Education Method by Master-Apprentice Institution in Engineering

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Abstract: Engineering education aims at transferring the basic theory and its application in engineering to students. By installing the master-apprentice institution on campus, we intend to reinforce the interaction between teachers and students. With a series of courses about project design and practice, the master-apprentice institution when applied in engineering education provides a smooth transition from the theory to the practice. The whole process can not only cultivate students' creativity but also stimulate them to produce better quality work. This study is based on the educational concepts of Da Yeh University, where the master-apprentice institution has been put into practice for years, in the hope of promoting this institution.

Keywords: master-apprentice, engineering, education

1. Introduction

Though the pace of modern technological development is very fast, it is mostly the application of basic theories taught in school. However, due to the limit of time and the subdivision of knowledge, engineering education is often divided into too many subjects, which makes it harder for students to get a comprehensive understanding of the field. Under such circumstances, an engineer with a B.S degree still has difficulty solving problems in his job. To enhance their skills, we assign them to do integrated researches. To improve their ability to solve problems, teachers in our department provide professional advice and assistance to help students become competent professionals. This is why we have adopted the master-apprentice institution in Da Yeh University since its foundation in 1990.

The school education should be student-oriented. In this context, teachers are responsible for quality teaching while the administrative staff provides all the necessary assistance. In addition, teachers are expected to be students' friends while students must learn with the concept of cost. In the first part of this study, I will focus on the theoretical foundation of the master-apprentice institution and move on to explore the nature of engineering education in the second part. The third part of this study is based on the practice of such an institution in our department. Details about our curriculum, including the design of courses and methods of implementing, are provided to further the reader's understanding of this institution. According to our experiences, we strongly believe the master-apprentice institution intensifies the interaction between teachers and students. Furthermore, it makes students much more involved with their studies and identified with the department. In fact, their involvement with project design and practice will help them become professionals with creativity and a sense of quality control. That is the value of the master-apprentice institution, which demands our full attention.

2. Foundation of the master-apprentice institution

The master-apprentice institution embodies an attempt to break down the barriers between teachers and students to activate the traditional educational mode. Teachers and students must both identify themselves with this institution for the way they interact is going to decide the quality of this practice. The success of this institution also depends heavily on students' willingness to take teachers' advice and constructiveness toward their study. Include as follows:

a. Sense of Identification

What with the difference in age, education and personal experiences, and what with the confinement imposed upon by traditional educational methodology, teachers and students not only have little in common but also lack the occasions to communicate. As a result, the first thing we do when implementing this institution is to enhance teachers' and students' understanding of and belief in this institution. This way, they can identify themselves

with the spirits of this institution and take their responsibilities seriously. Without this consensus, this institution is nothing more than a dead mechanism.

b. Interaction

The nature of the master-apprentice institution in engineering education radically shortens the distance between teachers and students. Teachers must provide students with all the necessary guidance and assistance while students are supposed to raise questions they confront in their research. Since their questions are often centered around certain topics and issues, we think it necessary and beneficial either to offer an integrated course or to organize a club to sharpen students' thinking and motivate them to solve the problems on their own. The design and content of "The Project design and Practice" is the perfect embodiment of the master-apprentice institution. Teachers are expected to extend their concern for students in all areas, including their daily lives and even love affairs.

c. Obedience

To effectively carry out the master-apprentice institution, a new ethics between the master/teacher and the apprentice/student need to be established. Only when students are willing to take teachers' advice seriously can they get professional help to solve problems. What's more, the veracity of engineering knowledge will be the precondition for our requirement for obedience, which is quite different from the master-apprentice institution as applied in other fields. In other words, both teachers and students must base their discussion on facts and natural rules. This insistence on the veracity of engineering can't be altered even when opinions differ and disputes occur.

d. Constructiveness

As what is mentioned above, teachers' and students' constructiveness towards the master-apprentice institution and their involvement with the project design and practice are deciding factors of an effective and successful practice. As what is mentioned earlier, we can also carry out this institution by asking students to take part in different clubs, yet it is comparatively more difficult and against students' free will. On the other hand, other activities of the clubs might blur our focus of engineering as well. So, on second thoughts, we choose to offer project design and practice courses instead.

3. Nature of engineering education

The function of engineering itself is an application of theories, while that of education is to transmit knowledge to the new generations. Combined together, the nature of engineering education is the process of teachers' transmitting theories and related skills to students. It includes the following features:

a. Execution

The master-apprentice institution in engineering education is quite different from that in traditional service industry. Engineering itself is a highly complex and challenging field which demands precision, logic and veracity. As a master, the teacher must be familiar with the course-related skills, keep up with the latest technical development, and keep close contact with the industry so that he or she keeps informed of the tendency of upcoming development. In addition, the teacher's constructiveness decides whether he or she will be an efficient executioner.

b. Timing

At this stage of learning, students are quick to absorb knowledge and learn new skills. Through the master-apprentice institution, teachers can help students apply what they learn to their project design and practice. Those who take a more constructive attitude toward the whole process of learning are more likely to keep pace with the latest development and benefit more out of this institution.

c. Creativity

To stimulate students' motivation for learning and challenge their creativity, we assign our students to go on a project correlated with several fields. The requirement for such a project is much higher than what we usually expect of a term paper because we see this as a good opportunity for students to integrate what they learn in

different courses. For this reason, teachers must be very prudent when choosing topics for students in the beginning of the semester.

d. Quality Control

A successful engineering education must rely on continuous evaluation to pinpoint the problems within the existent institution and to initiate future changes. Teachers in the department can form an evaluation committee in charge of this significant task. The committee members listen to students' reports, raise questions about them, and allow students to defend for themselves. Afterwards, the committee scores their reports and offers suggestions for further improvement. The whole process will surely help us find out advantages and disadvantages of the current master-apprentice institution, which will offer valuable references for future improvement.

4. Design of the curriculum and implementing process

Since logic and veracity are two basic prerequisites for engineering education, we must adopt a prudent approach when we carry out this institution. First, we must choose suitable topics for students. Topics must be related with at least three subjects students take at school. They shouldn't be either too difficult or too simple. Students are free to work on either software or hardware. The financial support of the project comes from the industry, the subsidy from the school or partly from teachers and students themselves. Generally speaking, most of the financial support comes from the industry. Naturally, the less in number of student the teacher has to supervise, the better the teaching quality will be. However, in the current system, the ratio of teachers to students is too low, which will definitely influence the quality of engineering education. The foci of the curriculum design are the following aspects:

a. Autonomy: The master/advisor should respect students' autonomy and value their opinions and thoughts so that they can point the strong and weak points of students' ideas.
b. Independence: Since the master-apprentice institution is a student-oriented system, its aim is to cultivate students' independent thinking and improve their ability to solve problems. If we put too many constraints on them, we are going to deprive them of the chances of becoming independent professionals.
c. Sense of achievement: In our project design and practice, students have the opportunities of receiving adequate training and they do have a sense of achievement when they finish their project. On the other hand, this practice also provides teachers and critics with a good opportunity to observe whether this master-apprentice institution works in engineering education.

This study is based on my teaching experiences in the Department of Automatic Engineering of Da Yeh University. Our department offers a two-year technical training curriculum. Our students either come from admission through recommendation test or from joint entrance examination. Students from the former source tend to come from certain areas and be more independent, while the students from the examination are more average.

In carrying out the master-apprentice institution, we emphasize students' interests, autonomy and independence. In the beginning of their two-year curriculum, a curriculum committee will ask teachers in the department to submit topics and goals for their project design and practice courses. Then, two or three students with the same interest form a group and choose their own advisor. (Figure 1). As illustrated in Figure 2, the advisor goes through in-depth and detailed discussion with students to work out a practicable outline, which is often the most difficult part in engineering education. Once they have a clear outline, they can set their specific goals and schedules. At the stage of execution, the advisor, considering students' different theoretical background, instructs each of them to take courses which will enrich their understanding of related fields and enable them to apply the theory into practice. With a clearer sense of direction of their project, students now can choose to work either on software or hardware. Some possible topics on software may include the programming, the drawing of engineering, the application of software package. Topics on hardware may include the production of circuit boards, mechanical machining and the purchase of the standardized parts. During this period, the advisor and students should set and revise their schedule on a weekly basis and keep a check on the whole process. Questions posed by students should become topics of discussion between the advisor and students. Once a hardware or a software is done, it requires continuous testing and improving. A written report is also needed as a record of the whole process. Two-thirds of the budget comes form the advisor's research project sponsored by the industry, and the rest of it comes from the school's subsidy (two thousand dollars for each group) or the advisor and the students themselves. The ratio of students to advisors is 11:1. The whole department is divided into four or five project design and practices. To enhance the efficiency of the course, students are required to take one two-hour practice course at the second semester of their junior year and another similar course at the second semester of their senior year. The goal of the first semester is to set up the basic structure of each project design and practice while the goal of the second semester is to finish the whole project.

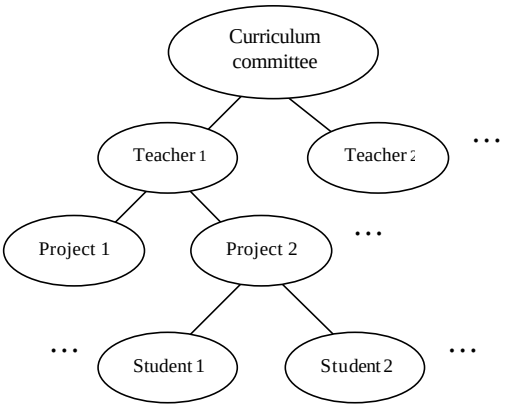

Figure 1 Pre-scheme period diagram

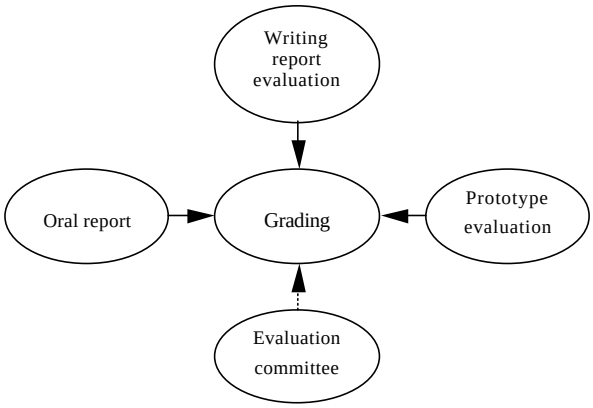

Figure 3 Evaluation period

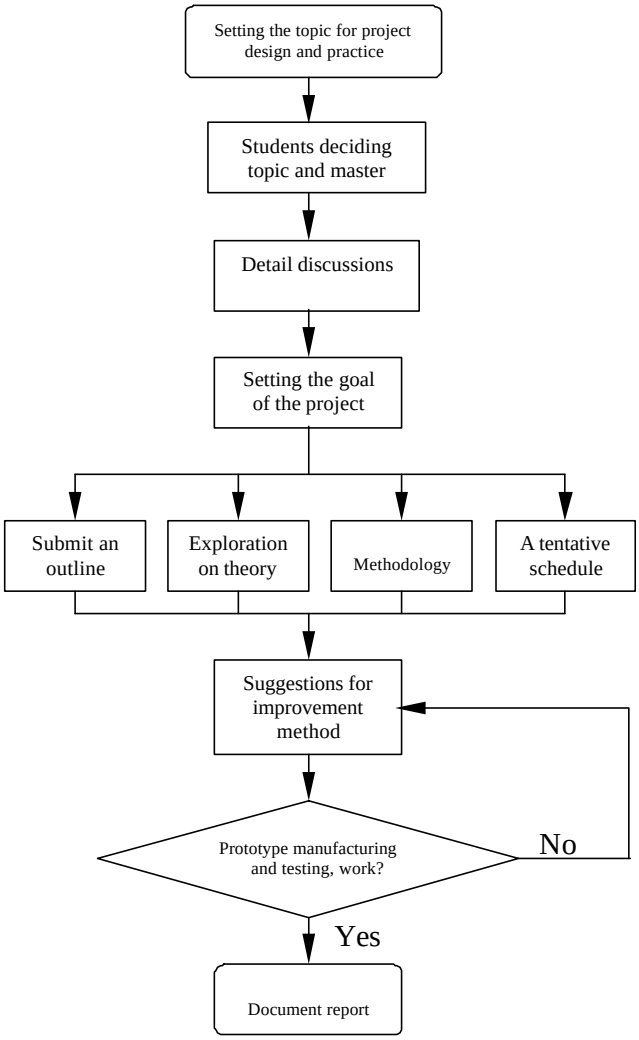

Figure 2 Execution period flow chart

This course is an ongoing program not to be interrupted by summer and winter vacations or the lapse of one semester in between. Teachers on average have to spend at least 12 hours discussing with students. To ensure the quality of this program, the department forms an evaluation committee to score students' performance, which will decide part of their final scores. The evaluation includes the following three parts (Figure 3):

a. Evaluation of reports: Students are required to write down the whole process of their research, including their approaches and results of experiments, in the form of a thesis, submit this document to their advisor for advice and then publish it as a book.
b. Oral presentation: By means of slides, projector or a documentary, students present the process and results of their research to the committee members. In return, teachers ask students questions to evaluate the validity of their results and the quality of their work.
c. Evaluation of model: Since the skill of manufacturing is one of the important items in engineering education, we must take a very serious attitude towards it. The best way to evaluate it is to put it on display.

One of the concrete examples of this study is "On the Controlling Servomotor by Motion Curve of the Simulated Cam" (figure 4)[1]. It covers courses including mechanical design, mechanical drawing, manufacturing process, automatic control, servo control, electronic circuit..etc. Applied skills used in this study include the method of servo motor controlling, mechanism design, Auto CAD, machining, interactive interface...etc. This is one of the perfect examples of the combination of theory and practice, software and hardware in engineering education concerning mechatronics.

Figure 4 On the Controlling Servomotor by Motion Curve of the Simulated Cam

5. Self-evaluation

After a few years' practice, the master-apprentice institution applied in our department comes to fruition. Students achieve their goals and have very positive responses toward this institution. However, owing to the low ratio of teachers to students and the complexity of the topics themselves, teachers in our department have a heavy teaching load. Students also have a hard time keeping up with both their other courses and the project design and practice, which demands their full attention and lots of time. Occasionally, they are forced to give up topics owing to the short of money. Therefore, if we can offer the course during winter and summer vacation instead or reduce the number of required credits for graduation, students and teachers will be less burdened and more devoted to the project design and practice, which will certainly contribute to a better quality education.

6. Conclusions and suggestions

The role of the teacher in our master-apprentice institution should be a model for their students in all aspects. Through a thorough process of training and a carefully designed curriculum, students who graduate from our department will be qualified and competent engineers in the future. Many successful examples have proved the effectiveness of the master-apprentice institution and strengthened our faith in it. Features of our department include:

a. We transform abstract theories into the concrete models. By this way, we set short-term but definite goals of our curriculum to replace traditionally long-term but vague goals.
b. By means of choosing suitable topics for students' projects, we make an integrated arrangement of the curriculum of engineering education.
c. We value students' autonomy and independence and strive to develop students' problem-solving skills.
d. The concrete results of students' projects include their model, written reports and final grades. Besides, the whole process of the project design and practice improves their professional skills and hence enhances their self-confidence.

7. References

[1]. H. Y. Cheng, "On the Controlling Servomotor by Motion Curve of the Simulated Cam", the Sixteenth National Conference on Mechanical Engineering, the Chinese Society of Mechanical Engineers, Vol. 2, pp. 172-179, Dec. 1999.