The Web-Based Learning Environment for Creative Design Course

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Abstract: For the development of new technology in industries in the Twenty-First-Century, the engineers must have creative and innovative talents to survive the competitions. Thus we need to cultivate the technological creativity in the engineering students for research and particularly for design and development. An interdisciplinary research team in National Central University has developed a set of learning modules with a web-based learning environment for cultivating the technological creativity in engineering students. The purpose of the web-based courseware is to promote creativity, team works, and to encourage the students to learn and apply pro-actively their domain knowledge through their involvement in the creativity projects. This paper describes how the web-based integrated courseware is built. This paper will also highlight our future plan to broaden the facilities in the web-based learning environment.

The web-based learning environment currently consists of three major components: the creative activity bulletin board, the engineering courseware crucial to design and implementation, and the search engine. Four crucial course materials have been constructed to support the creative activities: Machine Design, Electric Circuits and Electronics with Laboratory, Innovative Application of Engineering Software, and Creative Mechanical Design. Finally, we will also establish convenient on-line tools to support in-depth creative activities. This web-based environment should be useful to all who are interested in doing creative engineering design project. This web site (*CEdesign*) http://lisant.src.ncu.edu.tw/cedesign/ is accessible on-line.

Keywords: web-based learning, design, creativity, courseware, innovation, courseware.

1. Introduction

Creativity is inherent. Yet many researchers believe that the creative cognition can be trained and learned [1]. Chance [2] thought that the creativity is similar to skills and can be trained. The creativity is a practical art that can be improved through continuous practice [3]. Williams [4] believed that everyone had the potential of creativity, but the creative behavior may be different due to different environments of living and learning.

Creativity is a very important factor for a business to be successful. The modern industrial society is fast evolving due to continuous technological innovations. Creativity is an index of an engineer's potential to accomplish outstanding achievements. The future society requires more and more people imbued with creative cognition to push for further innovations in every direction.

Traditional education for engineering students focuses on the indoctrination of domain knowledge in their classes. Most problems given to students in most engineering classes are well defined with only one correct solution. The inspiration of students' creativity and innovation are ignored by most engineering professors. Because of the rapidly changing world, some engineering professors start to envisage this trend and try to melt the creativity into their courseware.

The National Science Council of the Republic of China launched a series of projects to promote the creativity of students in engineering colleges [5]. Therefore, the course of "Creative Mechanical Design" was offered in Department of Mechanical Engineering, National Central University since 1997. The purpose of this course is to inspire creativity, to provide students with an industrial working environment, and to train students to solve open-ended industrial problems. In traditional engineering training, the students are asked to solve the "text book" problems, which in general are simple, formulated in particular format and have typical approaches and clear cut answers. However, in industry, engineers often face complicated problems with no unique approach and solution. Hence, after graduation, engineering students usually find that what they learn in college are not helpful for solving

industrial problems and the industry needs to spend extra effort in trimming the rookies to match the industrial requirements. Therefore, we proposed to offer such a senior design course. In this course, we ask students to use their creativity to work like industrial engineers, to form mission-oriented teams, to communicate and cooperate with other peers, to apply their domain knowledge learned in college to deal with real industrial open-ended problems, to work pro-actively, to learn and to internalize on-the-fly.

With the experiences of this course, the students should be able to understand the industrial approaches of solving open-ended problems creatively. At the same time, they will also realize the importance of teamwork and learn the skills of communication and cooperation. These students will be ready for industrial projects and help to elevate our industrial level after graduation. The development and the teaching of this course is discussed in details in the other companion paper in this conference [6]. On this other hand, a web-BBS based learning environment *Cedesign* developed to support the integration of domain knowledge, the creative cognition knowledge, and the creative design project activities of this course is the focus of this paper.

With the advancement of the information technology, a web-based courseware is considered an important supplement to class activities. To inspire students' creativity in engineering design and help them to implement their original thought, we have constructed a web-based learning environment *CEdesign* for cultivating the technological creativity in engineering students. There are four major components in this web-based integrated courseware framework: (1) the creativity activity board; (2) the creativity supporting tools; (3) the engineering courseware of domain knowledge; (4) the search engine. The five factors, namely, people (lectures, students), things (learning activity), time, places and tools, of a successful web-based courseware were carefully thought through and be covered in the design. The structure of this web-based environment is shown in Figure 1. The spirit and contents of each major component are discussed in the following sections.

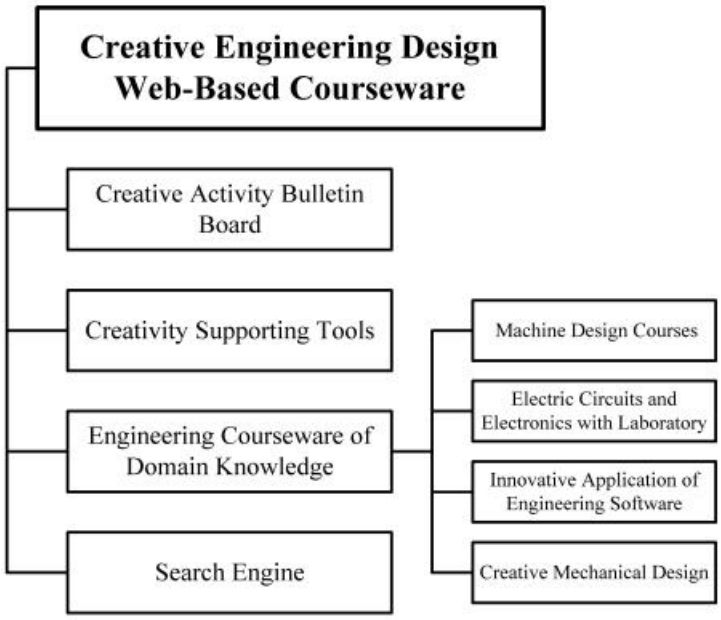

Figure 1: The structure of this web-based environment.

2. The creative activity bulletin board

The creative activity bulletin board, a user-friendly Web-BBS, is employed as the main interface for all creative activities. Each project team may have a BBS board section on the big board. Students are encouraged to actively utilize their own Web-BBS for discussing their design projects with teachers and with classmates. On the big board, they can announce hot messages (e.g., help wanted, resource acquiring, demo to come, etc.) and show their project status to inspire intra-team encouragement and a sense of accomplishments. More importantly, this board can be used to share their ideas and problem-solving approaches at any time with anyone who is interested in the topic.

For the convenience of communicating the creative ideas via network, a two-way (download/upload) FTP function is added in this board. Therefore, hand-drawn sketches, design artifacts, charts, and any kind of computer files can be transferred onto the Web-BBS server to be viewed and discussed over the web.

Creative activity bulletin board is the "center stage" of this web-based learning environment. Every user can participate in the creative activities through the web. Everyone can join and contribute. The whole process of creativity, namely, initiation, evolution and implementation of can be recorded for analyses and demonstration. These records can also be retrieved in the future as legitimate invention records. Proper intervention in the activity of this creative activity bulletin board can sustain the students' morale in struggling through their design projects.

3. The creativity supporting tools

In the process of creativity, many provisional ideas may pop-out and certain mechanisms must be designed to document those ideas. Specifically, two types of tools can be designed and implement in our web environment, which are idea-sorter and idea-organizer.

With these two useful tools, students' creative ideas can be recorded in detail on the web and being easily retrieved at later time for further brain storming sessions. Currently, these tools are under beta testing and we hope they will be available at the end of this summer.

4. The engineering courseware of domain knowledge

The creative activity cannot be successful without domain knowledge as its foundation [7, 8]. When students are working on their team design projects, they need to integrate their existing domain knowledge at the same time to acquire new knowledge as timely and necessary. Currently there are four course materials integrated in the creativity learning environment as the first shot because they are commonly crucial to all creative design projects.

4.1 The Machine Design Courses

This block-course "Machine Design" is divided, in accordance with the design process, namely, "conceptual design", "embodiment design", and finally "detail design", into a series of three sub-courses: "*Introduction to the Engineering Design*," "*Form and Structure Design of Machine Parts and Machines*" and "*Machine Elements in Machine Design*." The teaching materials of first two sub-courses were taken mainly from the research results of the European design methodologists, especially from the works of German professors such as Roth [9] and Pahl and Beitz [10]. Since design methodology offers an appropriate guiding approach to support the creativity [11], we believe that it is crucial to introduce this design methodology in the creative design education. A designer needs not only creativity but also enough domain knowledge to realize his ideas and his concepts. A designer needs to organize interdisciplinary knowledge for utility in their design works. This is of immense difficulties even to an experienced designer not just an engineering student because the knowledge is scattered and the possibilities are infinite. Therefore, a systematic approach is helpful in guiding creative designer to probe through potential possibilities and inspirations.

"Machine Design" makes a great difference from the other courses in the mechanical engineering. "Machine Design" uses the graphics as tools, instead of mathematical equations and literate words, to analyze and to synthesize working objects. Therefore a lot of pictures and drawings are used in the "Machine Design" courses as teaching aided tools. Web-based courseware is capable of presenting such information.

In order to help the students to learn "Design" without any limitation by time and by place, a web-based learning environment may be the best choice today. Especially the multi-media environment of the web is very suitable for communication in graphics, e.g. the engineering drawings in Machine Design. We have thus constructed seven different parts for this courseware "Machine Design" on web: (1) Lecture notes (both texts and pictures); (2) Reference sources and their introduction; (3) Design Tools; (4) Design Database; (5) Questions and Quiz about Machine Design; (6) Important Links on the Web (such as the machine parts suppliers); and (7) Selected examples of machine design. Some important design tools which are often used in machine design, such as the checking list, the design catalogues [9] and the search matrix for physic effects, will be also offered on the web for the students' conveniences on their design projects. We also have the electric catalogues from the machine parts suppliers gathered from the web. The students can not only review the courses but also use the design aids at home for not only their projects but also their homework. This way, they may adopt design as a way of their life.

4.2 The Electric Circuits and Electronics with Laboratory

Machines and systems are made intelligent and sophisticated by incorporating sensors, computers, and actuators through mechatronics. Therefore, hand-on electric circuit analysis and electronics are crucial domain knowledge for engineering innovations.

This courseware is intended to establish mechatronic design and implementation capability in mechanical engineering students with limited credit hours. Therefore, this courseware is fundamental, concise, integrative, and application oriented. The courseware has electric circuit analysis and basic electronic component properties at its core. Simple circuits of practical applications in mechatronic interfaces between sensors, actuators, and computers are introduced as examples to practice electric circuit analysis. Not only DC and AC circuit analyses are introduced, but also transient analysis and energy analysis of mechatronic systems are emphasized from an integrative point of view. The electric circuit property of instrumentation is also emphasized. By taking the instrumentation loading effect into consideration, the electric circuit analysis of actual circuits becomes much more realistic than that on test circuit components alone. This way, the circuit analysis results would fit the actual measurements much better. This way, the students may develop confidence in coordinating their hand-on work with their theoretical analysis and design synthesis. Such coordination is of crucial importance in empowering the students the capability to realize innovations and to construct innovations of in depth sophistication.

In addition to the domain knowledge, the courseware also contains pop quiz, which will require trials, observations, comparisons, and self-examinations before a reasonable solution can be revealed. Through such provocation, students can shed off their deeply rooted question-and-quick-solution type of reflective learning style, and start the evolution into a seasoned engineers who would test, observe, incubate, and innovate. After all, engineering education is not so much of some limited amount of domain knowledge, but, more importantly, a life long learning habit and the intrinsic motivation to innovate and to excel for better humanity.

4.3 The Innovative Application of Engineering Software

Real engineering problems are complex and multifaceted. In addition to technological issues, environmental, sociological and humanity impacts need to be taken into considerations. The analysis methodology that we were used to is no longer enough. Proper usage of the computer to solve engineering problems becomes inevitable and is the prerequisite of today's engineers. In response to such a prerequisite, we develop this course, *The Innovative Application of Engineering Software*. The purpose of this courseware is three folded

(1) Introduce the freshmen and the sophomore students to the characteristics of various engineering problems and their analyses by various software tools. Thus the students get prepared with the essential knowledge of computer aided analysis which is a fundamental engineering tool in practicing their creative engineering design.
(2) Bring the *process of creative-problem-solving* (*CPS*) into the courseware, in order to train the students for their creative thinking and problem-solving skills as early in their college days as possible.
(3) Implementation of web as the multimedia learning environment as to enhance the teaching and learning effectiveness.

Highlights of the courseware including lecture notes, engineering examples, and problem-solving procedure comparison between CPS and sequential approaches.

4.4 The Creative Mechanical Design

The purpose of this course was mentioned in Introduction. The course covers two semesters. There are lectures in the first semester. The topics covered in the lectures are (1) the introduction and incubation of creativity; (2) the process of creative-problem-solving (CPS); (3) the engineering design process; (4) the methods of engineering invention. The discussions are the crucial part of the lectures. Brainstorming technique is employed to inspire students' creative thoughts. Several mind twisting scenarios (e.g., the exploration of the Z-star, Heinz dilemma) were introduced to train student to solve problems creatively, especially to look at problems from various directions. One creativity contest is held in each semester in order to heighten students' learning mood. The students have to decide the theme, procedures, requirements, and rules for the contest and the teachers' role is limited to be only the facilitator of the discussions and the materials in order to develop an environment of maximum freedom for creativity.

There is also a final design project requirement. Every three to five students are asked to form a team to propose their design project. This project runs through two semesters. They should write their formal proposal and present it orally in class by the end of the first semester. They will focus on the hands-on realization of their proposal in he second semester. Through out this final design project, design, manufacturing and testing are required. They will demonstrate their prototypes at the end of the second semester.

The *CEdesign* web-based creativity learning environment is used to supply supplementary courseware as well as the bulletin board for the design projects. The web-based supplementary courseware on "The Creative Mechanical Design" contains the following major components: (1) the material of every lecture; (2) the discussions and

exercises in or after class, including their proposals for several training topics on creative problem solving; (3) the video records and the students' reports on the creative contests; (4) the student reports on the design project, in web-format; (5) the links to the creative activity bulletin board as the discussion sections for every undergoing project; (6) useful tools for engineering design; (7) the links to other related web-based courseware; and (8) the links to useful homepages.

The second to fourth items listed above are the records of student activities through out the course. The reports of every design project are asked to update for every week, and the creative and thinking processes should be written that could be evaluated by teachers. The discussions about their difficulty and obstacle during design process are important. The creative activity bulletin board (mentioned in Section 2) offers each team project a special board for discussions. These records could be a very valuable reference databank not only for students who would take this course in the future by also for the teachers to research on technological creativity.

Through the integrated web-based courseware, our students are able to seek help and to solve problems from these domains of knowledge. In the future, other course contents will be integrated into this environment to broaden the scope of creative activities.

5. The search engine

Students may encounter many difficulties through out their design projects. There could be a lack of initial stimulation, and there could be also a lack of know-how for an implementation. The related information may already exist in the courseware of domain knowledge or may already be discussed before in the creative activity bulletin board. The students can dig the information out easily by using the Search Engine with appropriate key words. The students can also search the vast intra-net for relevant information through other intra-net search engines.

6. Conclusions

We have created a learning environment which facilitates students' development of problem solving abilities, enhances their confidence in group discussion for cooperative creativity, and provides students with primary domain knowledge and know-how database for mechanical engineering design. We will also construct convenient on-line tools to sort and organize students' creative ideas in order to support in-depth creativity. The integrated web-based courseware encourages in-time pro-active learning as the knowledge database is conveniently at hand when the students are actively engaged in a design project of their deep interest.

We have demonstrated the power of design project as a tool for inspiring creativity out of engineering students. The approach of CPS is a well-defined methodology that encourages students to brainstorm and to generate their sketchy ideas, analyze the ideas, implement their plan, and finally evaluate the results. The learning process through the fabrication of design project puts students in the position of prospective engineers to investigate phenomenon, develop hypothesis, collect and analyze data, verify and revise hypothesis, and draw conclusion. After this experience, the students can graduate as better seasoned rookie professionals.

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