

## **Web-based Distance Learning Environment To Teach Computer Aided Engineering Design and Analysis Tools**

**Rujin Cheng, Keith Adolphson, Kurt Gramoll**  
**Aerospace and Mechanical Engineering**  
**University of Oklahoma**

### **Abstract**

Computer aided engineering design and analysis technologies have become very important in engineering development. They increase product reliabilities and decrease product development time and cost. Many engineering students hope to learn and use these tools for their research projects and in their future careers. This paper describes a distance learning initiative at the University of Oklahoma to help teach and train the engineering students about engineering computer aided design (CAD) and analysis technologies.

There are two distinct advantages of this learning environment. First, it accommodates multiple learning styles, such as traditional teaching, interactive multimedia-based training, and case studies, to assist users to understand two commonly used CAD tools, Pro/Engineer and Solid Works; second, it was built not only for individual study, but also to facilitate use in a class structure. This feature is supported by a well-designed database. The user can either register as a regular user, which means he/she will study individually and freely. Or, the user can register as a student of a specific class. Furthermore, user forum was built into this environment to encourage collaboration between users and to discuss problems. Teachers can register their classes on the training site and monitor their students' progresses.

While the asynchronous mode of teaching is becoming more and more popular, there is still much to explore in the online teaching arena. The use of an integrated database on a web server provides new opportunities to research these methods. Many essential features of a large-scale learning environment, such as user tracking, community collaboration, and assessment, are supported by the database in the background. In particular, the system coordinates the learning activities of each user to help them understand the fundamentals of CAD and acquire the basic functions of the CAD tools. The learning methods utilize case studies, tutorials and concept pages. Each is independently monitored for user activities, to provide information that the users may need as they progress.

This paper also discusses the development and maintenance of the distance learning site, as well as the unique requirements of online training of engineering contents.

## **I. Introduction**

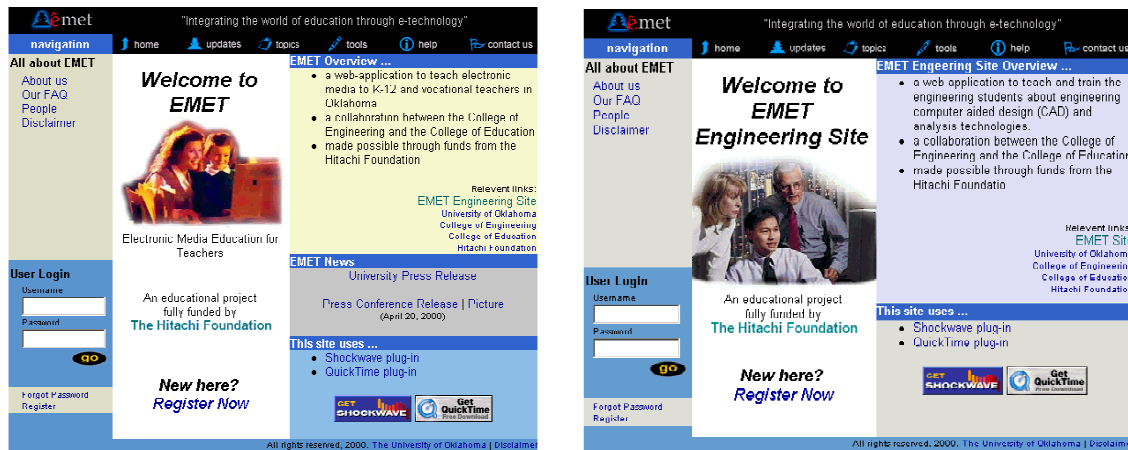
For many years, instructors from all levels of the education community have used various techniques to reach students in remote locations <sup>[2]</sup>. Distance learning gives educators a new solution to declining budgets for education, because it requires less time, cost and teaching resources to operate.

The accelerating expansion of distance learning can be attributed to the growing popularity of the Internet. Deborah Coppola <sup>[1]</sup> believes that the rapid growth of the Internet is an incentive to change the fundamental design of courses. This change should affect both the structure of the classroom, the educator and, of course, the student <sup>[2]</sup>.

This paper presents research in the development of a web-based distance-learning environment using a database to teach engineering students about computer aided engineering design and analysis tools, which was developed at the University of Oklahoma. This asynchronous learning environment is a branch-site of a three-year project began in January 2000, which is named "Electronic Media Education for Teachers" or EMET. EMET is supported by a grant from the Hitachi Foundation, and is a joint collaboration between the College of Engineering and the College of Education at the University of Oklahoma.

EMET, as its name denotes, was built to facilitate teaching educators how to use multimedia elements and multimedia development tools to create interactive content for use in their courses. The EMET multimedia site is based, in part, on the successful multimedia course for engineering students that have been conducted by Dr. Kurt Gramoll at the University of Oklahoma for the last four years <sup>[2]</sup>. Now, after successfully developing web-based content to teach twelve widely used multimedia tools corresponding to the most important media types to educators, the EMET program is branching out to accommodate another user group, engineering students. The goal is to teach computer aided engineering design and analysis software to engineering students so that they can use their newly acquired multimedia skills to improve their research and coursework. Figure 1 shows a screenshot of the newly created EMET engineering.

The content on the EMET engineering site were developed based on a series of successful computer aided design and analysis courses offered by Dr. Kuang-hua Chang in recent years in the University of Oklahoma. The involvement of Dr Chang insures that the EMET engineering site will maintain a continuity of vision and meet the students' and engineering program needs in a reliable and effective manner.



**Fig. 1. EMET Distance Learning Site**

This paper also presents the various teaching strategies employed on the EMET engineering site and describes administrative features of the EMET engineering site that enable teachers to set up different course groups to manage students. In addition, currently available technologies such as the relational database management (RDBMS) and server-side scripting languages were used in the development of EMET engineering site. These are all good experiences in building the EMET engineering site.

## II. Topic areas of EMET

The EMET online teaching environment covers two main fields: electronic media and computer aided engineering design. In the first field, considering the demands that modern web sites and courseware place on all media types, such as: text, diagram, picture, sound, simulation, video, and 2-D/3-D animation, EMET electronic media site teaches twelve major multimedia development tools. These particular tools were chosen to insure that all major media types are covered using a selection of the most widely used software available. As the media types and tools are not tied to a particular discipline by design, teachers from many disciplines can use them to develop or augment their own individual courses. For the computer aided engineering design field, EMET chose to teach solid modeling, FEA (Finite Element Analysis) and motion analysis tools. These analysis features were selected as the most mature and accessible computer aided design (CAD) techniques for our initial effort with the engineering site. Also, the corresponding tools are the most effective software available. Acquiring CAD analysis knowledge and skills will provide engineering students an advantage in their research and future employment. EMET anticipates adding more topics in the engineering field in the near future. Table 1 shows the topic areas and tools covered on the EMET and EMET engineering site:

<b>Electronic Media</b>		
<b>Phase</b>	<b>Tools</b>	<b>Descriptions</b>
Beginning	Dreamweaver (HTML)	<ul style="list-style-type: none"> <li>• Advanced web page builder</li> </ul>
	Freehand (drawing)	<ul style="list-style-type: none"> <li>• Vector-based</li> <li>• Small files</li> </ul>
	Photoshop (photo editing)	<ul style="list-style-type: none"> <li>• Pixel-based photo editing</li> </ul>
	SoundForge (sound editing)	<ul style="list-style-type: none"> <li>• Basic recording and editing</li> <li>• Simple to use</li> </ul>
Intermediate	Flash (2D animation)	<ul style="list-style-type: none"> <li>• Vector-based</li> <li>• Supports sound and interactions</li> </ul>
	Premiere (video editing)	<ul style="list-style-type: none"> <li>• Industry standard for video editing</li> <li>• Producing new videos from parts of others</li> <li>• Special effects</li> </ul>
	Excel (data visualization)	<ul style="list-style-type: none"> <li>• Creates worksheets and charts</li> <li>• Performs calculation and formatting</li> </ul>
Advanced	Director (simulation)	<ul style="list-style-type: none"> <li>• Scripting capabilities</li> <li>• Easy manipulation of graphics, sounds, movies</li> <li>• Interactivity</li> </ul>
	Carrara (3D animation)	<ul style="list-style-type: none"> <li>• 3-D animation</li> <li>• Both modeling and rendering</li> </ul>
	JavaScript (client-side scripting)	<ul style="list-style-type: none"> <li>• Programming language embedded into HTML coding</li> <li>• Dynamic web page, interactivity</li> <li>• OOP (Object-oriented Programming)</li> </ul>
	ASP (server-side scripting)	<ul style="list-style-type: none"> <li>• Access database</li> <li>• Security</li> <li>• Interactivity</li> </ul>
	PERL (server-side scripting)	<ul style="list-style-type: none"> <li>• Interactivity</li> </ul>
<b>Computer Aided Engineering Design Tools</b>		
<b>Phase</b>	<b>Tools</b>	<b>Descriptions</b>
First	Pro/ENGINEER	<ul style="list-style-type: none"> <li>• Solid Modeling</li> <li>• Design analysis</li> <li>• Modification and regeneration</li> </ul>
	SolidWorks	
Second	Pro/MECHANICA	<ul style="list-style-type: none"> <li>• FEA (Finite Element Analysis)</li> <li>• Motion analysis</li> </ul>

**Table 1. Topic areas on the EMET Website**

### III. EMET Teaching Strategy

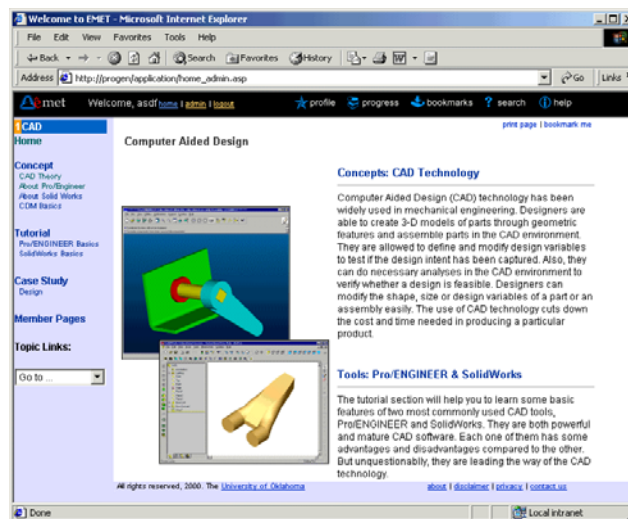
EMET engineering site is an online education environment. It is built to teach users how to use selected modern computer aided engineering design and analysis tools. That means that, like other more traditional educational models, teaching strategy is an important consideration that has a direct impact on the teaching outcome. This is why the EMET team has put extensive thought into appropriate teaching strategies for the EMET site.

EMET is designed to support asynchronous access. Rather than coercing them to adopt a traditional classroom schedule, students can access the courses anytime of the day or night. In other words, each student determines their own schedule to meet their needs. Moreover, there is no general class schedule required for all users except for any completion deadlines set by the course instructor. Furthermore, students are not limited to a linear progression through the topics step by step. Instead, they can focus on the specific areas that they need. Finally, EMET's

asynchronous learning is ideally suited to meet the needs of nontraditional students as it can easily accommodate those students who are working full-time (e.g., teachers).

During the design phase of the EMET multimedia site, it was decided that there would be three distinct teaching strategies employed. They are: (a) the concept pages, (b) tutorial simulations and, (3) case studies. Each strategy differs in the degree of interactivity afforded to the learner. Based on the past year's experience, it has been proven that these three methods are effective and straightforward for the EMET education content. So the same three teaching methods were chosen to use on the EMET engineering site. This can also keep the EMET multimedia site and the EMET engineering site the same structure, since they are both parts of EMET project.

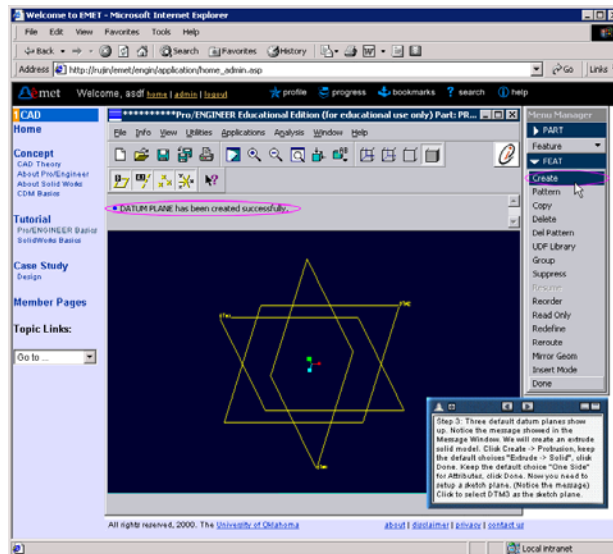
“Effort was placed on separating the differing learning methods so that each method complements the other instead of replicating the same educational material.”<sup>[2]</sup> This is true of both the EMET multimedia site, as well as, the EMET engineering site. These different methods are illustrated by screen captures in Figures 2, 3 and 4 below.



**Fig. 2. Sample of a Concept Page**

The concept page describes the development and theory of a certain computer aided engineering design and analysis technology concepts and topics in greater detail through textual references and is comparable to the information found in a traditional textbook in many respects. Unlike a textbook, however, the concept pages may include a modest amount of interactive illustrations of the concepts discussed. These pages provide the user a general overview of technical background information, design and implementation considerations, and ideas or useful tips about an individual topic area. Information on these pages is generally not suitable for inclusion in tutorials and case studies for various reasons. The specifics on the concept pages may include supplemental information needed to extend what is learned in the tutorials, it may not lend itself to simulations, or may not be a realistic, suitable topic for a case study. Thus the concept pages

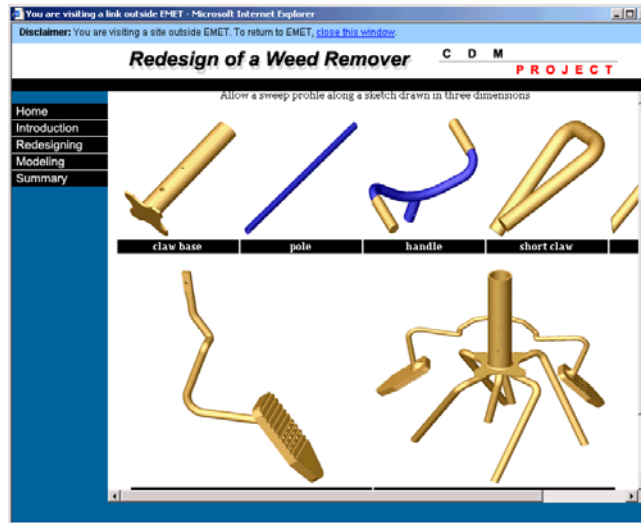
are used to complement and supplement the interactivity of the tutorials and diversity of the case studies without duplicating them.



**Fig. 3. Sample of Tutorial Simulation**

On the other hand, Tutorial Simulations place the most demands upon students in terms of interactivity, especially in comparison with the concept pages. EMET simulations are developed using Macromedia Shockwave technology using Macromedia Director. The purpose of the tutorials is to teach the user how to use specific computer aided engineering design and analysis tools such as Pro/ENGINEER or SolidWorks. The tutorials closely mimic the software interfaces that are simulated. To the student, it appears as if she or he is working in the actual program with the added benefit of interactive instructions and message cues. However, the actual software is not, nor is it required to be loaded on the user's computer in order to master the concepts. Having learned the material, the student may then create actual media in a computer lab on campus or, if desired could purchase the requisite software for installation on her or his personal computer.

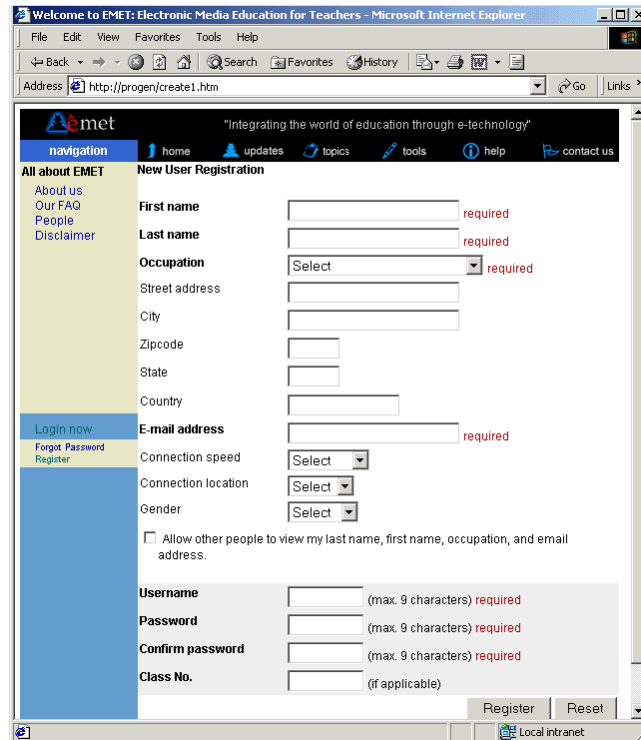
Each tutorial consists of about ten objectives. Each objective consists of several goals for the users to accomplish. For example, a CAD goal might be how to create a default coordinate system or a cut feature in a solid model in Pro/ENGINEER. Upon completion of the objective, a brief quiz is administered to primarily to collect information about how well the user understood the objective.



**Fig. 4. Sample of a Case Study Page**

Case studies are the final learning method employed (Fig. 4). Case studies are effective because they provide actual example of what can be created once the EMET topics are mastered. EMET staff and School of Engineering faculty developed the initial case studies available on the site. As the program matures these case studies are planned to be supplemented/replaced by case studies submitted by actual EMET users. The intent is to illustrate how particular computer aided engineering design and analysis tools could be or are being used to improve or prove engineering students' design work or research. For example, in teaching the user how to capture a designer's design intent in using SolidWorks, it would be helpful to show the user how design intent will decide if the design works. EMET has a feature that allows users to upload and make their own creations available to others as case study examples. They can also modify their pages or even delete them.

For site development purposes, there is a user-tracking feature that is incorporated into each of these learning methods and tied to the user's registration (Fig. 5). For example, in addition to the quizzes in the tutorial section, users are tracked as to which parts of the site are visited. For example, a visit to a concept page in a topic area, such as CAD Tech., is tracked to determine if a user has visited the web page. This helps determine which aspects of the EMET instruction are being used, which are more effective or, conversely, which are ineffective. This feature permits developers to determine of the overall effectiveness of the respective learning strategies. With this information patterns indicating the preferred learning style(s) can be identified and used to make adjustments to the program. This mechanism is similar to methods used by commercial web sites. For example, e-commerce sites also examine the behavior pattern of users at their website. Using this information, these sites can evaluate, re-distribute and improve development efforts more effectively.



**Fig. 5. New User Registration**

The user-tracking feature is also used to record a user’s progress on the site. Users can always check their progress page to remind themselves what they have done on the site (Fig. 6), what remains to be done, and check their scores for the various quizzes in the tutorial simulations. This feature should help users effectively manage their study of the topics on the EMET engineering site.

John Black's Progress (Username: asdf)

Note: Click the subtopic to view the details. Numbers represent the order of the sections as shown in the menu.

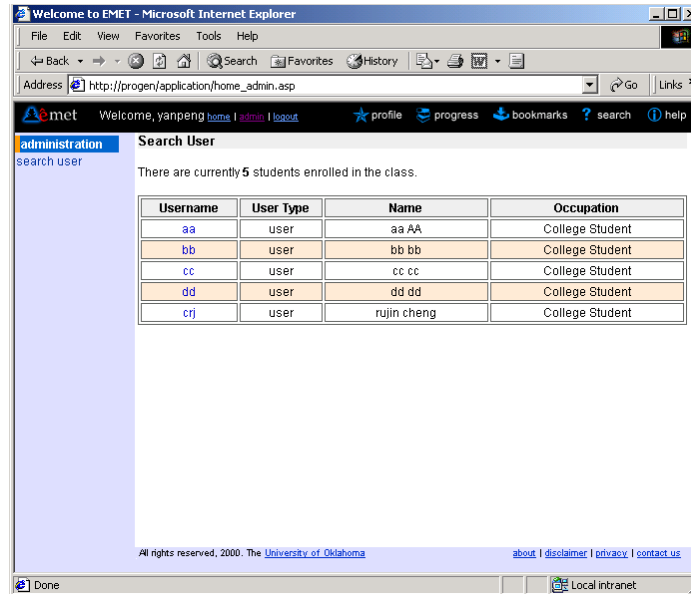
	1	2	3	4	5	6	7	8
CAD								
Concept	x	x	x	x				
Tutorial								
Case	x							

**Fig. 6. A User’s Progress Report**

The EMET engineering site also allows specific users, such as faculty, to register as a group administrator if they desire to do so. Professors who want their students to use this site as an augment or component of their course can then monitor students’ progress themselves. They can register a class through the EMET engineering site. This privileged user type is registration-limited; meaning that the EMET site manager screens the requested accounts for validity before

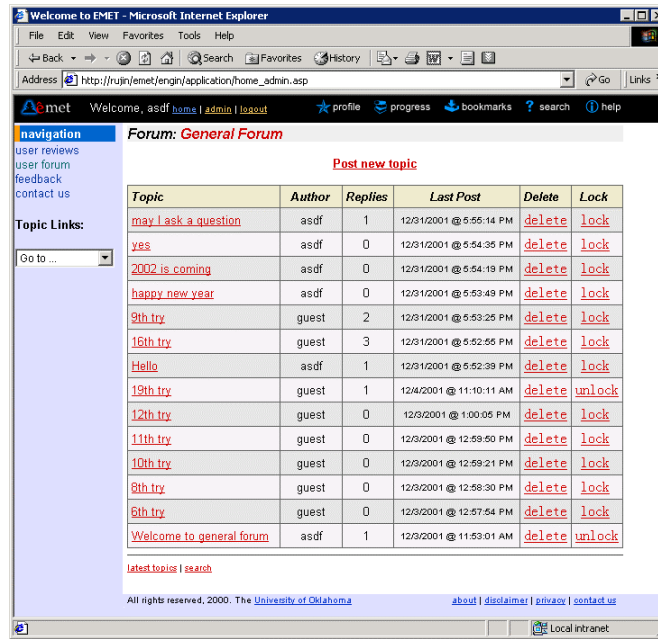


providing privileged access. Once the account is issued, their students can register as a user in that specific group. Then they form a unique and independent class on the EMET engineering site. A group administrator can monitor his/her students' registration profiles and progress reports, just as they could do in their own classrooms (Fig. 7).



**Fig. 7. Students in A Teacher's Class**

In addition, to encourage collaboration between users and help users to enhance their understanding, the EMET engineering site includes a User Forum (Fig. 8). The User Forum is made up of a general forum and individual forums specific to each topic area. The general forum is for users to ask general questions and provide comments that address the overall site. The forums for each specific topic areas, on the other hand, are for users to exchange additional information with other users and to share their own experiences and advice regarding the topic area or using the respective engineering design and analysis applications. In addition to direct email contact, users can provide feedback to EMET developers through the User Forum.



**Fig. 8. The User Forum**

#### IV. Technology And Software Used

The Concept pages, Tutorials, and Case Studies in the EMET engineering site represent the user visible dimension of the distance-learning site. Another dimension of interest to developers is the variety of web technologies employed in EMET. Among these technologies are the Relational Database Systems (RDBMS), Open Database Connectivity (ODBC), Internet Information System (IIS), ActiveX Data Objects (ADO), Active Server Pages (ASP) and Structured Query Language (SQL). Additional technologies less intensively employed include client-side scripting languages such as JavaScript, as well as, interactive streaming media such as Macromedia Shockwave.

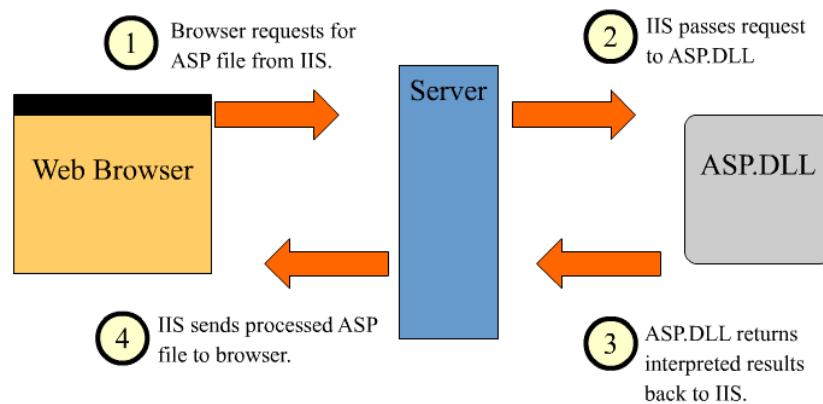
Although there are many technologies that could be used to develop the EMET program, the technologies listed above were selected for a number of reasons. First, this suite of technologies enables the client/server model to work quickly and seamlessly across the Internet interface. The EMET database is assigned the central role as the repository for storing information. The client (i.e., the users' web browser) requests data from the database on the server. Second, most of the mentioned technologies originate from Microsoft. In other words, the chosen technologies were considered to be mature and less problematic to integrate. They were also understood to be stable and well documented.

Shockwave was used because it allows the streaming of interactive media and data from the server. Streaming provides a useful work-around solution for slow Internet connections, as users do not need to wait for the entire file to be downloaded in order to view the file. This facilitates

the rapid and seamless download of the rather large, multimedia laden Tutorial files at typical 56K modem speeds.

The preliminary back-end database was created using the commercially available Microsoft Access database. The Access database stores data associated with the activities of a registered user such as their academic progress, user registration information, track user clicks and the total time they spent on the web site. Tracking user clicks is important to record historical data for later profiling of students using web-based training. In order for the front-end web page to interface with this database on the server (back-end), several other technologies had to be incorporated.

Active Server Pages (ASP) – a Microsoft technology, is used in conjunction with the ActiveX Data Objects (ADO) and SQL to create a connection to the database within the scope of the Microsoft web server (IIS). This interaction is shown in Fig. 9. As mentioned previously, the client machine sends requests for information to the server. In response to these requests via the server, ASP dynamically generates web pages for the client. Depending on the nature of the information requested, ASP will interact with the database through the use of ADO. Most ADO requests to the EMET database involve queries for user-related data stored such as user academic progress, user registration data and user tracking information stored within the database.



**Fig. 9. ASP Page – Web Server Interaction Flowchart**

Several software tools were used to development EMET such as Macromedia Dreamweaver, Director and Microsoft Access. These tools were used to create the web pages, simulations and ASP files necessary for the client/server interactions.

### Macromedia Dreamweaver

The majority of the Concept pages and Case Study pages in EMET engineering site consist of static web pages. Most of these pages were created using Dreamweaver as a visual HTML editors. Since there was a need for fast, easy creation of static web pages, this visual editor (otherwise known as What You See Is What You Get or WYSIWYG) became one of the most important software development tools and was intensively employed in all phases of building the site. Dreamweaver was used in EMET to create these static web pages because it has the following attributes – Roundtrip HTML (imports HTML documents without reformatting the code), support for DHTML, JavaScript and CSS, support for frames, and a strong site management utility that allows fast modification of web pages through use of templates, which ensure the uniformity of the layout of the EMET site.

### Macromedia Director

The tutorials in the various topic areas within EMET use a technology developed by Macromedia called Shockwave. Shockwave files are generated from Macromedia Director source files. One distinct advantage of using Director Shockwave is in its security. Since Shockwave is essentially a compressed compilation of the multimedia and scripting elements of a Director source file, this ensures that the end users cannot decode the downloaded Shockwave file and figure out how to disassemble the tutorial.

Macromedia Director was chosen as the major development tool for EMET tutorials also because of its scripting versatility. It affords developers tremendous flexibility in designing every thing from simple, straightforward processes to extremely complicated interactions. Scripting in Director was the principal vehicle used to create realistic simulations of the actual engineering design and analysis tools taught by EMET. It also has strong capabilities of importing and integrating the various multimedia elements needed to effectively mimic the real tools.

The attractiveness of Director is further reinforced by Macromedia's streaming technology. Streaming allows the final Shockwave simulation to be viewed while parts are still in the process of downloading. This technology allows users to participate in the interaction earlier with less waiting time. Apart from streaming technology, Shockwave files have a small file size. Tutorials on the EMET web site using Shockwave have an average size of about 95 kilobytes. On a good 33.6 kbps connection, this would take an estimated download time of 20-30 seconds.

Shockwave files require a plug-in, available from Macromedia's web site, to be installed in the client browser. Most major browsers include this plug-in within the basic installation package. This plug-in has a small file size but requires an active connection to the Internet for the installation to be successful. Shockwave files can be linked directly or embedded as an interactive element within a web page. Currently there is no direct competition to the power and functionality of Macromedia Director.

### Microsoft Access

Microsoft Access is essentially an RDBMS desktop database system designed for personal users. However, it has several limitations such as performance deficiencies when dealing with huge volumes of data or large numbers of users. Access does not do a good job of sharing data with team members and has few tools to help optimize and manage the database. However, this RDBMS program is effective as an initial web server-based database due to its simple-to-use interface. Furthermore, the Access database can be conveniently upsized to SQL server database by using the included Upsizing Wizard. This changeover will be implemented once the EMET database expands sufficiently and Access degrades.

### **V. Summary**

The EMET program is rapidly growing and maturing. This asynchronous learning environment allows students to effectively manage their own time and learning without compromising educational objectives. The Concept Pages, Tutorials, and Case Studies are features designed to provide an appropriate level of interactivity best suited to the nature of the concepts discussed while accommodating multiple learning perspectives. The use of an integrated database on a web server provides new opportunities to research these methods. Many essential features of a large-scale learning environment, such as user tracking, community collaboration, and assessment, are supported by the database in the background. In particular, the system coordinates the learning activities of each user to help them understand the fundamentals of CAD and acquire the basic functions of the CAD tools. With the advent of the EMET engineering section and privileged user capability, EMET is developing into an effective tool to meet the needs of engineering faculty and students into the future.

### Bibliography

1. Coppula, D. "Getting Hyper Over Learning." *ASEE PRISM Online*, 2000 (URL <http://www.asee.org/pubs/html/hyper.html>)
2. Rujin Cheng, Tze-Leong Yew and Kurt Gramoll, "Web-based Distance Learning Environment Using a Database to Teach Educators about Electronic Media," *ASEE Annual Conf. Proc.*, Albuquerque, NM, Jun 24-27, 2001.

#### RUJIN CHENG

Rujin Cheng is now a Ph.D. student in Mechanical Engineering at the University of Oklahoma. She received her Bachelor of Engineering in Beijing University of Aeronautics and Astronautics in July 1999. She also has worked for e-commerce firm developing electronic media for business in China.

#### KEITH ADOLPHSON

Keith Adolphson is a Ph.D. student in Instructional Leadership and Academic Curriculum (emphasis in Mathematics Education) at the University of Oklahoma. He is a member of the EMET design team and is conducting research in mathematics learning and robotics. He teaches mathematics education courses for undergraduate education majors and is a former middle school mathematics and technology education teacher. He has a M.S. in Technical Intelligence and a M.A. in Strategic Planning from the Naval Postgraduate School and a B.A. in Distributive Science from Gustavus Adolphus College.

#### KURT GRAMOLL

Kurt Gramoll is the Hughes Centennial Professor of Engineering and Director of the Engineering Media Lab at the University of Oklahoma. He has developed and published CDs and web-based sites for engineering education, K-12 instruction, and training in industry. He has started two multimedia companies for the development and distribution of technical electronic media. Dr. Gramoll received his B.S. degree in Civil engineering and M.S. degree in Mechanical Engineering, both from the University of Utah. He received his Ph.D. in Engineering Science and Mechanics from Virginia Tech. Previously, he has taught at Univ. of Memphis and Georgia Tech.