The effect of problem-based learning in computer-aided engineering software course to solve the problems of mechanics of materials

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ABSTRACT

In this project, a virtual experimental lab was developed based during the Computer-Aided Engineering Software Course to solve the problems of "Mechanics of Materials". The project examined learning achievement of students enrolled in the course "Computer-Aided Engineering Software", which was developed by following the industry requirements and included real design process and analysis. A questionnaire was administered as the measuring instrument at the end of the course of study. This was designed from the students' perspectives; data were analyzed by describing statistics, and explained by description and illustration. In conclusion, the results establish that problem based learning is highly effective when coupled with creative teaching as in the problems of "Mechanics of Materials" and the virtual experimental lab is established. The students developed greater confidence utilizing these advanced learning strategies and thus were better prepared for future work.

Keywords: *problem-based, mechanics of materials, computer-aided engineering*

INTRODUCTION

In engineering college, mechanical education desires to provide the students with greater knowledge and practical technological capabilities. Industries hope students who graduate from university may have the ability to learn independently

and become innovators in their workplace. Recently, the modern technologies have developed faster ever before. Above all, computer software and hardware has changed all the technologies. Therefore, students now use the computer more often than before, and they are called E-era kids. They like to use the computer to solve problems, write reports and communicate with each other. However they cannot use the computer to completely combine their knowledge learned from the classroom unless they have the opportunities to access the training. How to provide the students with the abilities to combine their learning with the computer, become a major job and a challenge for the teachers.

When teachers want to develop a new curriculum in the technical field, they have to consider many factors. For example, how to reach the curriculum aims and expectations, how to interact with the students and enable the students to get the technical skills they want to have. Teacher's experiences and concepts also affect the expectance of the curriculum. In other words, creative teaching time is coming and the teaching methods may have to adjust. The teachers may have to consider the following subjects: (1) what the curriculum has to contain (a) how to encourage the students those who want to learn by themselves, (b) how to lead the students to cooperate with each other to learn, (c) how to evaluate the student's increased knowledge - (d) how to turn the student's mistakes into learning opportunities, (e) how to encourage self-evaluation to enable the students to develop, (f) teachers have to answer the student's questions sincerely, (g) teachers have to help students create different opportunities and environments to solve the problems, (h) teachers have to help students overcome fluctuation, (i) have rules to give the students the rewards and consequences. The important thing is that the curriculum must have a complete plan and contents, then the concepts such as the following can be incorporated into the class. These are: (1) work-based learning, (2) project-based learning, (3) problem-based learning, (4) subject-based learning and (5) contract-based learning. From the technical view point, project-based learning and problem-based learning are the best learning methods. Problem-base learning or project-based learning for the technical learning is proposed by Mita et al., (2007), Mita (2000). He wanted the students to learn in the real society, students can solve problems through the problem-based learning or project-based learning.

Problem-based learning can solve problems through the following procedures:(1) form a small group that may have 3 or 5 students, (2) investigate the problem, then solve the problem. During the proceeding, all the students can learn how to define the problem, how to create the model, how to mesh the model, how to assign the boundary conditions, what kind of the material can be selected, and how to solve the problem, and how to describe the results, and finally how to verify the analytical results. Through the procedures, students generally cannot apply the knowledge to solve the problems. The problem-based learning or project-based learning can combine different fields to solve the problems and will know the relationships between different courses. These learning methods can enable the students to corporate with each other, and through the learning procedures, to activate their creative abilities.

THE TEACHING DESIGN

The complete curriculum planning and case study can be designed and the teaching design will become the major job of the instructor who has to propose the teaching prospect, teaching methods, teaching contents, teaching procedures, and curriculum evaluation. The questionnaires for evaluation must be designed to understand the duties of both the mentor and mentee. The instructional system development can offer the mentor an effective teaching design module. Right now, there are many teaching design modules being used, but ADDIE modulus that included Analyze, Design, Develop, Implement, and Evaluate are applied more often.

The subjects will be described in the following manner. (1) Analysis: consider the mentee, ie what they want to learn. The students in the department of MEEM want to learn mechanical and mechatronic technologies. They want to know how to make and control the machine and how to make the machine work. (2) Design: consider the mentee, i.e. how they want to learn. To consider the mentee's capabilities and the courses they had learned, the instructor must design problems that use their knowledge and improve their abilities. (3) Development: how to edit the curriculum materials. Lots of courses in MEEM are generally theoretical courses. Therefore, how to design the curriculum contents to apply the theoretical principles into the practical cases. (4) Implement: how to build up the environment to perform the problem-based learning. The instructor has to offer different problems those can stimulate the students learning motivation and can be really practiced. (5) Evaluation: design the evaluation questionnaires to evaluate the student's thinking and their achievements. Through the evaluation, the mentor has to encourage the student to develop. The mentor has to continue modifying the evaluation strategies to improve the teaching methods and qualities.

THE CURRICULUM CONTENTS

The students in department of MEEM from freshmen and sophomore already study many courses, such as factory practice, computer program design, and many elementary mechanical courses such as mechanics of materials, thermodynamics, fluid mechanics, automatic control. Additionally, they also study some advanced mechanical courses such as vibration theory, advanced mechanics of materials, power system, finite element analysis etc.. Therefore, the students have the basic concept of the mechanical part or component, but they didn't have the full picture for the system and machine. They also have studied many mechanical courses such as physics, static, dynamic, mechanics of materials, thermodynamics, mechanics of vibration, and material properties related to the mechanics, but they don't have the opportunities or any course to combine all of the knowledge obtained from the above courses. They also had learned mechanical drawing, computer-aided design, so they knew how to design the machine parts or components, but they don't know if their design can work very well or not. They don't know how long can their products be used and how to avoid the products' defect. They don't know how to modify the design and how to improve their

products through their mechanical knowledge they had learned. To improve and raise the abilities of the students in combination the design and mechanical knowledge, we propose the use of a problem-based learning curriculum that combines the virtual lab concept with many mechanical courses such as mechanics of materials.

In this course, the student has to propose what kind of mechanical parts or product they want to design and finally may be produced. They can start to design their product by using the computer-aided design software such as AutoCad, Pro/Engineering, Solidwork, or Designplorer, then the following procedures must be followed.

1. Students have to think how to apply their products.
2. Students have to use the computer-aided design software they had learned to create the solid model.
3. They have to transfer the solid model into ANSYS/Workbench Engineering software.
4. They have to use Mesh functions to create the mesh of the solid model to get the finite element model.
5. After the finite element model is obtained, the material properties they learned from the mechanical material properties course must be selected.
6. Also the boundary conditions they learned from many mechanical courses such as Mechanics of Materials must be determined and assigned in the model.
7. After the above conditions are assigned, the solution can be performed.
8. After the solutions are obtained, the post-processing can be proceeded and the results can be described by using the table or figures. The analytical results can be verified by using the theoretical formula or experimental date they obtained from the other courses.

AN EXAMPLE

A complete example made by one student is presented in the following. A gear is a major product of a machine that can produce different elements or components Therefore, the gear is an important element. Geometric shape and size of the gear is plotted in Figure 1. The mesh of the gear is plotted in Figure 2. The boundary conditions for analysis are major concern of the problem. To simulate the mechanical behavior of the gear, the center area of the gear is fixed and shown in Figure 3. One tooth of the gear is assigned to have the pressure of 500MPa shown in Figure 4.

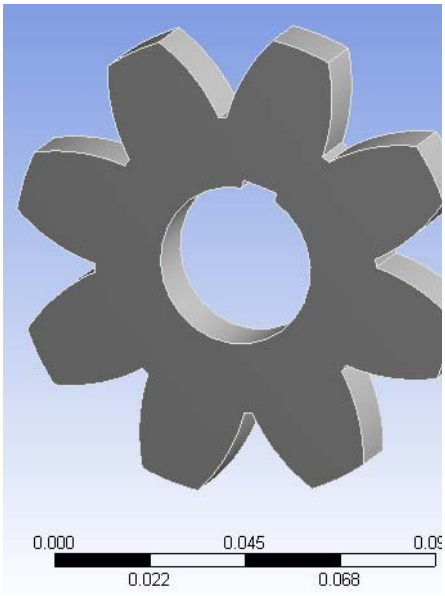

Figure 1: Solid model of the gear.

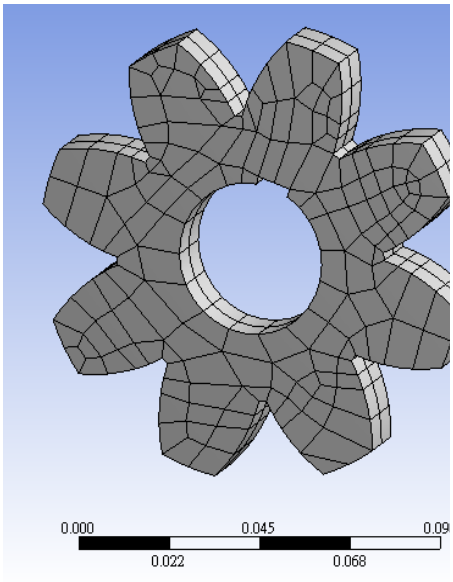

Figure 2: Mesh of the gear.

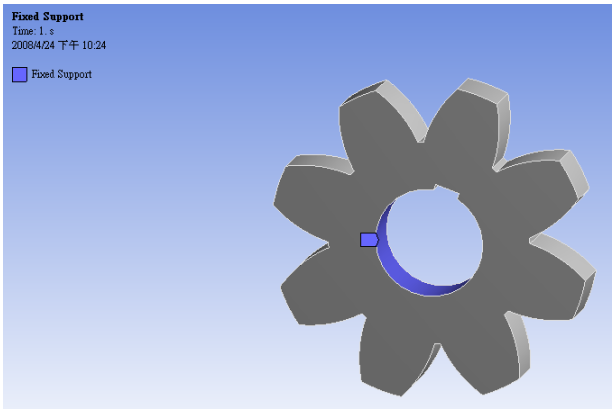

Figure 3: The central area is fixed.

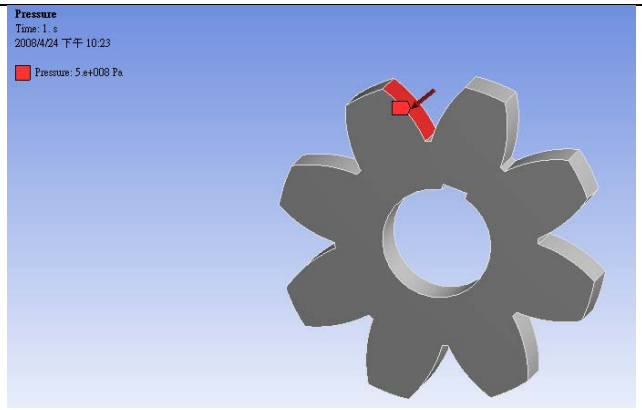

Figure 4: Pressure is applied on one surface of the tooth.

Figure 5 is the deformation corresponding to the applied load. Figure 6 is the stress distribution of the gear. Aviation plot can be stored in the computer to see the continuous change of the deformation and stress.

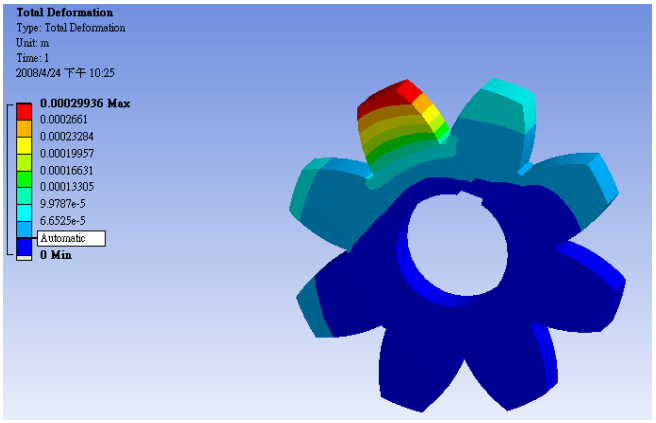

Figure 5: The deformation distribution of the gear.

After the course is finished, the evaluation questionnaires are designed to understand the effect of this teaching method. The students acknowledge the virtual lab teaching method shown in Figure 7 can combine lots of knowledge they learned before. In this class, 28 students out of 37 students agree that using this method they can learn more than by using another method. Figure 8 also presents most of students agree this method can raise their interest in their self-learning. Figure 9 also showed that problem-based learning combined with the virtual lab teaching method can increase the learning efficiency of the students. This teaching method can extend into other curriculum areas, however teachers may have to spend more time on this method.

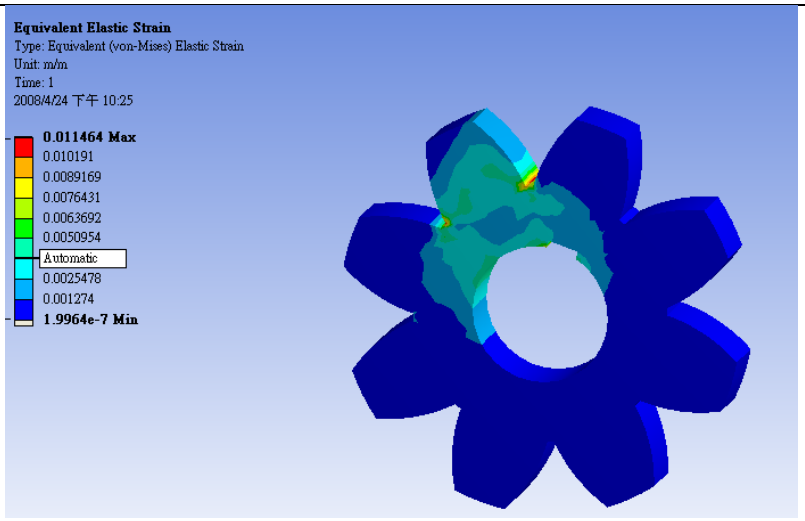

Figure 6: The stress distribution of the gear.

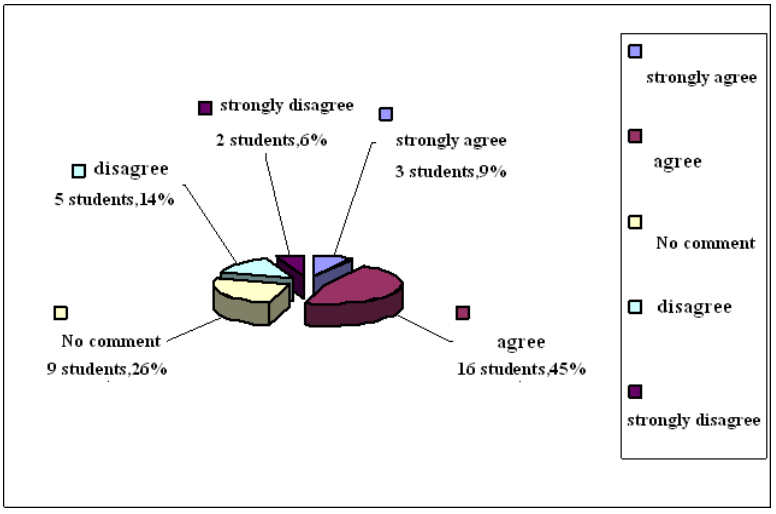

Figure 7: Combine lots of knowledge they learned before.

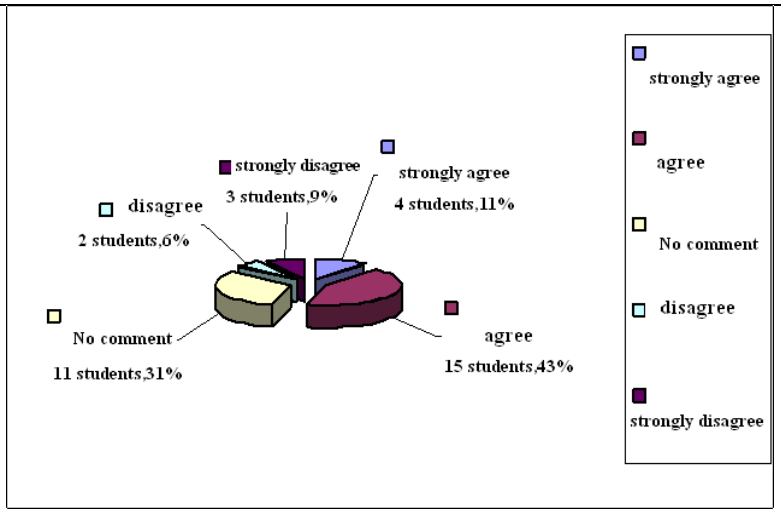

Figure 8: Students agree this method can cause their interesting in their self-learning.

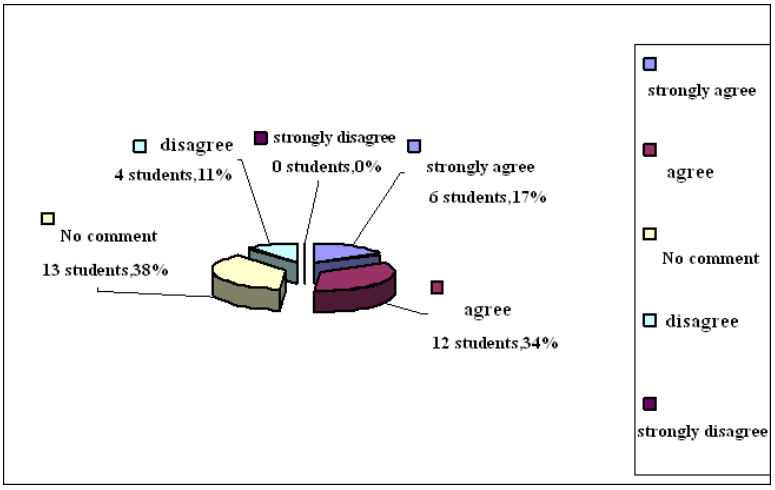

Figure 9: Problem-based learning combined with the virtual lab teaching method can increase their learning efficiency.

CONCLUSIONS

In this report, the virtual lab teaching method can design a method that enables students to combine the knowledge they learned before, and the teacher can find or collect many problems based on the subjects that the students have already learned. The example shown in this report, shows how many courses such as mechanics of materials, computer-aided design, computer language, physics, finite

element method, vibration theory, were combined and are also used in this curriculum. We will continue developing different curriculums to raise the student's abilities and their interest.

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