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Research on the Reform of Experimental Teaching in Mechanical Engineering Testing Technology

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Abstract: *Mechanical engineering testing technology is a key and challenging course for mechanical majors. In terms of teaching, emphasis is placed on learning basic test knowledge. However, the experimental sections corresponding to practical ability, innovation ability, and hands-on ability are relatively weak. Further reform is needed for the teaching content and mode of course experiments. This article specifically analyzes the existing problems in experimental teaching, such as outdated experimental equipment, limited experimental teaching hours, disconnected experimental teaching content from engineering, single dominant experimental teaching mode, and unreasonable evaluation of experiment results. Then, specific reform methods are proposed to address these issues.*

Keywords: *Mechanical Engineering Testing Technology; Laboratory teaching; Reform*

Mechanical engineering testing technology is a comprehensive and practical course, which serves as the main course in the mechanical design, manufacturing, automation, vehicle engineering, and material forming and control engineering programs of our university. However, there are still some problems and deficiencies in experimental teaching, and further reforms are needed to improve the teaching content and mode of this course's experiments.

In addition, the outbreak of COVID-19 earlier restricted the development of offline experimental courses due to the pandemic. As a result, designing reasonable open experiments and constructing an appropriate laboratory opening system can provide a new way to solve the problem of insufficient lab time under similar emergencies while ensuring experiment hours and teaching effectiveness[1-2].

1. Current Problems

1.1 Aging of experimental table equipment and insufficient number of table sets

Mechanical and electrical equipment is severely aged due to numerous factors such as quality of domestic equipment, sensor characteristics, maintenance and management of experimental teachers. The incompatibility of module connections makes it difficult for students to achieve desired results during hands-on operation, which greatly troubles teachers' teaching and weakens students' enthusiasm.

Our college's measurement and control laboratory is a specialized laboratory established to provide experimental teaching for the "Mechanical Engineering Test Technology" course, which is mainly offered to students majoring in mechanical design, manufacturing, automation, vehicle engineering, and material control and engineering. The laboratory currently has 8 sets of measuring and controlling experimental tables, with an annual requirement of 1080 student hours for experimental teaching. If each group of two students uses one set of experimental table for experiments, it will take 34 batches of students to complete all the experiments. However, this does not include the fact that due to equipment aging, one or two groups of students are usually unable to use the equipment during one batch of experiments, resulting in a maximum of 3-4 students per group. This objectively leads to some students being unable to effectively participate in the experiments as they do not have hands-on experience. Without practical experience, they cannot truly understand the operating process and cannot effectively develop their hands-on ability, thus greatly reducing the actual teaching effect.

1.2 The number of experimental teaching hours is limited

In recent years, a large number of general education courses have been introduced, gradually reducing the hours of professional and experimental courses. As a result, the limited number of

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experimental hours has become even smaller, leading to a decline in the effectiveness of experimental teaching. Students find it difficult to deeply understand theoretical knowledge within the limited time, thus failing to achieve the purpose of experimental teaching. After introducing more general education courses, the teaching outline for "Mechanical Engineering Test Technology" was revised. The original course had 36 study hours and 6 experimental hours; after revising the outline, the course became 32 study hours and 4 experimental hours, with one comprehensive experiment reduced by 2 hours.

1.3 The dominant mode of experimental teaching is single

As mechanical engineering test technology is a cross-disciplinary subject, it involves a wide range of knowledge areas. Due to the limitations of experimental hours, experiments mainly serve as a validation of theoretical knowledge learned in class and cannot design experiments that reflect actual engineering projects. This means that students are reviewing theoretical knowledge learned in the classroom in the laboratory, rather than applying it to practical production practices[3].

Currently, experimental teaching is mainly led by teachers, with experiments conducted around pre-prepared experimental manuals. Students follow the instructions and complete the designated experiments, observing the results. However, this approach has its drawbacks. Students have no room for independent creativity, and cannot demonstrate their subjective initiative during the experiment process.

1.4 The evaluation of experimental results is not reasonable

The final evaluation of experimental results is mainly based on the preview, writing, and completion of the experimental report. The evaluation criteria are single and ambiguous, with little difference in student differentiation, and the report writing is merely formalistic. The experimental score accounts for 10% of the overall evaluation score, which is obtained by summing up the scores of two small experiments. Each small experiment's score is equivalent to the score of one test question, thus, students' enthusiasm for doing experiments in terms of total course assessment is not high. Most students simply copy the pre-experiment report assigned by the teacher without proper preparation. After the experiment, the teacher primarily grades based on the experimental results, giving the same score to each group, making it difficult to accurately evaluate each student.

2. Reform measures.

2.1 Configure an advanced comprehensive testing experimental platform

In the 2021 Central and Local Co-development Project, in order to address the issues of old and insufficient test equipment in the control and monitoring laboratory, 20 GSY-998 sensor experimental devices and 2 sets of GSY-3000 intelligent sensor integrated experimental platforms were purchased.

The GSY-998 sensor tester is composed of the casing, the head (sensor installation table), the display panel and the adjusting circuit panel (the sensor output unit, the sensor conversion amplification unit). The DC power and the oscillation signal board are installed in the casing. The sensor installation platform consists of two parallel cantilever beams with suspensions and a vibration table. The adjusting circuit panel includes the sensor output unit, the secondary power supply, the bridge, the differential amplifier, the capacitor converter, the voltage amplifier, the phase shifter, the phase sensitive detector, the charge amplifier, the low pass filter, the eddy current converter and so on.

By selecting the corresponding module, the most common sensors can be tested and applied, which include metal strain sensor, semiconductor strain sheet sensor, thermocouple (thermoelectric) sensor, differential transformer, electrical eddy current displacement sensor, Hall sensor, magnetoelectric sensor, piezoelectric acceleration sensor, capacitor sensor, pressure resistance pressure sensor, optical fiber sensor, junction temperature sensor of PN, thermal resistor, photoelectric speed sensor, smart sensor module terminal, wet-sensitive resistor, ultrasonic sensor, visual sensor detection, laser distance sensor and so on. More than 60 sets of experiments can be developed.

The experiments can be adjusted as follows:

The strain bridge experiments, including single-arm characteristic, half-bridge characteristic and full-bridge characteristic, and the comparson of the single-arm, half-bridge and full-bridge characteristics; students with spare time can also do the application of DC bridge - electronic balance

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experiment;

The application of common sensors and the measurement of common physical quantities, including pressure, vibration, displacement, velocity and other physical quantities.

2.2 Open-ended experimental design matching to the experimental platform

The GSY-998 sensor experimental device can be used to conduct experiments on metal foil strain sensors and equilibria performance, common sensor measurements, measurement of commonly used physical quantities (temperature, speed, vibration, displacement), as well as data acquisition systems for both static and dynamic measurements.

The GSY-3000 Internet of Things (IoT) intelligent sensor integrated experimental platform can offer a variety of experiments, including multi-sensor experiments based on the innovative platform for smart IoT systems,experiments, 4G networking experiments, and IoT experiments. Additionally, it can also provide innovative experiments such as manual control experiments based on the AI intelligent control experimental platform, smart control experiments, and facial recognition experiments.

2.3 The ideological and political practice, literature reading, and industry research reports

Combining the characteristics of the course and teaching content, guide students to have good learning ethics while studying this course, with lofty aspirations, down-to-earth attitude, and adherence to discipline, so that the diligent learning becomes the driving force for youth to soar; examine students' core values; and assign theme literature reading and industry research tasks related to the development of new technologies in measuring and controlling sensors, submit reading reports, let students experience the necessity and importance of mastering core technologies, and cultivate students' spirit of "self-reliance and hard work".

2.4 Building an Open System for Control and Measurement Laboratory

The reservation platform in the open system of the control and measurement laboratory is used as shown in the figure 1, mainly composed of four parts: equipment query, experimental project query, laboratory reservation, and laboratory management.

Students can access information about the equipment available in the control and measurement laboratory, including function items, operation manuals, and loan status. Based on this information, they can make a reservation as needed.

Students can also check the open experimental projects available in the control and measurement laboratory, including the content of the experiment, operation steps, and theoretical results presentation.

Students need to systematically study the laboratory safety management system before they can make a reservation.

After students make a reservation and the project is open, the course teacher or laboratory assistant will review it and grant permission to enter the laboratory for experiments only at the designated time.

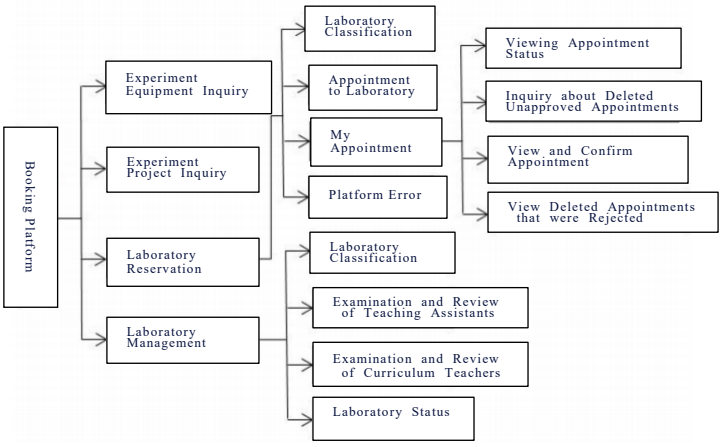

Figure 1: Schematic diagram of appointment platform

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2.5 Unreasonable evaluation of experimental results

In the process of experimental assessment, it is emphasized to evaluate the process and ability. The learning outcomes of students are taken as the guidance, and multiple evaluation links are set according to the teaching objectives of the course. The evaluation is carried out throughout the entire experimental process. At the same time, specific evaluation criteria are developed for each assessment point to form a comprehensive and process-oriented assessment method centered on ability. Taking the integrated experiment that must be done and optional experiment as an example, the main evaluation links include experimental preview, operation, report writing, summary and defense, and peer evaluation. Multiple aspects of evaluation content, criteria, and weighting are designed from various perspectives. Through comprehensive evaluation of each experimental link, the rationality and fairness of the assessment results are ensured[4].

3. Conclusion

This article summarizes some problems in the experimental teaching of the mechanical engineering testing technology course and provides corresponding reform measures. In addition, in practical teaching, the proportion of theoretical lectures, micro-lectures, classroom experiments, and open experiments should be controlled. According to the students' acceptance, the number of open experiment projects should be appropriately increased to improve students' self-learning ability and innovation ability, further promote the reform and construction of the mechanical engineering testing technology course, and ultimately achieve the goal of improving the quality and efficiency of experimental teaching.

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