An Emerging Engineering Education-Oriented University–Industry Cooperative Practical Teaching Model for Electrical and Information Engineers

He Wen, Zhaosheng Teng, Jing Zhang, Feng Wang, and Zhikang Shuai

Abstract—The subjects of electrical and information bear an important task of transporting high level engineers to the electrical measurement and instrumentation industry. It is of great significance to build a practical project that reflects the latest development of the electrical measurement and instrumentation industry and technology. It is also an important part of the new engineering construction and helps to improve the theoretical level and practical ability of the electrical and information engineers. Combined with the training needs of electrical information professionals in China’s electrical measurement and instrumentation industry, this paper explores the design and management ideas of joint electricity measurement practice projects for school-enterprise-oriented engineers trained by electrical and information engineers, and provides reference for relevant teaching reform.

Index Terms—Emerging engineering education, subjects of electrical and information, engineer, practice projects, personnel training.

I. INTRODUCTION

Emerging engineering education (3E) requires institutions of higher education to expand the education reform of engineering professionals, take advantage of the close relationships between institutions and industries, become oriented to the current and future needs of industrial development, and expand the content and key development areas of engineering programs to vigorously train professionals who are involved in engineering technological and industrial innovations [1]-[3]. Today, 3E-oriented practical teaching has become a focal area in the education reform of electrical and information engineering (EIE) disciplines.

Internships for engineering students have always been a headache for the engineering education community [4], [5]. Businesses feel that students in school are unable to do their jobs, which will not only delay time, but also consume raw materials. The cost of training is high, and the average enterprise cannot afford it. The students believe that the frontline production is complex and it is difficult to complete the actual operation safely and in a standardized manner [6]-[8]. In this way, the very important production internships for engineering students basically become ‘walking through’ to visit the production line [9], [10].

Hunan University offers four EIE majors, namely, electrical engineering and automation, electronic information engineering, automation, and electrical and information technology and equipment, with the aim of training advanced engineering and technological professionals in the equipment design and manufacture, technological development, application research and operations management areas of the EIE field. Therefore, addressing the problems of inadequate practical training and the disconnection between education and industry has become the key to ensuring that 3E training model reform satisfies relevant industrial development requirements.

In this paper, based on the characteristics of scientific research and teaching at the College of EIE of Hunan University, the demand of the electrical measurement and instrumentation (EMI) industry for system analysis, design, operation and research and development professionals in the forefront of production is analyzed, a 3E-oriented university–industry cooperative practical teaching model for EIE professionals is explored, and university–industry cooperative practicum projects for undergraduate students are designed with the aim of providing a reference for reforming the training plans of relevant specialties.

II. DEMAND FOR EMI INDUSTRY PROFESSIONALS IN THE 3E BACKGROUND

A. 3E and EMI Industry

China’s emerging engineering education (3E) construction and action guidelines (“Tianda Action”) clearly state the need to update and reform traditional disciplines and specialties, serve the transformation and upgrade of traditional industries, develop toward the middle and high ends of the value chain, provide an impetus to combine existing engineering disciplines and the integration of engineering disciplines and other disciplines, extend applied science disciplines to engineering disciplines, and cultivate and form new interdisciplinary specialties.

Electrical measurement and instrumentation (EMI) is an engineering and technological field that studies and implements various types of static and dynamic, direct or indirect electromagnetic parameters to measure and control instruments or systems. The EMI industry is a typical industry with an integration of electrical, automation, instrumentation and electronic disciplines. After more than 50 years of development, industrial clusters that encompass a complete range of disciplines with a relatively high scientific research capacity have formed in the EMI industry in China,
which primarily includes fields that develop and manufacture
electrical safety inspection and analysis devices for power
distribution systems, power supply units, electrical energy
meters (EEMs), electromagnetic parameter measurement
instruments, electromagnetic parameter analysis and
recording devices, standard and calibration devices,
automatic meter reading systems (meterless), electrical load
management systems, measuring range extending devices,
electric power automation instruments and systems,
non-electricity electrical measuring instruments and devices
and other electrical instruments and products. Currently, the
EMI industry in China has more than 700 enterprises that are
larger than the designated size, with a production and sale
capacity that exceeds 200 million pieces of equipment and a
total industrial output value of more than 30 billion yuan. The
EMI industry in China is ranked first in the world in terms of
production and sales capacity for EEMs and portable digital
multimeters. In addition, the EMI industry in China has
proprietary intellectual property rights for the majority of
products and has one of the highest domestic production rates
in China. Currently, the EMI industry in China has an export
rate greater than 15% and very high international
competitiveness.

Introducing the latest industrial and technological
developments and professional training requirements of the
EMI industry in the courses for electrical and information
engineering (EIE) undergraduate students of Hunan
University and establishing new practicum project resources
to help students “get through the last mile of education” are
important measures for the conscientious implementation of
3E reformation.

B. Requirements of the EMI Industry for EIE
Professionals

The training of professionals has vital importance in the
development of an industry, such as the EMI industry. The
development of the EMI industry requires the continuous
integration of new professionals with a continuous drive for
innovative development. In less than ten years, the scale of
training of professionals in the EMI industry has nearly
quadrupled, and both student recruitment and graduate
employment have been successful. However, the number of
trained professionals remains significantly less than the
workforce that is required for the development of the EMI
industry.

With development toward virtual, networked and
intelligent electrical measurement instruments and systems,
interdisciplinarity will become more common, which
establishes new requirements for the current training model
for EIE professionals in the EMI industry in China.

1) EMI industry-oriented engineering competence:
   Students should be trained to become familiar with the
   policies and regulations related to the EMI industry,
   develop excellent professional ethics and psychological
   qualities, understand relevant enterprises in the EMI
   industry in terms of culture, business processes, function
   division and employee professionalism and nurture the
   spirit to assiduously learn and passionately work.

2) EMI industry-oriented practical engineering ability:
   Students should be trained to become familiar with the
   technical standards related to the EMI industry,
   systematically master basic theoretical knowledge, basic
   specialty knowledge and specialty knowledge of the EIE
   field and develop the ability to develop, design and
   manufacture instruments and systems and perform
   technological transformation.

3) EMI industry-oriented engineering innovation ability.
   Students should be trained to understand the
development trend toward virtual, networked and
intelligent instruments and systems, become familiar
with new materials, technologies and equipment, as well
as advanced manufacturing systems, disciplinary
frontiers and development trends in the EMI industry,
develop an innovative mindset and the initial ability to
innovatively apply emergent technologies or
technologies from other industries to address practical
engineering problems and master their language and
written communication capabilities.

III. DESIGN OF 3E-ORIENTED UNIVERSITY–INDUSTRY
   COOPERATIVE PRACTICUM PROJECTS

A. EIE Practicum Projects Oriented to the EMI Industry

Based on an in-depth integration of Hunan University and
the EMI industry, the practical training of EIE students of
Hunan University will consist of two stages, namely, the
on-campus stage and the enterprise stage. By utilizing
complementary advantageous resources of the university and
the industry, innovative practicum bases will be established
both on campus and off campus. Hunan University–industry
cooperative practicum projects for EIE engineers are
designed as follows:

1) A systematic method will be employed to conduct all
electrical measuring practicum projects in specific
electrical measuring systems.

2) The content of the practicum projects is arranged to
ensure gradual progression from the elementary to the
profound, from the classical to the modern, and from
simulation to practicum.

3) The concept of combination of theory and practicum
entails practicum teaching, which reflects the content of
science-dominated engineering.

4) All practicum projects have an actual engineering
background and reflect the principle of industrialization.

5) All practicum projects are typical and representative and
can help students understand all aspects of the EMI
industry utilizing experience gained at key points.

EIE students of Hunan University are encouraged to
participate in university–industry cooperative projects,
conduct scientific research and engage in practical training in
collaboration with teachers and the industry. During the
process of receiving enterprise training and completing their
graduation projects, EIE students of Hunan University are
guided to abstract practicum teaching and innovative training
projects from modern industrial scientific research and the
forefront of production; a system for establishing practicum
and innovation projects for students will be implemented;
and students are encouraged to engage in engineering
practicums and innovation via policy and funding support.
Students will also be encouraged to apply for national, provincial and municipal innovation and entrepreneurship programs. Students will improve their practical ability and creative thinking ability by participation in multilevel, comprehensive practicum and innovation training. Table I summarizes the EIE practicum projects implemented at Hunan University that are oriented to the EMI industry.

<table>
<thead>
<tr>
<th>Number</th>
<th>Project Name</th>
<th>Type</th>
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<tbody>
<tr>
<td>1</td>
<td>The basics for electrical parameter measurement</td>
<td>Demonstration and verification</td>
</tr>
<tr>
<td>2</td>
<td>Standard sources and measuring transformers</td>
<td>Demonstration and verification</td>
</tr>
<tr>
<td>3</td>
<td>Experiments on the effects of the electromagnetic environment on modern electrical measuring instruments</td>
<td>Demonstration and verification</td>
</tr>
<tr>
<td>4</td>
<td>Ammeter and voltmeter testing and calibration</td>
<td>Design</td>
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<tr>
<td>5</td>
<td>Electrical parameter measurement and error analysis</td>
<td>Design</td>
</tr>
<tr>
<td>6</td>
<td>Composite electrical impedance measurement</td>
<td>Design</td>
</tr>
<tr>
<td>7</td>
<td>Harmonic wave detection and analysis</td>
<td>Demonstration and verification</td>
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<tr>
<td>8</td>
<td>Effects of harmonic waves on electrical energy measurement</td>
<td>Demonstration and verification</td>
</tr>
<tr>
<td>9</td>
<td>Smart grid-oriented interactive electrical energy measurement and management</td>
<td>Demonstration and verification</td>
</tr>
<tr>
<td>10</td>
<td>Remote control of electronic devices based on the Web platform</td>
<td>Design</td>
</tr>
<tr>
<td>11</td>
<td>Principle and structure of smart grid-oriented modern electrical measuring instruments</td>
<td>Demonstration and verification</td>
</tr>
<tr>
<td>12</td>
<td>Application of the Internet of Things technology based on a smart grid</td>
<td>Comprehensive</td>
</tr>
<tr>
<td>13</td>
<td>EEM testing and calibration</td>
<td>Comprehensive</td>
</tr>
<tr>
<td>14</td>
<td>Manual and fully automatic EEM calibration</td>
<td>Comprehensive</td>
</tr>
<tr>
<td>15</td>
<td>Effects of electromagnetic interference on electrical measuring instruments</td>
<td>Comprehensive</td>
</tr>
</tbody>
</table>

### B. Examples of Practicum Projects

Fig. 1 shows the design approach for an EMI industry-oriented practicum project based on the EEM module testing process, which consists of the following steps: barcode scanning, module positioning, hole check, voltage check, powering on the tools, liquid crystal display (LCD) test and circuit board voltage test. After board cards are preliminarily installed, barcodes need to be scanned. The unique barcodes of the currently tested EEM circuit boards are input into the test system. Then, the circuit boards are placed in the grooves of the tools and fixed. After positioning the EEM circuit boards, the connecting wires of the test needle plate and the test voltage settings for the tools need to be checked to ensure correct parameter settings for the test equipment and correct test conditions. The EEM circuit boards that have passed the test will be passed to the next normal step: they will be subsequently employed in the entire machine assembly process. The EEM circuit boards that have failed the test will be sent to the repair system, and the erroneous or faulty units will be clearly marked.

As shown in Fig. 1, four functional units are arranged for the EMI industry-oriented instrument production and testing practicum project designed based on the EEM module testing process, namely, understanding the functional units of the EEM circuit boards, inspection of the welds on the circuit boards of the electrical measuring instruments, liquid crystal display (LCD) testing technique, and LCD fault analysis and circuit board voltage testing technique and its implementation. By matching the four previously mentioned functional units with the steps of the EEM module testing process, students who are majoring in measurement and control technology and instrumentation will have a comprehensive understanding of electrical measuring instruments in terms of research, design, manufacture and operation. Utilizing a “teaching, learning, doing” teaching method, the EMI industry-oriented practicum project based on the EEM module testing process alternates between the theoretical content of courses and the content of practicums to facilitate an understanding of the production process by students and improve their practical operational ability.

### C. Practicum Project Implementation and Management

Hunan University’s EIE practicum management system consists of five components, namely, a practicum management system, a practicum content system, a practicum teaching materials system, a practicum teacher supervision system and a student practicum quality system. The entire practicum management system is operated in a coordinated manner to ensure success at each step of the practicum.

The practicum management system primarily includes a series of standardized management systems that are formed for the personnel, matter, units and processes involved in the teaching given to EIE students of Hunan University during their practicum in enterprises in the EMI industry. A comprehensive practicum management system (suitable for specific situations) can provide strong support that will ensure effective progression of practicum teaching.

The practicum content system primarily includes the specific tasks of the practicum process. This system should be appropriately adjusted based on the specific situations of EIE students of Hunan University and the requirements for disciplinary and market development.

The practicum teaching materials system includes the paper and electronic teaching materials that are employed in the practicum process. Practicum teaching materials relatively significantly differ from the course materials used at school because they focus on ensuring that the EIE
students of Hunan University learn to formulate standards for technological operation and organize and manage production. The practicum teacher supervision system includes the basic methods and regulations that are designed for teachers during the practicum process.

The student practicum quality system primarily includes the quality control standards for each step of the practicum for EIE students of Hunan University. This system is an important means to ensure that the practicum attains the desired goal and provides a basis for further adjustment and optimization of the practicum work system.

IV. CONCLUSION

Establishing practicum projects that reflect the latest industrial and technological developments is an important component of 3E construction. The EMI industry in China has substantial demand for EIE professionals but is experiencing a severe shortage of highly qualified EIE engineers. Therefore, designing practicum projects that are oriented to the EMI industry and improve the results of the practicum teaching of EIE students are important parts of the investigation of 3E training models.

Based on the experience gained with the reform of practicum projects for the EIE students of Hunan University, the demand of the EMI industry for EIE professionals in a 3E construction background is analyzed in this paper, and practicum projects that feature engineering practicums are abstracted and designed from university–industry cooperative projects, modern industrial scientific research and the forefront of production, which provide an important reference for 3E reform of EIE professionals.

Through this research, the Hunan University combines production, scientific research, and management of the base with students' production internships and graduation designs, and gradually forms a training model for the in-depth fusion of school and enterprise monitoring and control technology and instrumental innovation talents, and realizes the base company, school, and Student's win-win.

REFERENCES


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