Construction Thinking and Practice of "Sensor Technology" Course Chain

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Abstract. The sensor technology plays an increasingly important role in recent years. Based on the comprehension of sensor technology, as well as the research and practice of sensor teaching, the author has established a systematical sensor technology course chain in Beihang University to meet the diverse needs of undergraduates and postgraduates with different majors and grades. The course chain consists of the general course "Approach Sensors" for freshmen and sophomores, the major basic course "Sensor Technology and Application" for juniors, the core general course “Resonant Sensors” for juniors and seniors, and the degree course “Advanced Sensor Technology” for postgraduates. This sensor technology course chain is actually in accordance with the four levels: academic enlightenment, academic standard, academic expertise, and academic improvement. The teaching practice in recent years shows a good effect, which aims to build an optimized integrated curriculum system for the instrument discipline, to improve the quality of teaching and education, and to provide a certain reference for the construction of "Double First-Class".

Introduction

Information technology is very active in the development of science and technology today and plays an important role in social progress and economic development. Information acquisition, which relates to measurement technology or sensor technology, is the front end of information technology and is in a very important position. If there is no sensor to measure the original parameters accurately, reliably, online and in real time, no matter how powerful the function of information transmission and information processing is, it has no practical significance. Since the acquisition of raw data or information is inseparable from any field, sensor technology is important and necessary in any field; mastering sensor technology and rationally applying sensors is a basic literacy required by engineers and technicians in almost all technical fields.

Since the beginning of the 1950s, Beihang University has attached great importance to the development of courses related to instrumentation, measurement technology and sensors. For the third-year undergraduate major in aircraft instrumentation (now "Measurement and Control Technology and Instrumentation"), a core professional course of "Flight Instrumentation" closely related to sensor technology was opened. In the early 1980s, it was changed to "Sensor Principle", and it was renamed "Sensor Technology and Application" in the late 1990s. In terms of training graduate students, in the mid-1980s, degree course in "Advanced Sensor Technology and Application" were offered to graduate students who are majoring in “Aircraft Instrumentation and Sensors” (now the subject of “Measurement Technology and Instrumentation”). At the beginning of the 21st century, they were identified as “Instrument Science and Technical First-degree Subject Degree Courses”. Recently, experts from the Academic Degrees Evaluation Committee of the Academic Degrees Committee of the State Council decided to set up a graduate core course "New Sensing Technology" in the first-level discipline of Instrument Science and Technology. The author is the main drafter of this core course guide. In short, the core professional course "Sensor Technology and Application" for
undergraduate students plays an important role in the major “Measurement and Control Technology and Instrument Specialty”, so does the postgraduate degree course "Advanced Sensor Technology and Application" in the construction of the first-level discipline of instrument science and technology and the process of training students. After graduating in 1990 with a doctoral degree, the author joined the construction and classroom teaching of these two courses. With the guidance and help of senior professors, the author gradually took over responsibility for these two courses. After years of development, these two courses have formed certain advantages in the field of instrumentation and sensor technology and have also made a good impact. The core course “Sensor Technology and Application” for undergraduate students was awarded National Excellent Course in 2010; It was among the first batch National quality resources sharing courses to be built in 2012 and was one of the courses to receive this title in 2016. The postgraduate degree course "New Sensing Technology and Application" was rated as the excellent postgraduate course of Beihang University in 2011. In 2015, it was one of the courses to be built as MOOC project. In short, the "sensor" course of Beihang University has become a high-quality educational and teaching resource for schools. However, the curriculum still needs to keep pace with the times, constantly be improved, meet the overall development requirements of the society, keep up with the pace of scientific and technological development, and especially the benefit of students needs to be expanded.

For this reason, in 2015, the author put forward a teaching reform plan for building a "sensor technology" course chain at the Beihang Institute of Instrument Science and Optoelectronic Engineering. After several years of experience, as the course builder, leader and chief course instructor, the author has been consolidating the teaching effect of these two courses. Meanwhile, the author opened a core general (training) course “Resonant Sensors” and a general courses "Approach Sensors”. The author has preliminarily constructed a "Sensor Technology" course chain consists of four "Sensor" courses at Beihang University.

Construction Thinking and Main Content

Based on the classroom teaching experience in the past 30 years, theoretical research, experimental research, and engineering practice in sensor technology, the author proposed the basic ideas of constructing the “Sensor Technology” course chain in Beihang University. To meet the different needs of undergraduates with different majors, different grades, and different demand of studying "Sensor Technology" from postgraduates, the course chain consists of the general course “Approach Sensors” which is positioned as “Academic Enlightenment”, the major basic course “Sensor Technology and Applications” which is positioned as “Academic Standard”, the elective course “Resonant Sensor” which is positioned as “Academic Expertise” and the degree course “Advanced Sensor Technology” which is positioned as “Academic Improvement”. The construction and development process of relatively mature "Sensor Technology and Applications" and "Advanced Sensor Technology and Applications" ("Advanced Sensor Technology") have already introduced before. Here, we will mainly introduce the newly opened courses “Approach Sensor” and “Resonant Sensors”.

The general course "Approach Sensors" was opened on the Shahe Campus, mainly for freshmen. Its purpose is to make students having opportunity to learn basic knowledge about sensors as soon as they enter Beihang University. By explanations of teachers, face-to-face communication, and discussion with teacher, we share these freshmen with the important academic achievements made by Beihang University in the field of sensing technology, make them understand the important contribution of Beihang University to national demands of sensor technology, and make them know the important role of sensor technology in the rapid development of information technology. We try to stimulate their interest in sensor technology and its hot research topics by using some typical cases of "sensor technology" in the context of aerospace applications. This can lay the foundation for their study and further research in related disciplines, including the major of Measurement and control technology and instrument, the major of Instrument Science and Technology. At the same time, it guides students to establish a correct academic outlook and scientific methodology, then provides a
reference for lower grade undergraduates to form scientific academic research methods and correct academic ethics.

Table 1. Basic information of "Sensor Technology" course chain.

| Course name                      | Approach sensor | Sensor technology and Application | Resonant sensor | New sensing technology               |
|---------------------------------|-----------------|-----------------------------------|-----------------|--------------------------------------|
| Course nature                   | General courses | Major compulsory course           | Core general (Research) course | Core course of Instrument Science and technology |
| Course orientation              | Academic enlightenment | Academic attainment | Academic Specialties | Academic improvement |
| Object students                 | Freshmen first, sophomores second | Junior students of our major are first, other majors second | Junior and senior undergraduates, our major is first, other majors second | Postgraduate of our major are first, other majors second |
| Total teaching hours            | 16              | 48                                | 32              | 32                                   |
| Teaching model                  | Teacher-centered | Teacher-centered | Student-centered | Teachers and students discussing together |
| Semester                        | Autumn, Spring  | Autumn                            | Autumn, Spring  | Autumn                              |
| Teaching rounds                 | 4               | 29                                | 5               | 28                                   |

The core general (training) course "Resonant Sensors" is set up on Xueyuan Road Campus, and it is mainly for undergraduates who have passed the professional standard course "Sensor Technology and Application". Its object students are those who are really interested in sensor technology based on the principle of resonance. In this course, they are separated as the form of group. In this way, they can think independently and do further study about certain questions in Resonant Sensor Technology and form the stage research results with some new ideas. It should be noted that the author has been engaged in basic theoretical, experimental, and applied research on resonant sensors since he received the guidance from Professor Liu Guangyu in 1984. He has accumulated rich academic research experience and produced certain research results. As the first finisher, the author won a second prize for national scientific and technological progress in 2008 and a second prize for national technological invention in 2013, both of which were generated during the research of resonant sensor technology. Resonant sensing technology has become the academic direction of the author's expertise and a distinctive and advantageous academic direction of the first-level discipline of Beihang Instrument Science and Technology. The author's experience in this research direction can be transferred to teaching in an orderly manner to form a weighted training course, which can allow students to directly contact the academic frontier of resonant sensors and share the scientific research results accumulated by the author. It also enables students to carry out scientific research independently, that is, to find the core problems that need to be solved in scientific research, analyze the key factors, find the correct solutions, get the best results under certain constraints, and provide a good studying atmosphere and training environment.

Several rounds of teaching have been carried out, which shows that the new two general courses have achieved positive teaching results and have been fully affirmed and praised by students. The sensor technology course chain composed of four courses has played a better role in each course.
Table 1 lists the basic information of four sensor technology courses with the author as the principal and the lecturer. It includes Course name, Course nature, Course orientation, Object students, Total teaching hours, Teaching model, Semester, Teaching rounds, etc.

These four courses are not only related but also independent. Among them, "Sensor Technology and Application" course, as a national top-quality course and national top-quality resource sharing course, is the core course of measurement and control technology and instrument major carried by School of Instrumentation and Optoelectronic Engineering in Beihang University, the core of the course chain, and the most important task of education and teaching undertaken by the author for many years.

The course chain is mainly for undergraduate courses, covering the whole process of undergraduate training. The new general course "Approach Sensors" and the core general course (study course) "Resonant sensors" are offered in the fall semester and spring semester, which is convenient for students to choose according to their own learning interests and time arrangement.

Future Work

The first is to further summarize the experience in the construction of sensor technology course chain, optimize the teaching content, teaching model and teaching process of the four courses, and constantly improve the teaching quality of the courses, so that students can have a better learning experience.

The second is to expand the content of the sensor technology course chain orderly based on the open mind. In the four courses of the current sensor technology course chain, the author is the direct person in charge and the main teacher. Our teaching team, focusing on the "special" content of sensor technology, combined with the academic expertise of young and middle-aged teachers, provides general courses for freshmen and sophomores, and core general (Research) courses for juniors and seniors. The Course that have been included in the future teaching plan include: MEMS and Micro-Nano Sensor, Sensor Network and Internet of Things, Medical Ultrasound Imaging Sensing Technology, EEG Signal Perception and Processing, etc.

The third is to promote the experience in the construction of sensor technology course chain. Around the Error Theory, Signal Processing, Measurement and Control System, we also build the corresponding curriculum chain in the four levels of "academic enlightenment, academic standard, academic expertise, and academic improvement", optimize the integrated curriculum system for the instrument discipline, to improve the quality and efficiency of curriculum teaching resources.

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