Teaching reform and exploration of the course *Sensor Technology*

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ABSTRACT: In light of the characteristics of the traditional curriculum teaching of *Sensor Technology*, an exploration of the course was conducted to determine how to alter its teaching mode with the aim of cultivating the practical abilities of students. The characteristics and objectives of the conventional course teaching were analysed, based on which some measures to reform the course were raised, including updating teaching content and adjusting the experimental teaching methods. At the same time, the performance appraisal methods were reformed to improve the students' enthusiasm. As a result of these changes, students can be equipped with the capacity to complete a system design independently and change their study attitude from passive to autonomous learning. Hence, the students' interest in study is increased and the teaching effect is improved.

INTRODUCTION

Sensor Technology is a compulsory course for students majoring in engineering programmes, such as automation, measurement, and control technology and instrumentation. It plays an important role in the entire professional curriculum. This course is not only a comprehensive application of the taught course and a foundation for students' future courses, but it also impacts on their future career development. Especially in the past few years, with the rapid development of micro-electronic technology and industrial automation, industries' dependency on sensors has increased gradually and, in turn, increased the requirement for professional talents in automatic control and intelligent sensor detection. Therefore, the application level skills of sensor technology has become an important criterion by which to evaluate the professional skills of engineering students [1][2].

Many companies require students to have a capability in applying sensor technology and to be able to develop a detection system before being employed by the company. Since *Sensor Technology* is the main course developing these skills, it increases the pressure on the teachers' teaching and the students' study. However, the contents of this course are broad and lack meaning and continuity. Besides, its strong practical nature makes it hard to learn and boring for students, thus, creating a huge teaching and learning difficulty [3][4]. Doing a good job in teaching this course seriously challenges teachers' knowledge, ability and skills.

THE CHARACTERISTICS OF TRADITIONAL SENSOR COURSE TEACHING

According to the course outline and teaching objectives, *Sensor Technology* contains 72 credit hours, 60 of which are theory and the rest experiments. The teaching contents include the structure, measuring circuits, performance characteristics and applications of various sensors. It involves not only the various subject fields, such as electricity, optics, magnetics, electronics, semi-conductor technology and information processing, but also the principles of automatic control, materials technology and the sensors used in industry [5]. The content of the traditional *Sensor Technology* course is shown in Figure 1. In conclusion, as a comprehensive professional course, *Sensor Technology* has the strong practical and application characteristics, but, as mentioned above, its contents are very broad and lack meaning and continuity.

In traditional teaching, importance is attached to the explanation of various sensor principles and measuring circuits with classroom teaching dominant. In addition, there are replication experiments to verify the principles and usage of various sensors. This approach has significant shortcomings. Additionally, with the rapid development of new materials technology, micro-electronic technology and computer technology, new sensors keep appearing. For example, optical fibre sensors, solid-state image sensors, infrared sensors, chemical sensors and biological sensors were recently

launched and are used widely [6]. However, the teaching mainly addresses the *typical* sensor. Scientific and technological advancement has brought many new problems and requirements for sensors used in signal detection.

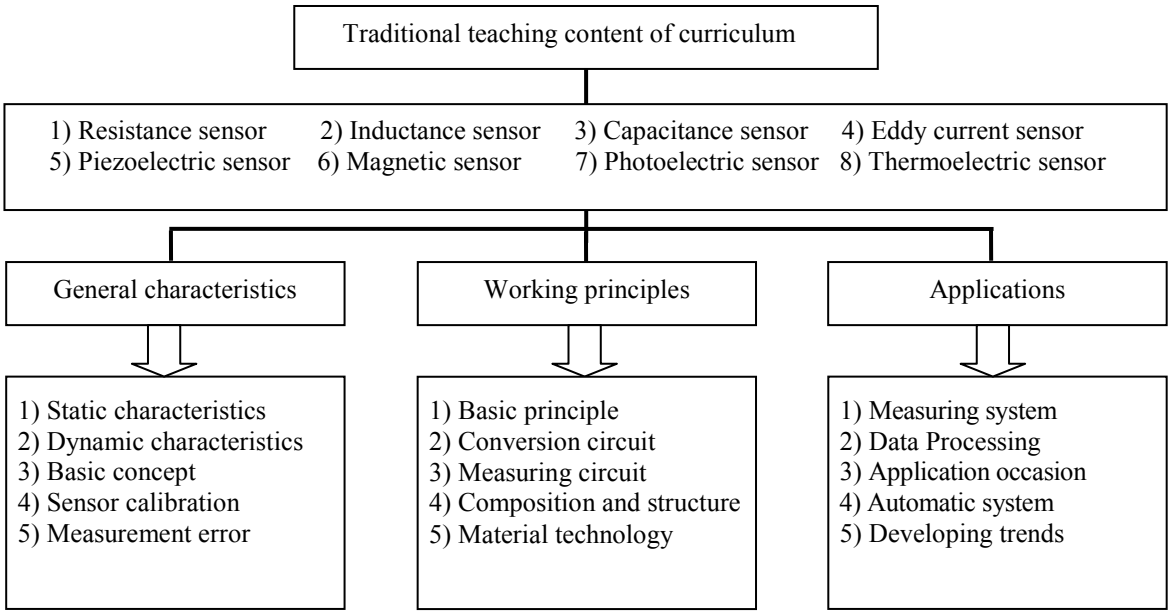


Figure 1: The traditional teaching framework of *Sensor Technology*.

THE IMPLEMENTATION PLAN FOR COURSE REFORM

In order to solve the above problems while meeting the objectives of the *Sensor Technology* course, the guiding thought for course reform was to pay attention to both the theory and practice and develop quality students with comprehensive engineering skills [7]. Teachers should attach importance to fostering the students' engineering ability and awareness.

The theory teaching reforms were aimed at updating content with new teaching material and improving the teaching methods. This should then increase the students' interest in learning. The hope was to deepen the students' understanding of the theory, while reinforcing their initiative to study by researching the use of multi-media and project-based teaching. Hence, it was expected to introduce problems into the theory and to solve problems with the theory. The practical teaching cultivates the practical hands-on ability of students and includes experimental selection and design, and also the selection and testing procedures for the sensors. The intention was to integrate production practice with scientific research experience and, hence, strengthen students' interest in learning. To enhance the students' initiative to learn, the appraisal of students' was reviewed. There are three components to the appraisal: final examination, daily performance and practical projects. The specific reform contents can be seen in Figure 2.

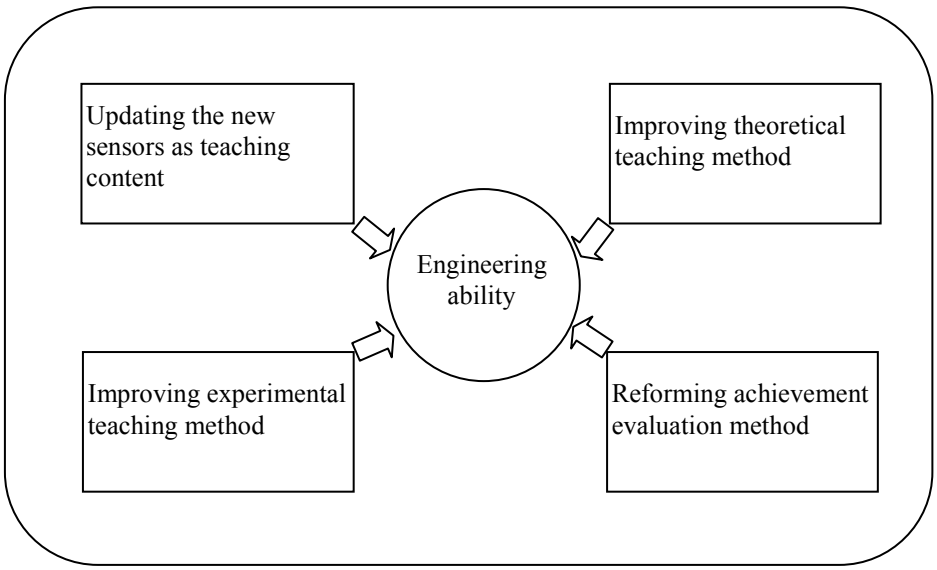


Figure 2: The content of curriculum reform.

Adding New Sensors in the Teaching Contents

The students have shown great enthusiasm for the newly developed sensors. However, hardly any new updates have been made to the teaching materials. To solve this problem, the students' knowledge will be enhanced by including a lecture covering the development of sensors after the basic outlines have been covered. This should update the students' knowledge of the dynamics of sensor development. In addition, teachers will undertake research and have in-depth discussions to learn about corporate opinions. Corporate leaders will be invited to participate in the development of teaching materials; hence, combining the developments in the subject with market requirements.

According to the new requirements for quality engineering education, the research team is expected to clarify their thoughts, reach a consensus and modify the teaching outline and contents. This modification reduces the purely theoretical design of the traditional sensors covered in the course and adds teaching content covering, such areas as intelligent sensors, newly integrated sensors, together with practical applications of the sensors.

For example, in the previous teaching, some students asked questions about biological sensors; therefore, bio-sensors have been added to the course content in response to the students' needs. As indicated in Figure 3, content has been added for ultra-sonic wave, bio-chemical and optical fibre sensors. Their mechanisms and applications in modern industry are explained, thereby, provoking the students' interest and laying the foundation for their future research on sensors.

Figure 3: Examples of new sensors.

Improving the Theoretical Teaching Method

1. Adopt project-based teaching. Project teaching involves small tasks for teaching content that the students finish independently. This produces good teaching results, as well as integrating theoretical knowledge and skills. A number of different projects are used in the teaching and they are mainly engineering projects. The projects mainly integrate equipment in the newly built sensor laboratory and different projects may be independent or related. Project teaching of the sensor course greatly reduces the gap between theory and practice and improves the student's ability to solve practical problems.

For example, when teaching content about the thermo-electric temperature sensor, a small project was designed using an AT89S51 single-chip and temperature sensor to make a temperature measuring system. The system is required to display the measured data, is set by pressing buttons and has an alarm function. In setting the theoretical foundation, the students are taught theoretical knowledge about the structure, design and contents of the AT89S51 single-chip and I/O set-up. This project has the common functions of a detection system, including input, output and data processing. It extends the scope of the students' knowledge and improves their learning. The basic framework of this small project can be seen in Figure 4.

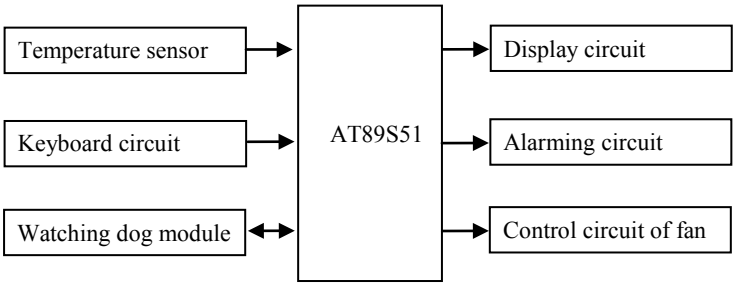
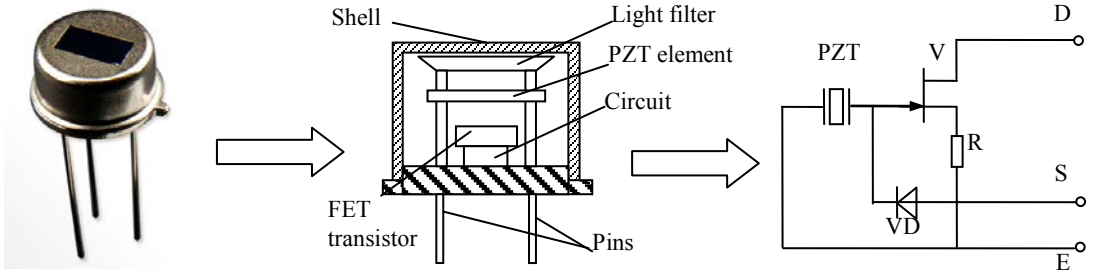


Figure 4: Framework of a small project for detecting temperature.

2. Enhance traditional teaching using multi-media techniques. Multi-media and traditional teaching methods were integrated to make multi-media pictures and animations of the structure and appearance of sensors and schematic

circuit diagrams. Traditional blackboard teaching was used to explain the basic principles of sensors, as well as to cover complicated formulas. Demonstrating the various structures and working principles of sensors using Flash software can deepen the students' understanding of the theory. Besides, a multi-media player can be used to play videos about the role that sensors play in various areas of life, to make the students aware of the extensive applications that sensors have in various fields of society. At the beginning of every class, the working process of a sensor will be displayed. Then, the sensor will be *torn down* using the instructor's circuit diagram to present the internal structure. The sensor will, then, be reassembled and the working principles analysed theoretically. The tear-down and reassemble processes left a deep impression on the students, enabling them to understand the relevant knowledge about sensors. After the demonstration, the teachers pose questions tailored to the characteristics of the sensor and lead the students in discussing the fields the sensor can be used in. The students learn study-skills by developing answers. This question-answer process changes the teachers' role, from teaching to instructing.

An example is indicated in Figure 5. The teacher shows the pyro-electric sensor to the students, analyses its structure and gets the students to learn about the internal circuit of the sensor. Under the instruction of the teacher, the students show good initiative leading to good teaching.



a) Physical picture of sensor b) Structure of sensor c) Internal circuit

Figure 5: Route of pyro-electric sensor image-based teaching.

Improving the Experimental Teaching Method

Experimental teaching on the *Sensor Technology* course was investigated. The objective of experimental teaching is to cultivate basic and comprehensive abilities and equip the students with an awareness of design modularisation. The practical teaching topics include basic principles, basic electronic components and basic functions. Handouts need to be compiled according to the experiment and, hence, develop the content of the experimental teaching system (seen in Figure 6). This consisted of modules for basic, innovative and applied-engineering experiments. Experimental conditions are integrated to reduce the teaching difficulty and to target the teaching.

Some small models were made by integrating the undergraduate practical innovation training plan and the course design. One or more large comprehensive project(s) were selected as the main vehicle to train the students, in a professional occupation-oriented way, with the design and production of a real sensor and detection system as the basis for the project requiring them to integrate the components and organise the contents.

For example, a resistance strain gauge was used to design a digital electronic weigher and to integrate single-chip knowledge to design a multi-channel temperature and moisture detection system. This deepens the students' understanding of the applications of the sensors learnt in the classroom.

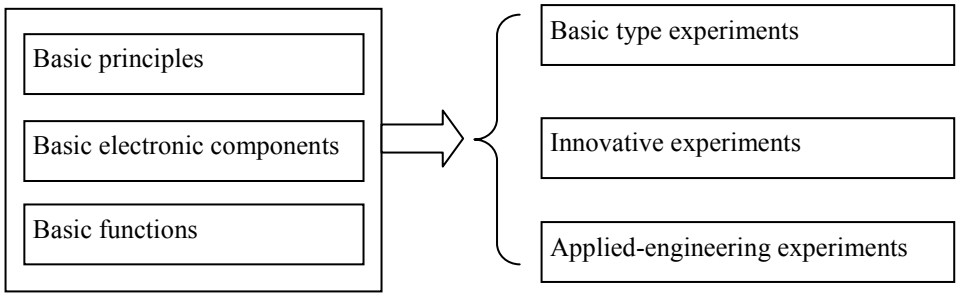


Figure 6: The basic framework of experimental design.

Changing the Scores Appraisal Methods

Evaluation is an extremely critical link in the course teaching reform. In traditional teaching, the students' final scores are the scores they get in the final examination. This is not the best way to cultivate applied talents. Therefore, in this reform, the students' scores are made up of three parts: the final examination scores, the daily performance and the experimental projects. Given the fact that this course has strong applicability, the ratio of the final examination is reduced to 50%, with more importance attached to the student's mastery of the basic content and flexible application of the learnt knowledge. The daily performance includes attendance and assignments (20% of the total), and increases attendance and improves their attentiveness.

The market research and project practice make up 30%, stimulating the students to proactively integrate theory with practical applications. This appraisal method changes the single examination appraisal method and is a good way to mobilise the students' learning and get them involved in the exploration of engineering practice. Therefore, the students can realise their own potential by their own efforts. This appraisal method is similar to the evaluation method that companies use in China. In practice, this teaching reform increases the students' interest and cultivates their quality in areas, such as practical ability, innovation and teamwork.

CONCLUSIONS

Sensor Technology is a comprehensive course with strong practical characteristics, but which is difficult for the teachers and students. By considering society's requirements for high-quality talents, the authors of this article have analysed the course and suggested corresponding reforms to the teaching content, methods and approaches. There is a dilution of theory and an improvement in the practical aspects of the course. This produces the advantage of carrying out employment-oriented teaching with the integration of theory and practice. The reforms are popular with the students and have resulted in better teaching. Later, textbooks will be compiled and students will be provided with solid foundation knowledge and strong hands-on skills to participate in sensor programmes and to lay a good foundation for fostering the innovative ability in students.

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