

Adaptive Learning Framework for Web-based Course of Mechanical Product-Oriented Quality Inspection

Janus S. Liang¹ and Chur-Tis Huang²

¹Yung-Ta Institute of Technology and Commerce, janus@mail.ytit.edu.tw

²Yung-Ta Institute of Technology and Commerce, c9005123@pchome.com.tw

ABSTRACT

One of the most important factors about maintaining product quality is quality inspection. To meet the product standard, quality inspection is a key technology to ensure that the product is good enough. The course is valuable in that it promotes the idea of quality inspection and reinforces the mechanism for product quality inspection. In this study, the contents consist of several sub-subjects, including concepts, purposes, inspection tools, and technologies, among others for mechanical products. Aside from adopting adaptive learning strategy, the course combines the Internet and multimedia technologies to develop the learning system. Teaching materials are especially designed to add to the lively and vigorous atmosphere in class as well as provoking interaction between teachers and students. Images, animation, virtual reality, etc. are applied to explain the operational process in a dynamical way. The framework of virtual interactive environment is built, which follows an individual student's need to adjust the advancement of the course, and it will be evaluated by scale for promoting the ability of quality inspection.

Keywords: Product quality inspection, Adaptive learning, Virtual interactive environment

1. INTRODUCTION

The process of production includes confirming the customer's needs, design, manufacture, and inspection, every one of which involves the concept of quality control. For example, when communicating with the customer, in addition to understanding the requirements of the client, the manufacturer has to assess whether the current productivity allows the manufacturing to be completed on schedule. The assessment is what we call "order quality management." The quality control of design starts with categorizing products into functional products, modeling ones, or both, then the designing procedure and its corresponding constraints will be confirmed. For manufacturing part, quality control refers to the policy-making process: according to the part drawing, then the proper manufacture approach is decided, the type of machines, the type of cutting tools, the machining parameters, and processing orders. As for inspection and quality control, it not necessary to say both has close relation. Quality control is the key factor in every step of processing, and each makes a difference in the quality of final products. The study will conduct quality inspection on a product on aspects of its design, manufacturing, and other aspects. Meanwhile, the study aims to realize the concept of improving both teaching and technology by discussing topics on how to promote students' ability of quality inspection.

Due to the complexity of mechanical product types, the study choose hub bearing which is important component of automotive transmission system and electric, as the products to be inspected.

On the other hand, as information and the Internet technology advances, the network learning system can free students from the constraints of time and space. Valuable resources can be circulated via the Internet, thus serving the purpose of sharing resources and popularizing education. As the Internet learning system boosts the quality and quantity of teaching, the study aims to develop a mechanical product-oriented web-based course on quality inspection. The course contains the procedures and methods of mechanical product quality inspection, as well as providing the learning materials and strategies of quality inspection for mechanical engineering majors in college. Adaptive learning approach is adopted, to promote students' ability to quality inspection of product. The goals of the first year were:

- (1) Planning the goals and strategies of on-line courses.
- (2) Developing the network-teaching materials and a quality inspection ability scale.
- (3) Building the course design module, multimedia module, students' data retrieving module, and course management module.

- (4) Generating a virtual learning environment to offer the students and professional people in mechanical or related fields.

2. PLANNING THE COURSE CONTENTS AND STRATEGIES OF ON-LINE LEARNING

A network learning system uses the World Wide Web (WWW) as a platform, combines words, pictures, video, audio, and other multi-media information, and provides hyper-links to make independent learning ever easier than before. It breaks away the limits of traditional teaching and learning because students have an access to diverse information any time they like. Network also makes it possible for teachers to fulfill the ideal of individualized teaching by designing courses that suit the needs of individuals.

In strategies for problem-solving field, Mayo, Donnelly, Nash, and Schwartz [1] pointed out that teachers should provide the necessary resources for problem-solving and properly give guidance and opportunities, so that students can acquire knowledge on their own through the process of solving problems and then develop the capability to solve problems effectively.

The team of Trop and Sage [2] consider learning through problems a teaching strategy and a learning process, in addition to a curriculum planning. According to another research by Aspy and Quimby [3], when compared with traditional teaching, an arranged learning situation through problem-solving can make learning process close to the hypothetical, experimental scientific learning process. It also corresponds to the concept of self-guided and student-centered learning. Now it has been a widely-used teaching strategy in all knowledge fields.

In discussion of modules for learning trouble shooting, Alexander *et al.* [4] proposes that subject-matter knowledge is an important index in predicting learning achievements. Whether a person is equipped with enough subject-matter knowledge has influence for learning, and it is one of the significant factors for successful learning.

In design curriculum contents, the study divides the contents into categories and then encodes the learning materials accordingly, so that the students can see concise and explicit descriptions of a quality inspection course on mechanical products. A further goal is to plan a network learning system and to develop on-line learning materials. The course contents break down into four categories: the purpose, the concept, the tools, and the technologies. Background knowledge for this program covers basic consuming knowledge, math, physics, and principles on mechanical elements. (See Tab. 1)

Subject	Topic
Mathematics	quantity and number, concept of triangle and trigonometric function, approximation and square root, etc.
Physics	quantity and unit, mechanics and energy, thermodynamics, optics, electrics, etc.
Principles of Mechanical elements	screw, gear, hydraulic/barometric pressure, spring, etc.

Tab. 1. Background knowledge for learning the course of quality inspection

Following the subjects in the chapters, the study will build a digital learning tree for the curriculum contents. By doing so the system allows students to decide which unit to learn first and in their speed, instead of being forced to learn the lessons in a given sequence. The more the flexibility there is, the more fun students have. As for the planning for learning paths of courses, this study adopts the mode of dynamic learning paths which allows students to choose among learning of reference orientation, objective orientation, or example orientation. The planning structure is illustrated in Fig. 1. The course content in this research is designed according to each subsystem. A tree structure of digital learning course content is established and used in coordination with the dynamic learning path mode to give students flexible selection of desired units without going through the first unit to the last.

Furthermore, to motivate students, the study employs the following activities as a teaching strategy:

- (1) Course reading activities: The on-line course materials of our graduate program are further divided into more detailed sections for students to choose from. Handling the preference in person and enjoying the flexible learning process.
- (2) Bulletin board: In each learning unit, students can share experiences, cooperate in teams, exchange opinions and course data, and list learning results. The contents on the board are presented in static forms such as words and pictures. Because the information will remain on the board for a certain period of time, the students can see the learning process of their own and of other classmates here. If a student has any question about the course, or wishes to have a private discussion with the teacher, use the mailing function to send an email to the teacher

directly from the board.

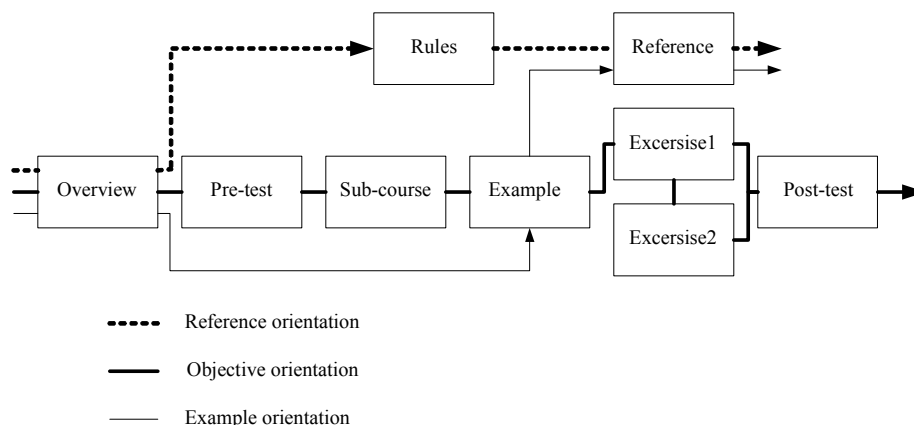


Fig. 1. Dynamic network-learning strategies

- (3) Discussion room: The most noticeable difference between the discussion room and the bulletin board is that the former is a place for real-time discussion. Students in different teams meet with the teacher in the discussion room at an appointed time. Here, besides discussing the course and clarifying concepts, the teacher can also set a course subject for further exchange of viewpoints among the program participants. The room is an ideal place for two-way communication not only in words and pictures but also with images and animations.
- (4) Quizzes: Every lesson is finalized with a unit quiz, which serves as an evaluation for the self-learning of the unit, the result of which will decide whether the student is qualified to go on to study the next unit, or has to repeat the unit again with provided resources, such as the discussion room or related reference materials. The quiz is mainly for evaluation of the learning performance of individuals, but the results can also provide a reference for the material designer to reflect on and modify the course contents.
- (5) Case study: Case study is for group work participants to engage in cooperative activities on a designated subject with the previously-learnt knowledge or skills. Learning how to collect data, drawing conclusions, analyzing problems, find out solutions in this activity, by using other integrated skills through teamwork.
- (6) Information searching activities: Collecting data related to the subject from websites, academic papers, technical articles, and others, to get acquainted with the ways to facilitate self-learning when learning a new lesson. Besides, these resources make an important auxiliary reference database for those who have to study the unit for a second time.

All the above-mentioned learning activities are for the purpose of adaptive learning. Considering personal needs and conditions, the individual student can adjust the speed and contents of the course for best self-learning. Adaptive learning makes up for what traditional teaching lacks and makes the whole learning process more dynamic, thus strengthening students' motivation to learn more.

3. DEVELOPING NETWORK-TEACHING MATERIALS AND EVALUATED TABLE

To practice the strategies mentioned in Section 2, and to understand the effect of the learning system, the study made on-line learning materials and a scale for quality inspection abilities. The followings are detailed descriptions.

3.1 Making on-line teaching materials

To comply with the course contents and strategies mentioned in Section 2, every chapter is further divided into several sections, as shown in Fig. 2, so that students can learn in a systematic way and achieve a better learning effect.

Apart from making appropriate learning materials, the study features auxiliary learning functions, which are drawn and integrated from professional researches and related papers. The functions include:

- (1) Auxiliary resources for learning: This part is placed at the end of every chapter, after the course contents. The function gives students access to related papers and reports after they have studied the contents. In addition to helping students know more about the objectives and subjects, these resources also serve as the reference area for

reports, projects, or after-class auxiliary materials.

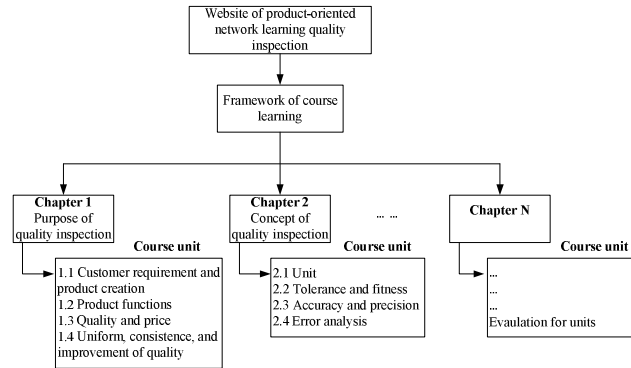


Fig. 2. Course framework of product-oriented web-based learning quality inspection

- (2) Supplement: This part is put within the learning system, containing the CAD/CAM-built design information about the assembly and components of mechanical products, such as datum planes, dimensioning, and tolerance. These data are important criteria for quality inspection. Supplement resources also present the appearance of mechanical products on web pages, again built by CAD/CAM. But the processes of the assembling and disassembling of mechanical products are displayed with virtual 3D technologies. Moreover, in order to give students projection concepts of the process of quality inspection, the system enables students to operate the 3D model by virtual panels. Using keyboard, or scroll bar or up/down button to enter the three rotating angles of the coordinate. Then the students can have immediate projection viewings of the mechanical components - front view, right view, and top view.
- (3) Operation: Operation is arranged in sections of “the use of measure tools of quality inspection” and “quality inspection techniques.” The operation function uses multi-media virtual technologies to create a simulated operating process for different subjects, which could be experienced only in the laboratory in the past. Meanwhile, all the noteworthy details about the operation are also presented in 3D forms.
- (4) Comprehensive practice: The study focuses on ways to enhance students’ ability to conduct quality inspection, and this unit is put after the operation of “quality inspection techniques” in each section. Integrating theories, methodologies, and techniques, then let students know how to apply them on real mechanical products.

The learning effect can be assessed by the above-mentioned operation, and by exams after class, too. As a result, the designing of on-line exam database plays a prominent role. The quizzes at the end of each chapter are particularly designed for a review of the contents of the chapter. Besides giving students some drills to exercise their brain, the quizzes provide the answers and interpretation. Bookmarks are added to show from which part in the chapter the question is drawn, so that students can go back to the chapter and find out why. Meanwhile the questions for the chapter will be changed from time to time to prevent students from memorizing the answers and losing the desired effect.

3.2 Estimating and revising the scale of quality inspection ability

The study created a scale for measuring quality inspection ability, containing 40 questions about the course contents. It is composed of four parts and they are concept, purpose, inspection tools, and technologies of quality inspection. To find out how the scale works, the study tested it on 36 freshman students of vehicle division, Department of Mechanical Engineering, Yung-Ta Institute of Technology and Commerce. The analysis of reliability and validity is as follows.

(1) Item analysis:

The questions are analyzed according to their difficulty, discrimination, and measures such as Point-biserial correlation coefficient. The appropriate questions have a difficulty of 0.50 (Ahmann and Glock [5], pp.163), a selection criteria of 0.40~0.80. As to item discrimination index, D, the study uses the criteria that Ebel [6] suggested. (See Tab. 2)

D	Item discrimination
0.40 above	Excellent
0.30 ~ 0.39	Better, correction is needed possibility
0.20 ~ 0.29	Good, correction is needed in general
0.19 below	Bad, eliminated or modified substantially

Tab. 2. Standard of item discrimination index (source : Ebel [6] , p.279)

(2) Reliability Analysis:

The study uses the Kuder-Richardson Formula, i.e. counting the scores by the number of correct answers, not affected by the time spent on doing the test, and measuring common factors to assess the coefficient KR-20. The standard is shown in Tab. 3 After prediction and computer encoding, the questions are analyzed by the statistics software, SPSS for Windows 10.0. The examinees' answers are processed by item analysis after they are entered into the computer. First the computer puts the 36 examinees' total scores in order, then making the highest 27% the Higher Group, the lowest 27% the Lower Group. Next it calculates the percentage of those who get the right answer for each question in both groups, and then it draws the discrimination index and the item difficulty index. Last the computer does a correlation analysis between each question and the individual's scores for comparison.

Scope of α	Illustration
$0.00 < \alpha < 0.30$	Least credible
$0.30 \leq \alpha < 0.50$	Less credible
$0.50 \leq \alpha < 0.70$	Credible
$0.70 \leq \alpha < 0.90$	More credible
$0.90 \leq \alpha < 1.00$	Most credible

Tab. 3. Standard of Cronbach coefficient alpha α

Following the standards of discrimination index and the item difficulty index, there are four items- 1, 10, 20, 31, are deleted in the concepts of quality inspection; there are four items - 2, 8, 32, and 39, are deleted in the purposes of quality inspection; in the tools of quality inspection, three items are deleted - 6, 18, 23; the techniques of quality inspection, four items are deleted - 15, 28, 29, and 34. Items of scale of quality inspection are 25 questions after detecting procedure. After the analysis of internal consistency, we got the KR-20 as follows: for those who chose (A): 0.645, (B): 0.663, (C): 0.731, (D): 0.648, and the ability to answer correctly as a whole: 0.853.

4. ESTABLISHING THE FRAMEWORK OF NETWORK-LEARNING SYSTEM

Because the Internet environment overcomes the limit of time and space, it has somewhat brought about an impact upon learning itself. As far as the student's social relationship is concerned, the strong interaction that the Internet encourages in which the student moves from a single class community to an Internet learning environment, in which student plays multiple roles. In such a diverse learning condition, the focus and object of learning is bound to undergo changes that make it different from traditional teaching modes.

For computer aided teaching, Asyerman [7] proposed that (1) hyper-media materials should be powerful enough to create effect on senses; (2) the individual's performance should be praised; (3) the study contents should be developed by the instructors; (4) the materials should provide optional learning activities for students; (5) communication and interaction should be encouraged; and (6) 3D animations should be employed. Hubbler [8] brought forth the idea of using World Wide Web as a platform for after-class exercises or homework, and as part of the training of developing problem-solving abilities. Via the Internet, students log in to have an on-line class in real-time conversations. This mode helps management and enables students to ask questions anytime they want to, without limit of time and space. On the other hand, students could view the record that included learning process, evaluations, as well as getting feedback from the teachers. So far there have been a great number of instructors using the WWW to conduct teaching, assist evaluation, collect students' responses to their teaching, etc. According to Creed and Plank [9], there are seven criteria for designing a teaching website: (1) fast download speed; (2) friendly for browsing; (3)

providing hot news; (4) easy to identify the units of course; (5) encouraging constant use; (6) able to help self-learning; and (7) allowing printing of the teaching materials.

In product knowledge management system, Kvan and Candy [10] used AutoCAD as the platform, and SQL database software to build up Smart Drawing, which then combines pictures and design data. With the suitable interface, the system allows the engineers to use the database of engineering data to search for related information when constructing a new product. The database is also shared with the other departments in the company as well as with customers.

By adaptive learning and a virtual learning environment, this study helps students develop problem-solving abilities for quality inspection techniques. The two strategies of real-time discussion room and case planning also help to cultivate abilities to cooperate and negotiate in a team. The web-based learning system will be explained in detail in the following sections.

4.1 The platform of Web-based learning system

The development of the Internet technology makes information collection ever easier than before. As a result, a variety of teaching materials can be accessed via the Internet, thus resolving the common difficulty in updating teaching materials in traditional teaching. With the learning system that this study designed, students can log in to the learning system via the Internet from the client end. Also by using various functions of the system, such as on-line discussion rooms, bulletin boards, students can raise questions any time. Using the operation module and understand the measuring procedure of instruments.

To sum up, the system provides students contents of course, discussion space, and practical operation in quality inspection. The system organizes interactive teaching contents in tools like HTML, PHP, Java, JavaScript, VRML, and Apache. The software framework is shown in Fig. 3. The platform is written in RedHat's Linux language, the database made in MySQL 3.0, and management system written in phpMyAdmin.

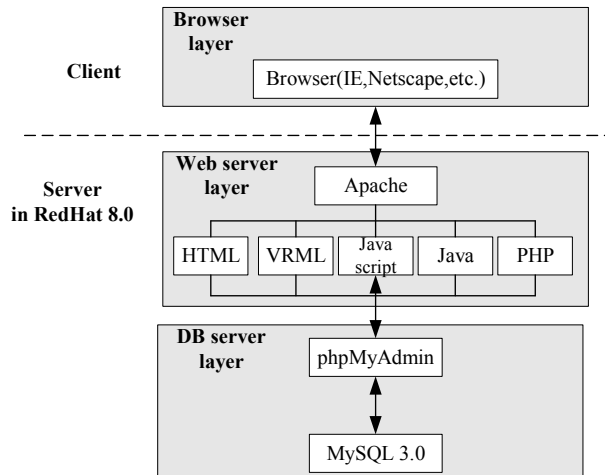


Fig. 3. Software framework of web-based learning system

The learning network system developed herein adopts the Apache Web Server (web page server software), PHP Script (dynamic web page language) and MySQL (relational database). Once upon completion, the system can operate across different platforms such as Linux, MacOS, or MicroSoft Windows. In the MySQL database of the research, computer languages such as Java, PHP and JavaScript are used to design modules of each unit and establish the connection among each module. The basic structure and communication environment of the modules is shown in Fig. 4.

4.2 The systems of course management

Apache Web Server, a web page server software, PHP Script, a widely-used general-purpose scripting language, and MySQL, a relational database, are used for the learning network system. The system can run on different platforms such as Linux or Windows. The database is a MySQL database, which uses Java, PHP, and JavaScript to design modules for different courses and to construct connections between modules.

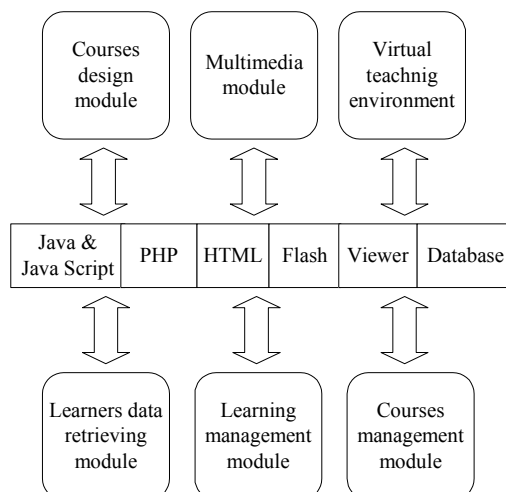


Fig. 4. Diagram of modules of building courses management and design

The study established the teaching management system according to the learning strategies in Section 2:

- (1) Virtual classroom: announcing latest news, curriculum schedules, and bulletin boards for posting learning opinions.
- (2) Remote system management: preventing cheating in tests and maintaining a fair test, there are many units that have to be managed, including basic data, password, curriculum management, evaluation, statistical data, test making (which randomly provides test questions or arranges test questions).
- (3) Curricular and academic management: making course materials; building interactive functions both students and system; options for lessons according to individual preferences are provided; increasing the flexibility of learning environment.
- (4) Personalized management: personalized studying environment is created; having a mechanism which traces flexible learning; integrating diversified teaching materials; uploading of homework.
- (5) Online virtual community: an interactive discussion room is a place for students to exchange opinions and raise questions, which will be responded by instructors.
- (6) Evaluation module: analysis the test results, creates a test sheet which is combined multimedia styles and text questions. Above all, it can be used for all levels of exams. The module can sort out the most difficult parts and make the same type of questions appear more frequently in exams. The test is in the package of web test; after the time is up, the system shows the scores and the answers automatically.

For remote system management, the study divides the system into four modules for users—guests, students, instructors, and the administrators.

The study uses MySQL object relative database as a foundation to design the databases of adaptive learning exams and of the management system. Some characteristics are included: (1) Crossing platforms: All components used are a kind of open source, which effectively backs up specialized functions that the system developed; (2) Open to languages: The databases support a variety of languages and can be saved in common formats like ODBC or JDBC ; (3) Supporting the Internet: In the near future, the influence of the Internet is as far and wide as can be imagined.

5. IMPLEMENTATION

The web-page framework of the quality inspection system is divided into the two parts - students and instructors. Fig. 5 depicts the static and dynamic technique to display the disassemble condition and the component information of hub bearing. Fig. 5(a) displays its assembly, while the result after exploding is shown Fig. 5(b), it is composed of five components. By clicking on the ball ring and hub, a new webpage is created and list the important inspecting information of component, including datum planes, normal dimensions and their tolerances, material, and viewing figures, they are displayed in Fig. 5(c) and Fig. 5(d).

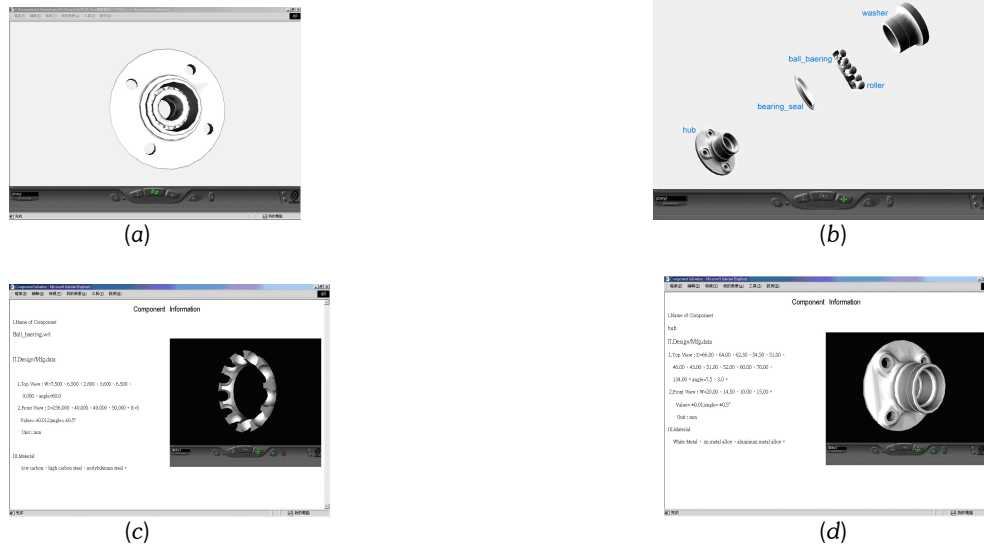


Fig. 5. Data for the components of automotive hub bearing in dimensional inspection

In Fig. 6, students can input three rotating angles for the coordinate through the control panel, and see a 2D projections of the component in three directions immediately. Fig. 6(a) and Fig. 6(b) show the ball ring before and after being rotated. Fig. 6(c) and Fig. 6(d) show the hub before and after being rotated.

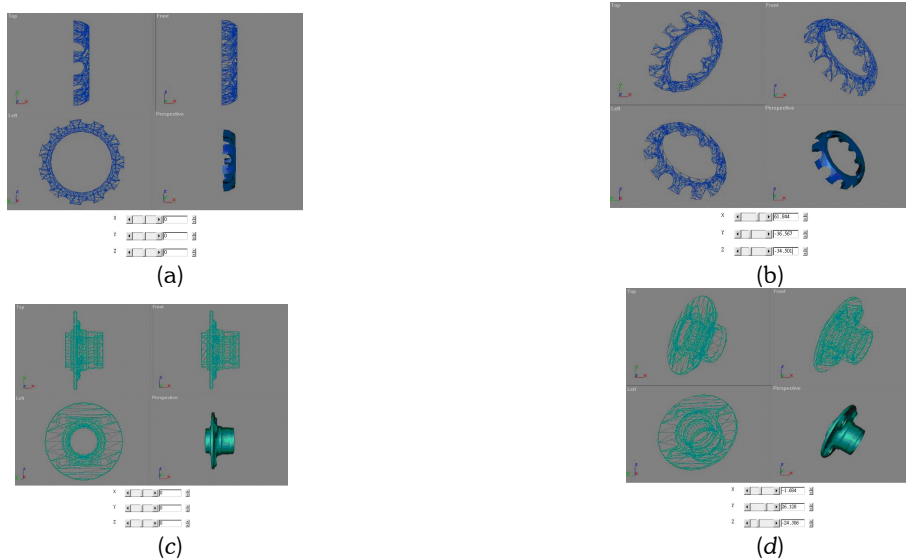


Fig. 6. Real-time 2D projected views of the components of automotive hub bearing

In operation, students can inspect any size (length, diameter, etc.) of the components which are chosen online, and then compare the result with the engineering drawing to find out if the dimension fits to the standard. For example, Figure 7 depicts the process for inspecting inner diameter of the bearing ring using vernier caliper. Conducting dimensioning inspections according to standard procedure, and the result is shown 36.05 mm (Fig. 7(b)), then find the diameter dimension is 36.00 ± 0.05 mm on the engineering drawing. Calculating the maximum dimension at 36.05 mm and the minimum dimension at 35.95 mm, and the measurement falls within the both values, it means dimension is qualified.

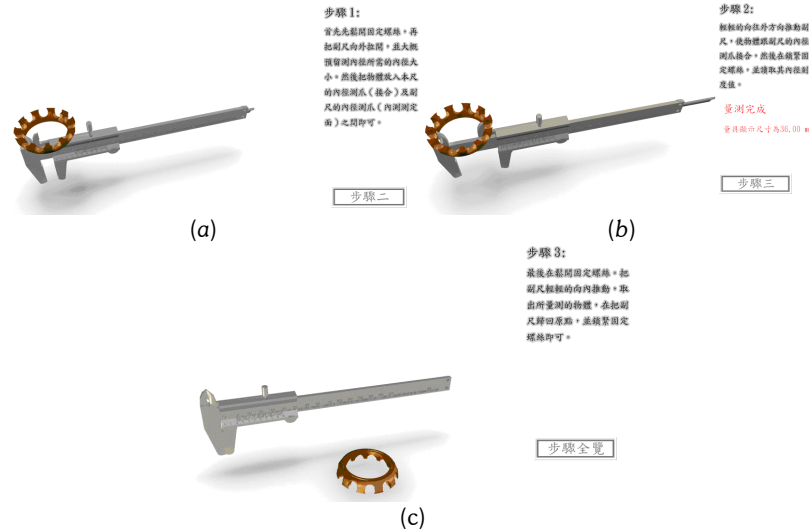


Fig. 7. Process for inspecting the components of automotive hub bearing using vernier caliper

The above is an explanation of the major systems only. For details about other systems developed for the study please refer to the website at <http://www.me.yit.edu.tw/~mec/>

6. CONCLUSION

This year being the second year of the study, the study has so far accomplished the construction of the system platform and learning modules. Estimating and revising the scale of ability of quality inspection is also done, the result and the relative data of which will serve as important reference for the third-year scale verification for promoting the ability of mechanical product-oriented quality inspection. Considering front-end design and manufacturing of the hub bearing, the study explains the procedure of quality inspection by the example of hub bearing, a key component in automotive transmission system. Meanwhile, various components of automobiles are also subjects of our curriculum planning. For one thing, they are the subject of the study; for another, they are excellent examples that show the variety of mechanical products to be inspected. As students are the main concern of the study, the course planning of mechanical product-oriented quality inspection skill follows the model of adaptive learning, which meets the request of course contents and learning strategies. Then the Internet and multimedia technologies help to put on a perfect presentation of the curriculum, which in turn encourage students to find information and use the know-how to tackle problems in real life. Auxiliary resources provide students with access to abundant supplementary materials, which facilitate learning and understanding of the lessons. In the future, apart from usage in school, the system can well involve the community, the automobile industry, and others who work in the mechanical engineering to join in this cyber campus through the distance teaching mode.

7. ACKNOWLEDGEMENT

This research was supported in part by the National Science Council in Taiwan through Grant No. NSC-93-2516-S-132-001.

8. REFERENCES

- [1] Mayo, P., Donnelly, M. B., Nash, P. P., and Schwartz, R. W. (1993), Student perceptions of tutor effectiveness in problem based surgery clerkship, *Teaching and Learning in Medicine*, Vol. 5, No. 4, pp. 227-233.
- [2] Trop, L., and Sage, S. M. (1998), Problems as possibilities: problem-based learning for K-12 education, *Virginia: Association for Supervision and Curriculum Development*.
- [3] Aspy, D. N., Aspy, c. B., and Quimby, P. M. (1993), What doctors can teach teachers about problem-based learning, *Educational Leadership*, Vol. 50, No. 7, pp. 22-24.

- [4] Alexander, P. A., Kukiowich, J. M., & Schulze, S. K. (1992), How subject-matter knowledge affects recall and interest., *Paper presented at the annual meeting of the American Educational Research Association*, San Francisco.
- [5] Ahmann, J. S., Glock, M. D. (1981), *Evaluating student progress: principles of tests and measurement* 6th ed., Boston: Allyn and Bacon.
- [6] Ebel R. L. (1979), *Essentials of educational measurement*, 3rd edition Prentice-Hall, Englewood Cliffs, NJ.
- [7] Asyerman M. I. (1993), An overview of the research on learning styles and hypermedia environments, *Paper presented at the Mnnual convention of the Eastern Educational Research Association*.
- [8] Hubbler A. W. (1995), An intelligent human computer interface for asynchronous wide area training and teaching, *Fourth International World Wide Web Area Conference Proceedings*, Boston Massachusetts, pp. 11-14.
- [9] Creed T. and Plank K. (1998), Seven principles for good course web site design, *The National Teaching & Learning Forum*, pp. 8-10.
- [10] Kvan, T., and Candy, L. (2000), Designing collaborative environment for strategic knowledge in design, *Knowledge-based System*, 9, 429-438.