Construction of Experimental Teaching Based on the Training of Excellent Engineers—A Case Study of Process Parameter Measurement and Instrument

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Keywords: Innovation ability; experimental teaching; construction

Abstract. The process of experiment teaching is one of the important ways to cultivate students' innovation ability. Based on the analysis of existing problems of experimental teaching in order to cultivate excellent engineers, this article launched the construction of process parameter measurement and instrument course experiment teaching. Around the thought of engineering practice ability and innovation ability cultivation, many experimental teaching implementation methods is given such as the experimental units setting, designing experiment setting up, and construction of opening laboratory. Practice has proved that these measures consistent with excellent engineers training target, satisfied to student's engineering practice ability and innovation ability training requirements.

1. Introduction

Excellent engineer education and training project is a major step in the reform of the education in our country, which aims at cultivating and creating a large number of applied talents that not only has the ability of engineers, but also has a strong ability to innovate\cite{1}. The experimental teaching is one of the important ways to cultivate outstanding engineers. It has a strong advantage in cultivating students' engineering practice ability and innovation ability and has an irreplaceable role in theoretical teaching. The process of experiment teaching is one of the important ways to carry out quality education and cultivate students' innovation ability\cite{2}. Our university set up the excellent engineer education and training project practice pilot class in the automation major. Process parameter measurement and instrument is an important course for this class, so we have carried out a series of construction work on the experimental teaching of this course.

In the past teaching, we set up experimental teaching. But there are some problems in experimental teaching.

(1) The experimental content is too unilateral and procedural and lacks the systematic and hierarchical of experiment.

Before the experiment, the teacher arranges each experimental content, prepares the material in advance and debugs the equipment. In the experiment, the students complete the whole process of experiment according to the existing experimental instructions, the given equipment and experimental content within a limited time. With the help of experimental guidance, students do not think deeply on the experimental content, principles and experimental goals, so the students are not clear about the contents and knowledge principle of the experiment even though they finished the experiment. They feel that the concepts and conclusions are still more abstract.

(2) Demonstration and confirmatory experiments are more proportionate than comprehensive and designed experiments.

The experimental teaching content is a simple process of verifying certain theories or familiarizing with some basic experimental skills for students.

(3) Less experiment time

Excellent engineer education and training project has a total of 64 class hours but only arranges 8 hours for experiment. Students are in a passive position in the lab, and it is almost impossible to solve the problem in such a limited time.
The current experimental teaching is far away from the requirements of strengthening the training of students' engineering capacity and innovation ability in the excellent engineer education and training project. Although the experimental teaching schedule is set to meet the basic requirements of the experimental outline, the knowledge that students gain is not complete. It causes that the creative thinking of students can’t be exerted. So we have re-designed and implemented the experimental teaching of the process parameter measurement and instrument course.

2. The Construction of Experimental Teaching

2.1 Construction Ideas

Excellent engineer is the technical person with innovative ability which is also the basic characteristics that differ from other engineers[3]. We take excellent engineer as the training target and focus on cultivating students' innovative ability. Teaching ideas are shown below.

![Figure 1. The construction ideas of experimental schedule.](image)

2.2 Specific Implementation Methods

(1) The adjustment of experimental teaching time

Process parameter measurement and instrument class makes a lot of time adjustments, from the original 64 hours to 72 hours. The experimental teaching time is adjusted from the 8 hours to 32 hours; the proportion of the experimental teaching part in total hours is greatly improved.

(2) Reform of experimental teaching content and method

The teachers should encourage students to self-directed learning, design their own experiment, implement the experimental process independently, and carry out mutual discussion. They also should advocate for innovative research experiments.

For example, we have a thermocouple temperature measurement system experiment in the previous experimental teaching. This experiment is to let the students measure the temperature inside an electric furnace. But the experiment limits the use of thermocouple. It uses cold joint compensator for the thermocouple compensation and displays instrument using millivolt meter. Students constitute a temperature measurement system only one form in such circumstances.

Now the practice is that the teacher makes the basic requirements and the purpose of the experiment. The students explore a variety of technical means to complete the required tasks. These are not limited to the experimental methods, the experimental steps, and the experimental induction. Teachers give the task of measuring the temperature of the furnace and students can use different design programs to complete the task. For example, the students can use thermocouple as a temperature measurement element, they can also use thermal resistance as a temperature measurement element[5]. The value of the furnace temperature can be not only used simulate or digital meter to display, but also directly used the acquisition card with a computer screen to display. After students determining to their own experimental methods and steps, teachers provide experimental equipment for students to complete the experiment following their own ideas. Students can discuss the solution with teachers when they have problems in the experiment. They
learn theoretical knowledge according to their needs, from passive acceptance of knowledge to active seeking knowledge.

(3) The implementation of open experimental teaching

Open experimental teaching includes the opening of experimental content and the opening of experimental time[6]. Teachers are responsible for providing students with free space. The opening of the experiment time is to allow students to enter the laboratory before opening this course. The students can complete their own design goals and ideas in the learning process according to their own time.

For example, using the existing sensor laboratories, we can carry out open experimental teaching. A variety of sensors can be used on the sensor test bench of laboratory. The teacher puts forward the design task: designing an electronic weighing, weighing the quality of an object. The teacher checks the student's design according to the student's weighing data and let the students think about ways to reduce the error. This experiment needs for multiple experiments in the laboratory in order to get satisfactory results. Students can experiment in the lab according to their own time, increasing the flexibility of the student's experiment time.

(4) Construct and develop practice base, make full use of the existing resources of the university, increase students' understanding of the instrument.

The current practice is to organize students to visit the heat transfer station in university when the first class begins. The heat transfer station has installed the temperature, pressure, flow, level instrument, as shown in Fig. 2. Students take instrument photos, access to information to understand the working principle after class and make the PPT to communicate in the second class. In order to better demonstrate their visit results, students very carefully observe the instrument and access to information. The visit laid a good foundation for the following lessons. At the end of the course, students also visit again to deepen and enhance awareness.

![Figure 2. Photo of heat transfer station.](image)

(5) The reform of examination methods in experimental teaching

We establish a variety of experimental teaching assessment system, focusing on process experience, innovative thinking.

The experiments that have been done by many people, it takes a demonstration and reply to complete the assessment. For some design experiments, such as throttle flow meter design, it can take the method of classroom communication. The person who will communicate in the platform can be determined by drawing. Some experimental contents can be added to the course exam content and occupy a certain proportion in the total score. Novel design can be scored. These ways promote their experimental ability, innovative thinking by self-learning and independent research.

(6) Reform the experimental report written

Many students did not think deeply about the relationship between experimental design and theory after completing report. So we let students to draw the experimental line, record the experimental data, and analyze the experimental results. And the students need to spend a large space to write out which knowledge points are used in the experiment. Students have a deep understanding on the relationship between theory and practice through completing the experimental report.

3. The Effect of Experimental Teaching

Experimental teaching is important which can’t be replaced by the theory teaching. Students take part in science and technology innovation practice projects actively and achieved remarkable results. Three students of automation 1101 experimental class made a first prize in the second session of the Delta Cup - automation design competition. Students of automation 1201 experimental class (a total of 30 students) are more prominent. The comparison of winning numbers between automation 1201 experimental classes and automation other classes (190 people) in the United States in 2015 Mathematical modeling contest as shown in Table 1. The summary of the winning situation of the smart car race is shown in Table 2.

Table 1. Comparison of the winners’ number of the mathematical contest in the United States.

<table>
<thead>
<tr>
<th>Awards</th>
<th>Automation 1201 experimental class</th>
<th>Automation other classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>First prize</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Second prize</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 2. Winning statistics table of automation 1201 class in smart car competition.

<table>
<thead>
<tr>
<th>Awards</th>
<th>University level</th>
<th>North China level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of winners</td>
<td>First prize</td>
<td>Second prize</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

4. Conclusion

The reform of experimental teaching has a pivotal role in the quality of students' training[7]. Students' comprehensive and innovative ability has been improved. From 2011 to recruit engineering practice classes, the reform of experimental teaching has been implemented in the four grades. Practice has proved that teachers and students have benefited a lot. The employer is also very willing to receive the class of students. This shows only full understanding of excellence engineer education and training project, changing the experimental teaching concept, reforming the experimental content and methods, building an open laboratory, the students engineering ability and innovation ability can be promoted.

5. References


