Website for Management and Guidance of Engineering Design Projects

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Abstract *¾ A website has been designed and implemented in an advanced level engineering design course. The purpose of the website is to provide course management and design process guidance. A very simple website structure is used and was developed using Microsoft FrontPage. The website does not provide interaction and collaboration between team members and client organizations; rather, it is used to provide design process guidance, monitor progress, facilitate timely reporting by student teams, provide useful documents, and evaluate progress. One of the most beneficial features of the website is a summary page that links key documentation for each project team with its client. Hyperlinks provide instantaneous viewing of these documents. A file transfer process makes it possible for the team to move a document from their computer to the web server and have the hyperlink immediately established. Microsoft Project is used to provide design process guidance and information. The task and sub-task definition features, task notes, and the project timeline management capabilities of Microsoft Project are used. Microsoft Project's html reporting feature are used in this website to report project progress and evaluate performance . The website gives the instructor more time to help the design teams with design issues and provides a better structure for the students to follow for meeting milestones, documentation control, and design process assistance.*

Index Terms ¾ engineering design, website, course management, design process

INTRODUCTION

Teaching introductory or advanced engineering design courses is one of the most challenging teaching responsibilities for engineering faculty. The problem selected for such courses is open ended in terms of the possible solution and often based on a real problem that is provided by an external organization. Students generally work in teams and the project must be completed by a specific date, the end of the term for the course. Over the course of 30 years, the author has had responsibilities for developing and teaching such courses at the introductory and advanced level, for different academic units, at different US universities, and at universities in Japan and Sri Lanka. The projects for these courses have ranged from those that were supported by modest departmental funds to projects with substantial funding by governmental and corporate organizations. Some of these projects were used to develop, test, and implement new engineering design methodologies. The nature of the problem, capabilities of the students, and the expectations of the client organization vary from project to project; however, the common elements that the author has found to be the greatest challenge were course management and engineering design process instruction. To make it clear how such conclusions have been obtained, some experiences of the author and others will be presented.

Engineering Design Course Experiences

In 1971, the author was a Fulbright Lecturer in Production Engineering at the University of Sri Lanka. The culture, pre-college experiences, and design process experience did not prepare the students to proceed independently to solve an open ended design problem. Design of a production system to make a simple, hand operated rice planter, made the context of the production problem more familiar to them but did not provide the motivation or problem understanding that was needed to carry out independent design. The only way to make progress was to guide them through the design process. This was the author's first experience that illustrated the importance of students learning and using a design process.

Later instructional experiences in engineering design at both the introductory level and advanced level provided more opportunities to use different design process methodologies. Many other faculty were developing, testing, and implementing design process methods for engineering design and the publication of their experiences in the engineering design literature was of great help. During the 1980's and 90's, corporations and consultants began to imbrace and apply the Total Quality Management methods that were started in Japan. These methods were primarily directed toward process improvement to meet custormer expectations; however, the systematic approach used provided many practices that were used in the engineering design and problem solving process.

The 3M company developed in the mid 80's a process improvement methodology called Optimized Operation, O^2, that provided a systematic proceedure for teams to evaluate processes and implement improvements. In 1992, the O^2 process was modified for testing and implementation to improve processes in small manufacturing companies [1]. The Higher Education Manufacturing Processes Applications Consortium

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(HEMPAC) was formed to modify O^2 and consisted of two state universities and four technical colleges. HEMPAC named this modified O^2 process the Manufacturing Improvement Process (MIP). For each company project, a MIP team was formed and consisted of student interns from the HEMPAC universities and colleges, employees from the company, and a faculty leader. In most projects, these were full time assignments for all team members. A total of 44 company projects were completed. Funding for these projects came from the companies, the State of Minnesota, and the Federal Technology Reinvestment Program. These projects were highly integrated into the companies operations and represent an extreme example of a university and industry cooperative project where the engineering design experience for the students was exceptional and the expectations of the company very high.

The O^2 is an example of a process improvement (design) process that had been successfully used in a large company and the HEMPAC showed that it could be applied to small companies using the student/employee team. The University of Minnesota Duluth (UMD) benefited from having faculty trained in the process, by stimulating further research interests in the design process, and by importing the process back to the University for use on other student design projects. Not all the projects were successful but the one's that succeeded had good teamwork, a good information gathering process that documented characteristics of the problem, a milestone event to obtain consensus regarding the deliverable, and a project management plan that assured that the design and implementation process would be completed.

The MIP projects were for upper division engineering students. In 1997, the author's sabbatical leave took him to Kanazawa Institute of Technology (KIT) in Kanazawa, Japan to work with a team of visiting foreign faculty in their engineering design department. In the mid 1990s, KIT created a new introductory engineering design sequence modeled on engineering design classes in the United States. The sequence consisted of two sophomore-level classes, Engineering Design I (EDI) and Engineering Design II (EDII). Classes in the sequence placed a high premium on teaching students to work in teams on open-ended, poorly structured problems, and to generate creative design solutions for a problem of the team's choice.

EDI and EDII at KIT each had an enrollment of 2000 students each year, with approximately 60 sections and 30 different faculty members. All sophomore students have to enroll in both design courses, independent of their specialization. The typical KIT sophomore student is 20 years of age and finished high school two years prior to enrolling in the first course of the design program. The student has never held technical industrial positions and has little to no experience in design. The Japanese high school educational system emphasizes knowledge acquisition and memorization with little consideration for applications and open-ended problem solving [2]. This background does not prepare the student to be immediately successful as a member of a design team. So, in addition to teaching the student a design process, there are many skills related to general design activities that the student needs to learn. .

There are many challenges in teaching design in this educational environment and the visiting foreign faculty formed a team to evaluate these courses and recommend improvements. It was apparent that the course structure had to changed to guide the students through a well defined design process, coordinate faculty instructional activities, and provide materials for students and faculty [3]. One of the methods used by this team to achieve these goals was the development of a bilingual (Japanese and English) website (http://wwwr.kanazawa-it.ac.jp/ideakit) for engineering design [4].

Since returning from sabbatical, the author has used many of the lessons learned from previous experiences in engineering design to develop a website for the current senior design course that is taught in the industrial engineering department at the University of Minnesota Duluth.

WEBSITE FEATURES

An engineering design website can have features that provide:

Colaboration and interactive capabilities
- among team members
- between team and client
- with training modules
- with design assistance modules

Course management and design process guidance
- client and problem information
- monitoring team progress
- instructor evaluation reports and project feedback
- timely submission of documents and posting of documents
- source of documents and information that site users can download

The first set of features can be best supported with collaboration software where environments for shared learning and coordination of project activity between team members and other project stackholders can take place. The Collaborative Software Laboratory at Georgia Tech university has an active program to develop anchored collaborative learning environments [5]. CaMILE is a product from their devlopment activities and helps students to interactively share, discuss, and reflect. These are powerfull capabilities that require the technical expertise of software specialists to develop and implement.

The second set of features were some that the KIT bilingual website provided and were also deemed to be most important to include in the website that is the subject of this paper. These are the easiest to implement, yet provided a substantial benefit for the instructor, student, and client.

The website development team at KIT had shown that these types of features could be provided in a timely way to instructors and students in engineering design courses. The KIT website did not use a commercial website development software package; rather, Perl programming and html document generation features in Microsoft Office were used. This was highly effective for development of the multi-level outline side-banner browser and the seamless bi-lingual display of information. It did not provide an easily learned or understood programming environment that could be used by others to expand the content of the website or to maintain existing features. To be combatible and useable in the Industrial Engineering Department at UMD, it was necessary to use Microsoft FrontPage or Dreamweaver as the website develoment tool. Frontpage was used and proved to be an easy way to implement the course management and design process guidance features that were needed to help reduce the workload of the instructor, freeing time for the instructor to work with the teams on problem solving and design aspects of their projects. The website to be described in the remainder of the paper is intended to provide these types of features.

WEBSITE

At the same time as the engineering design website was being developed and implemented, the author was creating a website for a simulation course. A website structure was developed that could be used for both courses as well as other coruses. It was a simple structure consisting of the following:

1. An index.htm file that explained the purpose of the website, who was authorized to use it, and a hyperlink to the first page. To link to the first page, the user had to have a university user id and password. Only students enrolled in the design course, client organizations, and instructors were authorized.
2. Figure 1 shows the frame structure used and is created using the following files:
   a. FCourse.htm that is the parent frame for the first page.
   b. FCourseMain.htm that is a child of Fcourse.htm and defines the screen space for display of linked material.
   c. FCourseName.htm that is a child of FCourse.htm and displays course identification information.
   d. SideBanner.htm that is a child of FCourse.htm and displays the side bar used for navigation to hyperlinked material that is of primary interest.

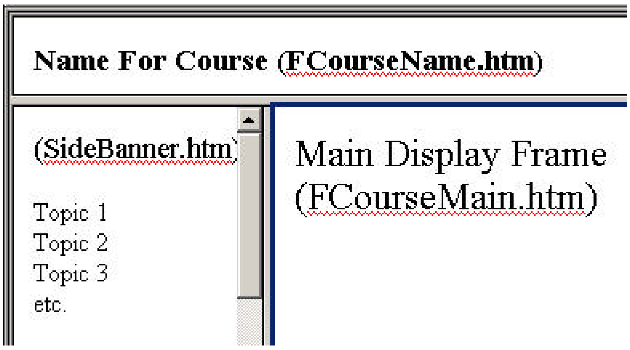

FIGURE 1
FRAMES FOR FCOURSE.HTM

TABLE 1
TOPICS FOR THE SIDEBANNER

The specific content for the website is organized as folders and sub-folders in the website directory. The folder organization used depended on the website course. The engineering design course website used two main folders, Sidebanner Material and Project Specific Material. The topics for the sidebanner are given in Table 1. The links from these topics connect the user with information about the topic, provide instructions for team actions related to the topic, and provide links to supportive material for the topic. The most important topic is Current Team Projects. This provides a complete summary of each team's progress on their project for thier client organization. Table 2 shows a portion of the Current Team Projects matrix that connects key project information and requirements to each client. The "click " is a hyperlink to a project specific document. The client information, problem, team, and project evaluation documents are established as hyperlinks by the course instructor. All of the other documents that are accessed using these links are submitted by each team. Table 3 is a complete listing of the categories of documents that apply to each team project and appear as the row labels in the matrix.

An important feature for the submittal of these team documents and the establishment of the link is a file transfer process called webdrop. This was developed for this website with the help of UMD's Information Technology Systems and Services department. The teams use the webdrop process shown in Figure 2 to submit the documents. The "Browse" button lets them locate the file on their computer that they want to submit. They then enter the file name for the document to be submitted. The

Item	Clients		
	1	2	3
Client Information	click	click	click
Problem	click	click	click
Team	click	click	click
Team Processes	click	click	click
Mission	click	click	click
Goals	click	click	click
Constraints	click	click	click
Specifications	click	click	click
Project Evaluation	click	click	click
Project Management	click	click	click
Poster	click	click	click
Status Report 1	click	click	click

TABLE 2
TEAM STATUS FOR CURRENT PROJECTS

Client Information	Poster
Problem	Status Report 1
Team	Status Report 2
Team Processes	Status Report 3
Mission	Status Report 4
Goals	Status Report 5
Constraints	Baseline - ZIP Version
Specifications	Baseline Presentation
Project Evaluation	Final - ZIP Version
Project Management	Final Presentation

TABLE 3
DOCUMENT CATEGORIES

"click" hyperlinks in Table 2 are already defined to link to the file that is being dropped. To make this work, each team must use a specific name. The format for these names is Client**n**_name.type where **n** is the client number, name the document name such as MissionStatement, and type the file type extension. If they use the correct name, the file is immediately linked to the appropriate matrix position in Table 2.

This feature has been a valuable project management tool and information exchange mechanism. On the due date for a status report, the instructor can quickly check for each team's status report. Also, the client organization can go on line and review the status report. All teams and clients have access to all of the projects so that they can compare their efforts against each other.

Course Description	Specifications
Course Syllabus	Project Management
Design Process	Status Reports
DesignProcess Schedule	Baseline Report
Current Term Projects	Final Report
Mission Statement	Project Paper
Goals	Project Poster
Constraints	Project Records

FIGURE 2
WEBDROP PROCESS

Only a few of the features in this website have been discussed in detail but they are the ones that have been most beneficial for management and evaluation of team progress. To provide design process guidance, the website provides a project schedule and design process task definition feature using Microsoft Project.

DESIGN PROCESS TASKS AND SCHEDULE

Design processes consist of a sequence of steps and the required number of steps varies. A seven-step process has been favored by many and Table 1 compares five versions of seven-step design or problem solving processes. Process A is the design process that is used at the KIT in Japan for their introductory engineering design courses. Process B comes from a popular engineering design textbook. Process C is the MIP process that was discussed earlier in the paper. Process D is a TQM problem solving process that is part of a TQM seminar given by Joiner Associates. Process E is a creative problem solving methodology that comes from the work of Sidney Parnes and Alex Osburn. A characteristic of these processes is that the first five steps focus on activities that prepare the team for the last two activities, final design and problem solution. The activities associated with these last two steps are often the ones that students are most comfortable with because they use knowledge gained from other course in their curriculum. The tendency is to jump from the problem statement to these last two steps.

Process A	Process B	Process C	Process D	Process E
Theme[6]	Analyze Needs[7]	Statement of the Problem[1]	Project purpose and scope.[8]	Mess Finding[9]
Sub-theme, Problem Discovery	Set Objectives	Mission Statement	Understand Current Situation	Fact Finding
Information Gathering and Problem Definition	Develop Target Specifications	Data and Information Gathering and Analysis	Cause Analysis .	Problem Finding
Generation of Concepts	Create Alternatives	Alternative Solutions	Solutions that Address Causes	Idea Finding
Evaluation of Concepts	Screen for Feasibility	Testing and Evaluation of Solutions	Final Solutions Implementation Plans	Solution Finding
Detail Design of Best Concept	Select the Solution	Implementation	Standardize Work Methods	Acceptance Finding
Communication of Results	Communicate the Design Solution	Standardization and Documentation	Future Plans	Action Plan

TABLE 4
COMPARISON OF DESIGN PROCESSES

Each team uses Microsoft Project to develop project tasks and monitor team progress. They are familiar with this software and it was decided that it could be used to help each team adhere to the design process and help them stay on schedule. A design process schedule was developed using Microsoft Project and presented design process tasks, explained the tasks, and provided a completion schedule for each taask. The Microsoft Project software provided a way to connect the design process sequence to a timeline and provide milestones that the teams must meet in order to complete the project. Figure 3 shows the seven main tasks that define the design process. Each main task has subtasks and Figure 4 shows the subtasks for the Project main task. With each

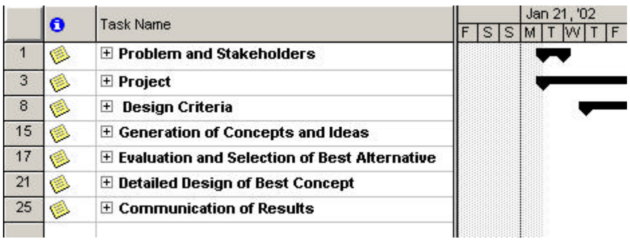

FIGURE 3
SEVEN MAIN DESIGN TASKS

main task and sub-task, notes can be attached and Figure 5 shows the note for the sub-task, Mission Statement. In a compact form, Microsoft Project provides information

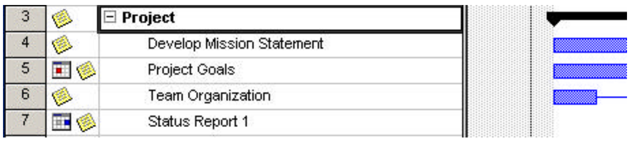

FIGURE 4
SUB-TASK OUTLINE

about the design process sequence, completion expectations, and design task information. This format was also used to give a rating to each team on how well they performed for each main task and sub-task. This was

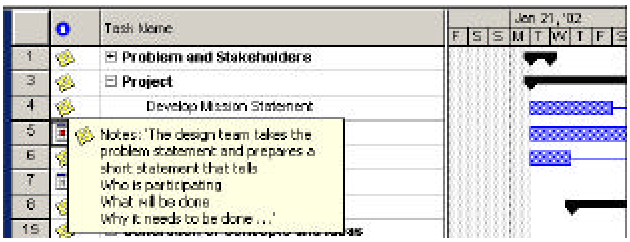

FIGURE 5
TASK NOTES

done by using the percent completed rating that is available for each listed task. Microsoft Project can generate html format reports for the website and these were used to keep the teams aware regarding how well the instructor rated their progress and performance.

CONCLUSION

A website was developed to manage and guide student teams in an advanced engineering design course. Open ended design problems came from external organizations. The website did not provide interaction and collaboration between team members and client organizations; rather, it provided design process guidance, montitored progress, facilitated timely reporting by student teams, provided useful documents, and evalauted progress. By using the website in this way, more instructor time was available to work with the teams on design issues.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Kendall, L.A., Powers, M.F., "HEMPAC: Improving Manufacturing and Manufacturing Education", *Fourth World Conference on Engineering Education*, St. Paul, Minnesota, October 15-20, 1995.

[2] Herbeaux, Jean-Luc, Matsumoto, Shigeo, Kubo, Takeshi, and Hattori, Yoichi," Development and Teaching of Two Sophomore Engineering Design Courses as Part of a Curriculum Reform in Japan", *Proceedings of the 20th SEED Annual Design Conference*, Imperial College of Science, Technology and Medicine, Great Britain, June 30-31, 1998.

[3] J.L. Herbeaux, L.A. Kendall, K.E. Ramdane, C.D. Sorensen, T.Kubo, and Y. Hattori., "A Structured Environment for Teaching Open-Ended Design Thinking in Japan", *Presentation at VI International Conference on Engineering and Technology Education*, Cincinnati, Ohio, June 14-16, 2000.

[4] Sorensen, C.D., Kendall, L.A., Ramdane, K.E., Herbeaux, J.L., Kubo, T., and Hattori, Y., "Development of a Bolingual Website Supporting Engineering Education", *Proceedings of VI International Conference on Engineering and Technology Education*, Cincinnati, Ohio, June 14-16, 2000.

[5] Guzdial, Mark, "Anchored Collaborative Learning Environments, CaMILE: Collaborative and Multimedia Interactive Learning Environment" website http://www.cc.gatech.edu/gvu/edtech/CaMILE.html , June 25, 2002.

[6] Herbeaux, Jean-Luc, Matsumoto, Shigeo, Kubo, Takeshi, and Hattori, Yoichi, "Development and Teaching of Two Sophomore Engineering Design Courses as Part of a Curriculum Reform in Japan", *Proceedings of the 20th SEED Annual Design Conference*, Imperial College of Science, Technology and Medicine, Great Britain, June 30-31, 1998

[7] Love, Sydney F., "Planning and Creating Successful Engineered Designs: Managing the Design Process", *Advanced Professional Development, Inc.*, 1986.

[8] Joiner Associates, "Master Improvement, Parts I and II, Quality Learning Series Seminar", The Quality Learning Services of the U.S. Chamber of Commerce, Duluth, MN, December 1993.

[9] Northeastern Minnesota Creativity Council Workshops, Based on research, publication, and training materials that come from Sidney Parnes and Alex Osburn that are made available from the Creativity Education Foundation, Buffalo, N.Y.