Design of an Effective, Web-Based, Global Learning Environment Using the Keller Plan.

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Abstract: This paper summarizes the authors' efforts to create effective learning environments suitable for qualified students anywhere, anytime. The University of Missouri Rolla (UMR) Engineering Management Department is currently responding to the challenge to deliver a Masters of Engineering Management degree program statewide. To facilitate this, a virtual campus must be created for students that may be place-bound at essentially any location in Missouri. In addition, recent contracts with The Boeing Company require the delivery of a new degree in Systems Engineering to Boeing sites worldwide, and non-credit courses in Saudi Arabia. This paper discusses the authors' thinking on and latest efforts to create effective learning environments using modern technology. The emphasis is on content rich, university level, courses for degree seeking students that choose to matriculate in an asynchronous mode. Various media-friendly tools are discussed, but the primary emphasis is on the application of Keller Personalized System of Instruction in a web-based environment.

Keywords: Web-based learning, Keller Plan, Asynchronous learning

1. The Challenge

So you want to offer a web based, distance education course? You are an expert in the field, have been teaching your course for some time, and your on-campus students seem happy with course content and delivery. Now, you would like to serve students anywhere, anytime, but continue to provide for your on-campus students. This is the challenge! This paper discusses our efforts to meet this challenge.

2. Synchronous and Asynchronous Learning Environments

University level courses are delivered in a variety of formats, and students learn in different ways [1,2]. Some students and most professors seem to prefer the lecture/discussion/question and answer format most commonly used in university courses today. On the other hand, there is variation in delivery format and use of facilitating technology. A typical college course will meet three times per week for 50 minutes of lecture and discussion. Other courses are presented with two lecture/discussion periods per week and a two-hour laboratory period. It is very common for all of these courses to require significant work outside of class, in the form of laboratory experiences and/or reading and exercises. In all cases, college level courses dictate a degree of synchronicity governed by the need to begin and end the term (semester, quarter, etc.) in a timely fashion. That is, faculty are usually employed on an annual basis and students pay fees in a similar fashion. Faculty are encouraged to devise and distribute learning objectives and schedules so that students will know in advance of required activities, such as tests, laboratory reports, homework, etc. Accordingly, it is quite natural to adopt a synchronous learning paradigm, where the professor lectures (class listens), professor responds to questions (professor listens), discussion occurs, class completes outside assignments (labs and/or homework), students discuss classwork (professor often not involved), and professor provides feedback through graded exercises and/or tests. These lecture/discuss/test cycles continue until time is up (university calendar decides course must end), and grades are reported as a function of weighted average performance for each student. Therefore using this paradigm, timing is fixed and grades are related to demonstrated performance or comprehension. Some students and some faculty find this learning paradigm useful; some do not.

Some students and some faculty find the synchronous learning paradigm confining. Faculty may ask, hy should my brightest students be held back by a schedule designed for the verage student"; whoever that is? Students have many demands on their time, even within a particular semester. Why is it so important for students to begin and end together? Is this sound pedagogy or accounting? Students have different styles [3] and tend to learn at different rates. Faculty also have many demands on their time. Research, service and travel tend to complicate faculty schedules. In addition, it is the authors' observation that learning is a very creative activity that can seldom be scheduled. That is, no teacher, no matter how good, can say ou will learn this, now!" Learning is basically an asynchronous, creative adventure. Accordingly, we should attempt to design learning environments that facilitate asynchronous learning experiences for all students. Synchronicity should be a choice not a demand.

3. Off-campus Students

Now consider students dislocated from the professor and fellow students by time and place. How shall we organize a course where students are located in different parts of the world, widely separated in time and place? In the limit, this is the situation we must be prepared to handle if we wish to provide learning experiences for students at a distance. This discussion is biased by our efforts to deliver MS level courses to degree seeking students in a variety of locations, but should also be applicable to non-credit situations as well.

Modern technology has provided an increasing menu of delivery opportunities; including but not limited to; in-person presentation by professor, video tape, live one way and two way vi deo, CD, and now the internet. The internet with current and emerging technology offers an unprecedented opportunity to bridge the time and space gap between student and professor. The general availability of high speed computers and advanced communication and compression technology used in concert with the internet now makes it possible to stream live video presentations and to archive them for later viewing independent of time or location. This emerging technology creates opportunities for the development of learning environments, which facilitate asynchronous learning experiences, which were barely imaginable only a decade ago. Now modern communication technologies such as email, streaming video, chat rooms, internet phone and related emerging technologies bring students and professors together even when they remain separated in place and time. The possibilities currently seem limitless!

4. The Keller Plan

F. S. Keller [4] began to implement his ideas for a new way of teaching in the early 1960 at Columbia University and later at the University of Sao Paulo in Brazil. His thoughts were influenced by the work of B. F. Skinner at Harvard and Charles Ferster at the Institute for Behavioral Research in Maryland. Generally, they ask the same question that besets us today – hy do my students refuse to learn?" Keller devised a plan, which was designed to maximize learning by stressing achievement and positive reinforcement. This approach has come to be known as The Keller Plan, Self-Paced Instruction, or the Personalized System of Instruction. The key elements of the system are:

- Clear educational objectives
- Small learning modules with associated achievement tests and immediate feedback
- Student self-pacing
- Positive reinforcement
- Student emphasis on doing rather than listening

Keller approach accommodates a variety of learning styles, and seems to be a natural for today college students, since it encourages asynchronous learning. With the Keller Plan, students move through the course material at their own pace, and in an ideal world begin and end the course at a time, which THEY find convenient. On the other hand, a strict set of rules governs progress through the course. For instance, a student is not allowed to progress to the next unit or module of the course until a satisfactory (near perfect) score is obtained on the current unit. Courses must be highly modularized and classes become like study hall, except for the occasional motivational presentation. Traditional lectures are almost completely abandoned.

The traditional Keller Plan requires that the professor in charge prepare many tests for each course module, and arrange for qualified student assistants to be present during assigned class times. Since students are allowed (even encouraged) to move at their own pace, the professor and student assistants must be prepared to help students where they are in the material, when they need the help. Accordingly, the traditional Keller Plan approach can be expensive as compared to a traditional lecture/discussion course. Billy V. Koen [5-9] has demonstrated the application of the Keller Plan to courses in engineering at the University of Texas. Koen experiments are especially useful, because he gives a balanced view, showing both the advantages and problems with application of the self-paced approach. Koen work does offer the hope that the Keller Plan may provide opportunities for content rich courses delivered on the web.

5. The Internet and the Worldwide Web

Consider now the situation in year 2000. High powered desktop computers equipped with large stores of random access memory, inexpensive and high-speed digital storage devices (CD, DVD, hard drives), fax modems and high speed internet connections are now generally available worldwide. Cellular phones and other hand held wireless devices, such as the Palm Pilot™ or the Handspring Visor™ extend further the reach and convenience of modern communication technology. In addition, it seems that progress in the relevant hardware and software arena is accelerating at a significant rate at the beginning of the 21st century. The technology is now in place to allow the realization of a worldwide learning paradigm. If knowledge is power, then certainly web-based learning environments offer powerful opportunities for students and faculty alike.

The University of Missouri Rolla (UMR) Engineering Management Department is currently responding to the challenge to deliver a Masters of Engineering Management degree program statewide [5]. To facilitate this, a virtual campus must be created for students that may be place-bound at essentially any location in Missouri. In addition, recent contracts with The Boeing Company require the delivery of a new degree in Systems Engineering [6] to Boeing sites worldwide, and non-credit courses in Saudi Arabia. These dynamic programs reflect the changing needs of on-campus and distance students for college level non-credit and credit degree programs, and lifelong learning opportunities. The Engineering Management department has decided to use the Internet to the greatest extent possible as a delivery mechanism for these new programs designed for off-campus students. Somewhat surprisingly, on-campus students seem to embrace the technology, as well.

6. Total Quality Management (Engineering Management 375)

Ragsdell has developed and taught a course entitled Total Quality Management since 1989 at UMR. This course is based on twenty plus years of interaction with industrial leaders in the US and Japan, such as General Motors, Ford, Xerox, Nissan, Nippon Denso, and government leaders in Missouri, the US and Asia. The course has been given using every conceivable format. In fall, 1999 the course was reorganized to a two-lecture/one lab period per week format. A web page was created for the course and contains all handout material (course schedule, lab assignments, publications, etc.), lecture slides, and grade book. Interested readers can visit the web page at http://www.umr.edu/~design by selecting EMgt-375. Total Quality Management, as presented here and increasingly understood throughout the world, is a philosophy, associated methods and tools, and actions which compel an entire organization, from the lowest to highest level, to excellence and efficiency in personal and corporate activities. Students are given the opportunity to select weights and activities, which will be used to calculate their grade at the end of the course. Typically, the students attach a relatively high weight to the laboratory exercises, which are completed outside of class. Many of these laboratory exercises require team action, and some a common team written reports.

6.1 BEST TQM

The laboratory portion of EMgt-375 is supported by a multi-media learning environment called BEST TQM. This is a self contained, information intensive and stimulating learning environment containing many topics covered in the course. BEST TQM is not designed to be a stand-alone course, but is useful as a convenient reference library of relevant material for a course in TQM. BEST TQM is a rich learning environment, which is designed to facilitate synchronous and asynchronous learning experiences for students at the university level and beyond. The

primary focus of the package is on asynchronous, self-paced learning experiences. It appears that the package could serve the needs of on-campus students, place-bound students and industrial employees in an efficient manner. This learning environment contains a number of simulations, which support student curiosity and enquiry. BEST TQM is currently available to students on the UMR computer network or on a two CD set. This package will be moved to the web in the near future. Additional details about BEST TQM can be obtained from the authors or by examination of recent publications [13-15].

6.1.1 Video

An example of the integrated use of video is shown in Figure 1. Xerox is a winner of the Malcolm Baldrige National Quality Award, and is one of the examples included in BEST TQM to demonstrate fundamental principles and implementation styles. Videos of these distinguished speakers are included directly in the various lessons and can be located conveniently from the course outline in the left panel display. The student simply clicks the start button, and the video plays. The speaker comments are outlined to the left, and particularly important portions can be replayed at the student discretion. Currently there are 33 video clips totaling 160 minutes of viewing included in BEST TQM. Additional video material is being added continuously, and the entire content of the package is reviewed and updated each semester.
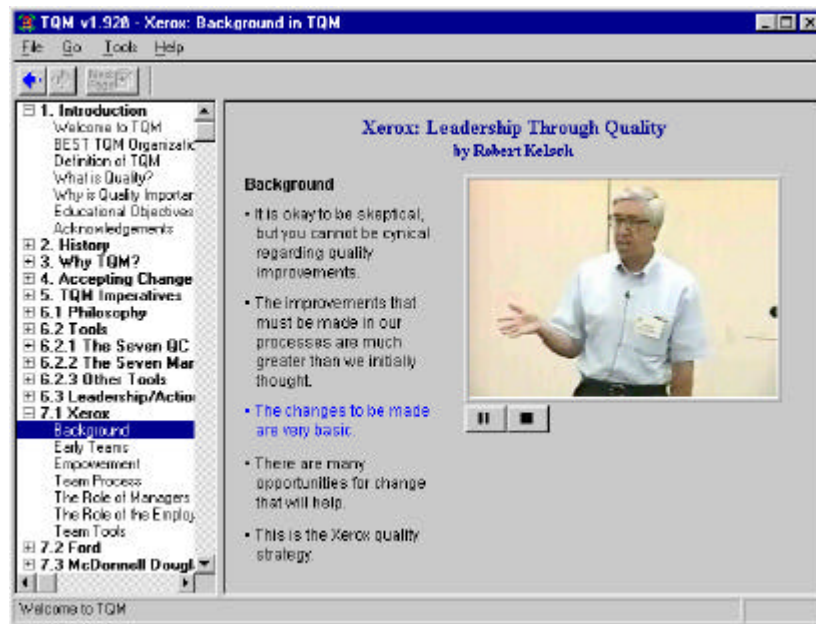

Figure 1: Video Integration in BEST TQM

7. Quality Engineering (Engineering Management 475)

During the spring semester of 1999 a graduate level course entitled Quality Engineering, covering the Taguchi System of Quality Engineering and related topics, was given to 18 on-campus students and 22 off-campus students. The off-campus students included officers in the Army in training at Fort Leonard Wood, full time employees at 3M in Columbia, TEVA (a pharmaceutical company in Mexico), a University of Missouri-Columbia student and full time employees at Boeing in St. Louis. An added complication was that the Army students were in an accelerated program, which required that they take semester courses in 8 weeks. Accordingly, the Army students joined the course at the halfway point and finished with the others. Clearly, it would be impossible to travel to each of the locations where enrolled students resided. The class had previously been taught via two-way audio and two-way video to students at McDonnell Douglas (now Boeing) in St. Louis. Channel capacity would not allow this approach, so alternatives were considered. In the end the course was offered to the on-campus students live, but in the video communication center; and copies of the recorded lecture/discussion periods were mailed to the remote sites. Feedback from prospective students prior to the first class made it clear that this would not be sufficient, so other avenues of communication were sought that would accommodate the off-campus students' need to fully participate in the course of study. All of the remote sights were visited during the semester, and several visits were made to the 3M site in Columbia. In addition, most remote students visited Rolla at least once during the term. Off-campus student feedback indicated that this was NOT enough! It is important to note that off-campus students tend to require much more personal attention than on-campus students do.

7.1 Guest Lecturers

Expert guest lecturers visited Rolla and gave case study lectures during the regular class time, which were videotaped and made available to students in the normal fashion. During the spring semester of 1999, Shin Taguchi (American Supplier Institute), Larry Smith (Ford Motor Company), Jim Cote' (General Motors) and C.M. Creveling (RIT) contributed to the course as guest lecturers. In addition, Dr. Creveling (co-author of the text currently used) provided solutions to exercises; which were, in turn, provided to EMgt-475 and EMgt-376 students via the course webpage (http://www.umr.edu/~design and select EMgt-475). Outside speakers are extremely popular with the students, and through videotapes of their lectures, they have made a significant and ongoing contribution to the course. Additional guest lectures will be added in future semesters, thereby creating a library of case studies given by the actual contributors. This is clearly superior to a discussion of the case study by even the most gifted professor.

7.2 Semester Project

Years of teaching this course and the encouragement of Dr. Genichi Taguchi suggested the need to include a semester project as a pivotal part of this course. All students are encouraged to propose an appropriate project early in the course. Students (both on-campus and off-campus) are encouraged to form teams in order to define and execute the project. Off-campus students are encouraged to select a project closely related to their work assignment. Students or student teams that fail to propose a suitable project in the allotted time are assigned a project. Usually this assigned project is used throughout the semester as a discussion vehicle to demonstrate the principles covered in the course. Project reports from past semesters are available on the course homepage. A major portion of the student   grades is associated with the project and the required written and oral reports. Some students fail to see the value of the project at first, but attitudes change rapidly as they make progress with the project. Many students report after the course that the project was the most significant learning experience of the course. Clearly, the project is an essential element of this course. Professors seem to believe that the profound content of their lectures coupled with their eloquent delivery offers the greatest opportunity for learning in any course. Students seem to disagree, and prefer to learn by doing rather than by listening!

7.3 Simulations

The textbook [16] currently used in the course includes several simple case studies, which clearly demonstrate the major points covered in the book and the course. One of these, the catapult, has been simulated using the ToolBook authoring system [17] as shown in Figure 2.
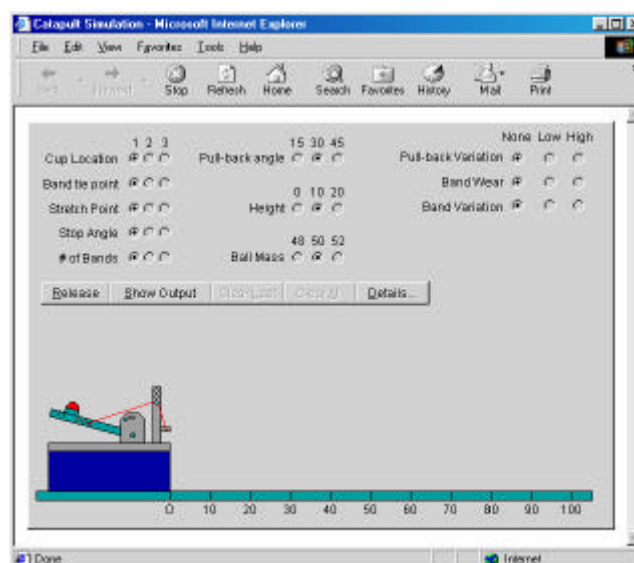
Figure 2: Catapult Simulation

This and other simulations are used in class and by the students at their convenience on the web as tools to encourage experimentation and application of the statistical and design methods covered in the course. Students use the simulation to gather and perform planned experiments using appropriate orthogonal arrays for control and noise factors. In this way data is collected accurately, but without risk of injury. Students use a spreadsheet package to organize the experimentation and check selected results posted on the web. These simulations stimulate student interest and invigorate class discussion.

7.4 Web-Deployed, Self-Paced Instruction

We are currently developing a web-deployed version of this course, which employs the key features of Keller Personalized System of Instruction. An early version of this web site is shown in Figure 3.
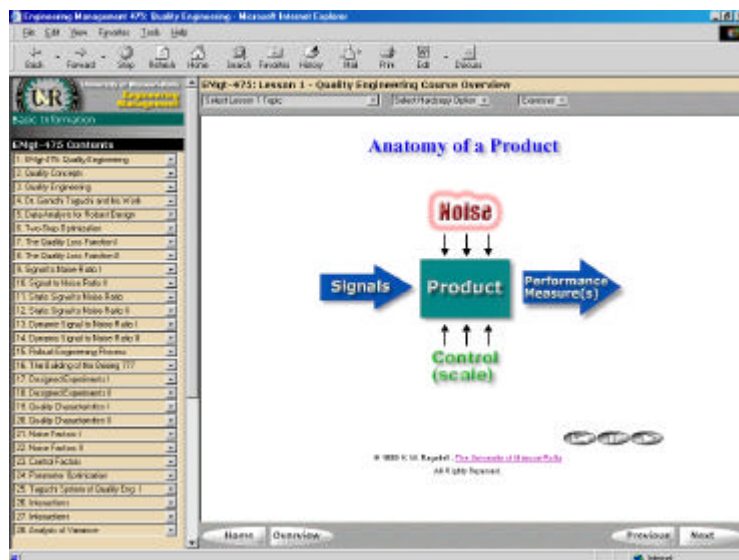

Figure 3: Quality Engineering 2000 Self-Paced Website

This resource offers all of the capabilities of the original course homepage, but also incorporates audio, video, and dynamic textual content, thereby replacing the lecture portion of the course and eliminating the need to distribute videotaped lessons to the off-campus students. Course content is arranged in appropriately sized learning modules, each containing exercises to assess the student   progress. Chat capability provides the key means of fostering teamwork and collaboration. WebCT [18] is used for course management and to automate pre and post module testing, grade keeping and reporting; and provides chatroom capability. Students are placed in learning teams so that they can assist each other with course material and to work in a simulated team environment (regardless of location) on the assigned semester project. One chatroom is reserved for discussion with all class members. Professor Ragsdell joins the chatrooms as required. As before, all of the course materials are available for review or printing in either text or pdf formats. When complete, this tool should provide a highly-effective means of delivering the entire Quality Engineering course to place-bound students using little more than a mainstream Pentium-class or Macintosh computer connected to the Internet.

8. Closure

We are working hard to meet the challenge. The web does offer very interesting opportunities for students and faculty alike. Clearly it is necessary to include efforts to facilitate face-to-face communication between

professor and student, since both seem to need this interaction. Hopefully, the quickly changing communication technology will address this and other needs in the days ahead.

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