JavaScript, and Macromedia Flash. The JavaScript game templates were used most extensively in the materials developed under the grant since they were developed first and are the easiest to openly distribute and modify. Additionally the Java applets and Flash files require the use of additional plug-ins to view and software to modify. Examples of each template are provided in the toolbox and are helpful in determining the appropriateness of each platform to accommodate a particular need.

![Sample Quiz Given in Toolbox as a Template](image-url)
Java Applets provide great flexibility as game templates and have an advantage over JavaScript in that the code can be protected. Applets are compiled programs that run on a web page. The applets were written in such a way that the content is easily modified using parameters. Using the fixed puzzle format of each applet a wide variety of instructional puzzles is easy to create. Use of the applets requires that the user enabled Java in their browser. The puzzle formats can be modified, however this requires a significant investment of time, knowledge of Java, and access to a Java compiler.

The toolbox contains two Java flexible applets that support all of the Java games posted in the course content projects. The first applet is the SCRAMBLED GRID which allows for the manipulation of a sliced image that must be arranged to meet a specified learning objective. The simplest application of this applet (designed for 1st grade students) is built on the image shown in Figure 3 and designed to teach the tabular organization of items in rows and columns. Using applet parameters the designer can specify the region of the image to scramble and what final arrangement constitutes a correct solution. In the example shown in Figure 4 all of the shapes are scrambled and the puzzle is solved when they are all returned to their original position. A program was written to help with the creation of the games that allows the designer to control all seven game parameters and build games with multiple levels. One game that makes use of multiple levels is the chemistry puzzle on the periodic table shown in Figure 5. The student can solve the puzzle for a single group of elements or scramble the entire table. The periodic table puzzle was built from a single image of the periodic table using the SCRAMBLED GRID applet without a single modification.

![Figure 3: Original Image for Shapes Game](image1.png)

![Figure 4: Shapes Game using Java Applet](image2.png)
The second game applet is PLACE FROM MENU and allows more flexibility than the scrambled grid in that a menu of items can be placed anywhere on the background image and multiple items can be placed. A program was written to help with the control of parameters that allows the designer to control the location and orientation of each placed image and each item in the menu. As the design parameters are more complex a set of tutorial movies was created to walk the developer through the puzzle design. The added flexibility of the puzzle means that the puzzles can be more open ended as there are by design an infinite number of solutions. The puzzle can be configured to give feedback with the placement of each image and notify the user when the puzzle is completed. The applet can be configured to only run on the developer’s server through a hyperlink or can be configured to be freely copied.

An instructive but challenging example of the PLACE FROM MENU applet is shown in Figure 6. The puzzle format was originally developed for an engineering graphics application but was implemented by another professor for use in an engineering mechanics course by simply changing the images. In the exercise, the user must select the appropriate forces and couples from the menu area and place them in the correct location on the beam that gives the shear and moments shown in the diagrams. The puzzle has several levels that increase in difficulty. Immediate feedback given in the early levels of the puzzle helps to reaffirm or correct the student’s understanding of shear and moment diagrams. Items from the menu can be placed on the image repeatedly. In some puzzles the menu is eliminated and the images are simply moved to the correct location to reduce the complexity. Each placed image is loaded as a separate image file and must be located on the base image in a location specified by the puzzle designer. Once the images were created, the puzzle shown in Figure 6 took only about 5 minutes to create using the puzzle creation program developed for the teaching toolbox.
JavaScript is a programming language that is interpreted by the browser. As part of the web page text, it is easy to modify the code and change the puzzle content. The JavaScript puzzle formats are not as general as the Java applets however there are five different formats in the toolbox, listed in Table 1, that are relatively easy to modify. Each format is presented with an example that can be downloaded as shown in Figure 7. Three tutorial movies show how to use the example puzzle, modify the images to teach a new concept, and modify the structure to create new puzzle formats. The ability to modify the puzzle format was utilized in the puzzle shown in Figure 7 where the puzzle was modified for a specific application to allow for the selection of multiple answers. The toolbox provides links to a variety of puzzles using the toolbox formats built by different developers for several disciplines and courses.

Table 1: JavaScript Puzzle Formats on the Teaching Toolbox Site

<table>
<thead>
<tr>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <strong>Scrambled Image</strong>: A grid of scrambled puzzle pieces must be placed in the correct order on a rectangular grid to launch a pop-up window. Each individual puzzle piece is a separate image file.</td>
</tr>
<tr>
<td>2. <strong>Reveal an Image with Questions</strong>: A grid of images is revealed one at a time with each correct answer. Each question is displayed in an image file and the user may answer by selecting a button labeled A-E.</td>
</tr>
<tr>
<td>3. <strong>Matching</strong>: A sequence of images is revealed that must be matched to images shown in a grid. Each correct answer reveals the next image in the sequence.</td>
</tr>
<tr>
<td>4. <strong>Identify Regions on an Image</strong>: A sequence of images is revealed that must be matched to hot-spots on an image. Each correct answer reveals the next image in the sequence.</td>
</tr>
<tr>
<td>5. <strong>Answer Questions about an Image</strong>: A sequence of images and questions are revealed that must be answer by selecting appropriate checkboxes labeled A-E. Each correct answer reveals the next image and question in the sequence.</td>
</tr>
</tbody>
</table>
Flash puzzles are easy to create and modify using Macromedia software. The puzzles are compiled programs that are run using a common browser plug-in. Flash is especially useful for puzzle formats that use animation. Modification of puzzles and/or content requires the purchase of software and a significant investment of time. Although the Flash puzzles are the easiest to create they are also the most difficult to use as a template for simple modification.

A Flash game for engineering graphics is shown in Figure 8. With the flip of a switch, four different solid parts begin to move along a conveyor. The parts which are randomly oriented must be identified and placed on the appropriate shelf. The puzzle has a time limit as pieces not placed in time fall off the end of the conveyor. The placement of parts on the shelves is evaluated after the last piece is placed. The animation and sounds of the puzzle make it more “game like” than other puzzles on the graphics web site. The game can be modified to accommodate different objects moving along the conveyor that need to be sorted. The sound, animation, and file handling system of the Flash games make them more specific to a particular application such as sorting items on a conveyor in the example shown. The same puzzle was
also made using the Java applet format except without the animation. It is interesting to note that students do not express any strong preference for the Flash puzzle and seem more interested in the content of the puzzle than in the delivery mechanism. There is also some aversion by students to timed activities.

![Figure 8: Flash Game used to Develop Visualization Skills by Identifying Reoriented Parts](image)

**B. Creating VRML Educational Environments**

The use of an interactive visually immersive environment for the delivery of instructional materials is effective and engaging. The “roman virtual world” developed for engineering graphics provides a virtual design environment that is an appropriate setting for the delivery of CAD content. The “roman virtual world” was constructed using a structured modular format such that the virtual world can easily be used to deliver other course content or reconstructed as another virtual environment. The virtual world structure has been used to create three other virtual environments; a virtual campus, space station, and conference center. The virtual conference center is presented in detail on the toolbox site.
Although the virtual environments have had a significant positive impact on the learning environment, this is the most costly tool presented in the toolbox in terms of the required skills and investment of development time. The need for collaboration is essential for expansion and sustainability. The toolbox provides training and utilities to aid in the development of new materials so that additional collaborators can easily enter the group. Additionally, students have been effectively used to develop content for the virtual world in learning through teaching exercises where the faculty member serves to assign, assess, and manage the developed content.

The virtual campus contains classrooms, offices, and labs. The virtual campus is currently being used as a “virtual” meeting place where students can chat and post content related to specific courses. Each room is devoted to a specific course in the engineering curriculum so that students interested in a specific course are grouped together. Students visiting the site may include those from other institutions or countries and greatly expands the definition of their peer group. The virtual campus, shown in Figure 9, models the engineering building at UTPA. The virtual campus gives students a familiar environment where student interaction can take place beyond the typical boundaries of the physical institution.

Figure 9: VRML Virtual Campus

The virtual space station provides a futuristic setting where some of the constraints of a contemporary setting may be relaxed. The futuristic setting encourages consideration and presentation of materials that have yet to be discovered. The space station represents a “state of the art” technological setting that highlights the accomplishments and possibilities of engineering, science, and technology. The roman world training camp has been replaced with an orbiting space station above a small moon which serves as the setting for the virtual homes and
center for student content. Visitors experience weightlessness in the space station and can float rather than walk through the content.

The virtual convention center provides a natural setting for the presentation of research or student projects where virtual conference attendees can interact with authors and tour visually oriented exhibits. The virtual environment encourages chat at poster sessions as the movement of virtual characters (avatars) shows what visitors are interested in and where conversations are taking place. The success of the open house in the engineering graphics course demonstrates the educational opportunity for posting virtual conferences in the virtual conference center.

The virtual conference center is also used on the teaching toolbox site to teach the creation of virtual worlds using VRML software. Several tutorial movies provide over one hour of instruction on the basic elements of creating VRML content and walk the user through the creation of the conference center. The last three movies show how to use the VRML world to deliver educational content and create resident experts that launch audio clips, video screens used to play instructional video, and posters that link to informative web pages.

C. Screen Capture Tutorials

Screen capture tutorials serve as the core of the tutorial instructional in the example projects presented on the toolbox and for toolbox instruction. The five to ten minute recordings of screen activity and audio provide an excellent mechanism for teaching anything that is resident on a computer, especially the teaching of computer software. There is a growing need for graduates to be proficient with a number of complex software applications. Teaching students how to use software without sacrificing other necessary course content is a challenge. Screen capture tutorials are an effective means of teaching software outside of the typical classroom setting as the training can be accessed asynchronously and at a pace and depth that matches the individual student’s needs. The tutorials may be delivered over the internet or on removable media and played using a number of freely available media players.

Several pages on the toolbox site are devoted to the instruction and use of screen capture software. The toolbox site contains examples of tutorial movies used in several different courses and created by a number of faculty and students. The examples demonstrate the variety of applications for the software and most notably the fact that students can create instructional materials as part of the educational process. To this end, the tutorial movies that instruct on using the screen capture software are housed on a page focused on student use. The page, shown in Figure 10, also serves to illustrate to faculty the possibility of student learning through teaching as they create instructional movies for use by their peers.
D. Supportive Toolbox Tools

Image Editing

Several tools in the toolbox require the ability to create and manipulate images with imaging editing software. However, learning to use image editing software can require a significant investment of time. The toolbox includes a set of tutorial movies providing step by step instruction on the use of image editing software. The movies teach skills needed for the creation of instructional materials using other toolbox tools. The tutorial movies on image editing give over 45 minutes of instruction on the basic elements of the software, batch processing of image files, and using recorded macros for repeated editing operations. The tutorials provide assistance to the novice and advanced user and shorten the development time for creation of new course
content whether the work is accomplished by a faculty member or a student under the faculty member’s direction.

**Dynamic databases**

Management of the virtual world would be time intensive without the use of dynamic databases that can be managed and assessed over the internet. The database programs PHP and MySQL were used for the materials presented in the toolbox and for the toolbox forum as these programs are available as freeware and are frequently used. The database software allows students to purchase homes in the virtual world in real time and post CAD design content in their homes.

Several tutorial movies are presented in the toolbox that explain all aspects of setting up and using a database program and explains the details of two database applications used in materials developed for the toolbox. The first group of movies shows how to setup a web server that hosts a database program and then how to setup and configure the database for particular needs. The last two groups of movies describing the toolbox applications demonstrate the usefulness of a database and how to access it.

The first application described is the “Student Photo Directory”. The directory is a database of student photos linked with full legal name, nickname, and email address that is updated by the students and used by faculty to create picture directories for their classes. The second application described is the “Virtual World Database”. The database is used to manage the ownership of homes and associated links in the virtual world. Students can purchase a home in the virtual world and link the home to the virtual model housed on the student’s web site. A number of PHP database management pages were created to allow students to create and update database records and faculty to view and manage the entire database structure.

**Faculty Web Pages**

The development of computer based instruction and teaching aids must eventually be delivered to students. One mechanism for delivery is through hyperlinks on course related web sites. Although students can be directed by their instructors to web sites that contain the educational content, it is most effective if instructors link to specific content on their own course related web pages. In an effort to disseminate the toolbox resources and ensure that they are delivered to students a series of tutorial movies was developed to teach faculty how to create course web sites. The movies show faculty how to create web pages that give general course information and provide links to other resources. The faculty are shown how to link to resources in the teaching toolbox and how to post content developed with the teaching toolbox tools. The tutorial instruction assumes only basic computer skills and has already been used effectively.

**III. Concluding Remarks**

Although many may use the toolbox resources to simply borrow developed materials from the project examples, the primary usefulness of the toolbox lies in the ability to create new applications. The toolbox has in many ways already served this purpose at UTPA. Tools have been developed by taking the effective materials and methods used in engineering graphics,
stripping out the content, and reforming the shell to be an adaptive tool that might be used to create and deliver new content. Use of these tools developed from the engineering graphics content has been instrumental in the development of all of the example projects.

Early in the development process the toolbox took the form of developers personally delivering their expertise to new developers rather than in the form of a toolbox web site. Much, but not all, of this expertise has been duplicated in the teaching toolbox. The tools and examples presented in the toolbox provide significant assistance to developers, however, there is still a critical need for developers to have access to others who have successfully used tools and can share information or answer specific questions not handled on a web site. This access is facilitated through a forum on the toolbox site and may be supplemented through personal correspondence with other developers.

The teaching toolbox offers several opportunities for assigning students the task of creating computer based instructional content. The templates for many of the games and quizzes presented on the teaching toolbox site were designed so that they could be used by students with limited computer skills. The creation of tutorial movies by students in engineering graphics has been successful to the extent that the student materials represent a significant portion of the course content. The greatest depth of knowledge achieved by students occurred in areas where they created instructional content for others.

**Bibliography**


