

TEACHING DESIGN OF EXPERIMENTS AT THE GRADUATE LEVEL USING PROMETHEUS

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ABSTRACT

A graduate-level course on the design of experiments was designed in 2001 and taught as a web-based course in 2002. This course was designed for the University of Wisconsin Learning Innovations and is available to students enrolling in the Master of Engineering degree program offered by UW – Platteville. Prometheus software was used to deliver the course through the Internet. This paper discusses the design of the course and lessons learned through teaching the course online. This paper summarizes how engineering design may be taught online. In addition, ideas provided by students are listed to serve as guidelines for effectively using distance-learning technologies.

MASTER OF ENGINEERING PROGRAM AT UW-PLATTEVILLE

The Master of Engineering Program at UW-Platteville offers a technical degree in engineering requiring advanced course work but no thesis. It serves the need of several major industries for the delivery of advanced technical education to be achieved without employee relocation. The program has two unique features: it includes a technical area of emphasis; and is Internet (Web) based. In the technical area of emphasis, the courses offered are developed to satisfy the needs and requirements of a specific technical specialty. This Web-based program makes the degree much more accessible to professionals working in industries within the state, region, and world. Furthermore, the Internet provides opportunities to deliver information in various formats to encompass different student learning styles. In addition to courses within a technical area of emphasis, the Master of Engineering program provides education for professional development in the areas of mathematics, technical communications, computer applications, and engineering management.

The Master of Engineering Degree requires a total of 30 credits. One 3-credit course must be taken from each of the following areas: Mathematics, Computer Applications, Technical Communications, and Engineering Management. Students must choose a technical emphasis in Engineering Design or Engineering Management and nine credits (three 3-credit courses) must be devoted to the chosen areas of emphasis. Technical electives may be selected for the remaining nine credits. More information about the core courses, courses in emphasis areas, course descriptions, and course availability may be found at the website <http://www.uwplatt.edu/~disted/engineering.htm>.

MIE 7300 – DESIGN OF EXPERIMENTS (DOE)

The course MIE 7300 – Design of Experiments is available within the Engineering Design emphasis of the Master of Engineering Degree Program and is divided into five sections. Two textbooks are used for the first ten lessons and these are : *Design and Analysis of Experiments*, by Douglas C. Montgomery, 5th edition, John Wiley & Sons, 2001 and *DOE Simplified*, Mark J. Anderson & Patrick J. Whitcomb, Productivity, Inc., 2000. Students are expected to select Minitab Release 13 or DesignEase 6 or DesignExpert 6 for the first part of the course that covers the above textbooks. The second part of the course covers Taguchi Method and the textbook used for this topic is *Design of Experiments Using the Taguchi Approach : 16 Steps to Product and Process Improvement*, Ranjit K. Roy, John Wiley & Sons, January 2001. The Qualitek-4 (QT4) software for Taguchi Method from Nutek Inc., is made available free of cost to students.

Lessons 1 - 3 review basic statistical concepts and analysis of variance (ANOVA). In addition, practical aspects of planning engineering experiments, checking model validity, and estimating sample size are discussed. Students begin to use the software Design-Ease (Minitab and DesignExpert are alternative software) for most of the statistical and graphical analysis. Lessons 4 - 6 cover the randomized complete block design (RCBD), Latin squares, and factorial designs. At this stage, students begin a course project. The course project may be performed individually or in teams of up to three people. The project consists of planning, designing, conducting, and analyzing an experiment, using appropriate DOX/DOE principles. Two written interim project reports are required, along with a final written project report. The context of the project experiment is limited only by students' imagination. Students may conduct experiments directly connected to their own research or to industrial projects. Lessons 7 & 8 cover fractional factorial designs and confounding present in these designs. Methods of improving the resolution of the design through blocking and folding over of experiments are discussed and applied. Substantial progress in the course project must be demonstrated in the second project report. Lessons 9 & 10 are devoted to advanced topics in the design of experiments, including response surface methods and designs, random factors in factorial experiments, mixed models, nested designs, and split-plot designs. Lessons 11 - 14 focus on the Taguchi approach to the design of experiments. Concepts of orthogonal arrays, and linear graphs are discussed in detail and experiments designed using these are analyzed. The last week of the course is devoted to the completion of the course project, project discussions, and project presentation.

The grading policy for the course required completion of fourteen discussions (15%), fifteen assignments (25%), two tests (20%), one group project (20%), and the final examination (20%). Assignments involved problems from two textbooks as well as review of one paper and use of two software for designing and analyzing experiments. Course outcomes and the type of commitment expected from students were clearly identified. All the student work was due by midnight on Mondays when the Web usage was at a low level and it also enabled students to consult the instructor, if necessary, to resolve difficulties before submitting their work. The course project involved the application of concepts taught in the course to plan, conduct, and analyze an experiment and a group of three students completed the project. Each group was provided a project discussion area so that their progress in the project may be monitored and assistance could be provided by the instructor on a timely basis.

UW Learning Innovations

UW Learning Innovations implemented the course online using Prometheus 5.0 for UW-Platteville's Distance Education Center. Students were provided technical support by the UW Learning Innovations Tech Support toll free at (877) 724-7883 or by e-mail at techsupport@learn.uwsa.edu. The course was designed by the author and UW Learning Innovations designed the course website. The author embellished the course website by adding the list of assignments (A1 through A15), online discussions (D1 through D10), technical paper view guidelines, and project ideas.

Prometheus

Prometheus is a web-based and extremely flexible course management system that allows instructors to post course related information for students and conduct courses online in a secure environment. Prometheus is template-driven and accessible through any computer with an Internet connection and a web browser. On a PC, Prometheus is best viewed in Netscape Navigator v. 4.0 - 4.7 or Microsoft Internet Explorer v. 4.0 - 5.5. It has run in Microsoft Internet Explorer v. 6 without any problem. On a Macintosh operating system, Netscape Navigator is recommended because Internet Explorer does not always refresh pages, but uses cached pages. Prometheus can also be viewed on both PC and Macintosh through AOL v. 4 and above. Within the browser settings, both Java and JavaScript must be enabled. The following introduction to Prometheus is based on the instructor's manual (2).

After login with the user name and password, user is at either the *Portal* or *Course Listings* page. Portal users access their courses by selecting a course from the portlet titled My Courses or by clicking on the Courses link at the top right side of the screen to load the Course Listings Page. Once on the Course Listings page, the user enters the course space by clicking on the highlighted course name link. The user is then at the Syllabus page which is always the first page the user will see when entering a course. The following navigation bars are available to the user at the right-hand-side of the screen to enter specific areas of the course website, view the course materials, communicate with the instructor, submit coursework, reset personal information, and participate with other students in the class.

Syllabus: Provides access to all information about the course, study guide, learning outcomes, and specific policies. Links to regulations, related courses and the home page.

Outline: Lists the activities for each week or session. Click on individual sessions to view Study Plan, requirements, assignments and other resources and materials for that specific week.

Testing: Create online quizzes and tests here and administer them also.

Grade Book: Tracks student grades for online and offline assignments.

Projects: A repository for describing group projects. These can be linked to sessions.

Lectures: A spot to load lecture notes. Students can print lectures out separately for offline viewing.

Files: A place to store personal work and view work posted by others.

Messages: E-mail and Announcement tools to facilitate communication between individuals and group members.

Discussions: Course bulletin board, allowing class members to participate in threaded discussions.

Chat: Real-time distance discussion tool including audio and text chat.

Utilities: Provides access to key course setting controls: feature on/off, user permissions, security, group creation, and user tracking.

Courses: Exit course and return to the Course Listings Page.

Portal: Exit course and return to the Portal (if enabled).

More Info: Links to FAQs and the online help system.

The three icons (**Help**, **Suggestion Box**, and **Exit**) at the upper right-hand section of the Course Listings page provide access to context-specific help, the suggestion box and Exit respectively. Other features of the Course Listings page are **Announcements** (links to all posted announcements), **Palm Pilot Users icon** (download information into a Palm PDA device), **Preferences** (change your personal information, change the way to view courses in Prometheus, access the File Manager where personal files are stored), **Course Controls** (create and delete courses, change dates for courses, create the frameworks for modular content that can be used in multiple courses), and **Archive Library** (take entire courses off-line to preserve a master copy of a course, or save courses that have been completed).

SUMMARY OF EXPERIENCES

Students preferred to submit their work by midnight on a week day as it gave them an opportunity to consult with the instructor before submitting their work. In this course, the due dates and instructor's office hours were set in consultation with students. Students did not like the online course materials and lecture slides in the pdf format. Lecture slides in PowerPoint were preferred because multiple slides may printed on each page. When the course was posted online, all the discussions and assignments were specified on the very first day and students were able to assess the amount of work involved before beginning the study. Audio and video supplements to lectures were not required by students, but the detailed lecture slides provided by the instructor were appreciated by all the students. Students did not face any problem during the course and the course was rated excellent and outstanding in all categories by students. Some students wanted to complete a second project in the course, but there was not enough time to accommodate additional work into the course. The topics covered in the course were 40% more that what is normally taught in a course on DOE in most graduate programs.

The engineering design component was covered in the course through discussions, assignments, review of journal paper, case studies, and the course project. For example, each of the fourteen chapter discussions required students to summarize how they would apply the models studied in that chapter on their job and this was considered by some students to be the most time consuming part of their coursework. Detailed and specific instructions provided by the instructor regarding the amount of detail required in assignments and projects prevented problems when the course was taught. In conclusion, detailed advanced planning of the course is essential to cover topics in depth and also provide realistic engineering design experience to students. It is also necessary to plan the group design project very early in the course and groups must be required to submit progress reports.

The grade book in Prometheus was not very good and the instructor used Excel spreadsheet to calculate the weighted average score for students in the course. The Discussions area in Prometheus was well organized and it was convenient to use. Most of the course materials were put online by UW Learning Innovations. When the instructor attempted to do the same for another course on campus, there were many problems in uploading the course information.

Students did not like the way course information was organized within Prometheus. For example, the entire course was placed online before the course started and any changes made after the first day of classes were placed in a different section. Students were reminded to check the “Essential Changes” section by the instructor. In some areas of Prometheus, it would have been nice if folders could be created and course materials could be put into these folders. For example, a large number of useful websites were relevant for the course. These were all listed in references under “Books” navigation bar. It would have been nice if these were classified and organized into folders with appropriate titles. Effective use of chat room depended on deciding the topics to be discussed well ahead of time and scheduling a short meeting in the chat room. Chat room served well in the initial introduction of participants and also in the course project.

ACKNOWLEDGEMENTS

The information about Prometheus is derived from the online help guides available at the Prometheus website for the course. The details about the master of engineering program at UW – Platteville are those at the website for the Distance Education Center.

REFERENCES

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BIOGRAPHICAL DATA OF AUTHOR

Dr. S. Balachandran is a Prof. of Ind. Eng., UW-Platteville. He serves as consultant and his areas of interest are ergonomics, continuous process and quality improvement, facilities design, and manufacturing simulation. He received B.E. Degree with Honors in Mech. Eng. from the University of Madras, India in 1968, and received M.E. degree with Distinction in Aeronautical Eng. with specialization in rockets and missiles from the Indian Institute of Science, India in 1970. He worked as Project Engineer at the Indian Space Research Organization, India from 1970 to 1974 and worked at Va. Tech. as Research Assistant, Instructor and Asst. Prof. from 1975 to 1985. He received a Ph.D. degree in I.E. & O.R. from Va. Tech. in 1984. He worked as Assoc. Prof., Professor and Chairman of Industrial Engineering at UW - Platteville from 1985 to 1994 and has over 170 presentations and publications. He continues to serve as a technical reviewer for the IJPR, IJPPC, JMPT and IJSM. He is an IIE/ABET evaluator for industrial technology programs. He is a member of IIE, ASEE, INFORMS, SME, ASQC, APICS and HF&ES. He is listed in several Who's Who publications.