The Reformation of EE and CE Curricula in Taiwan

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Abstract: The electrical engineering and the computer (or information) engineering are not integrated in a single department in Taiwan. Because of the rapid change in the inter-discipline of EE and CE, many universities are motivated to integrate those EE and CE related departments into a College of Electrical and Information Engineering (EIE). These colleges of EIE start to consider an integrated electrical and computer engineering (ECE) curriculum. In order to investigate the problems in current EE and CE curricula, the Ministry of Education initiated a project for evaluating the current curricula and planning the integration of EE and CE curricula. This project provided an occasion to think about EE and CE education for the future and to communicate with professors, leading researchers, industrial representatives for finding their needs and comments. Many successful cases of curriculum reformation in U.S., Australia, and other countries are evaluated. The goal of this project is to give a new concept in ECE curricular design and provide a sample of integrated ECE curriculum for the universities in Taiwan. The final report of this study is a set of documents to give suggestions to the Ministry of Education as well as the universities.

Keywords: ECE curricula, curriculum reformation

1. Introduction

The electrical engineering (EE) and the computer (or information) engineering (CE) are not integrated into a single department in Taiwan. Instead, the electrical engineering and information engineering are two departments in most universities. Some extreme cases show the separate establishment of departments in electronics engineering, communication engineering, and control system engineering. National Chiao Tung University in Hsinchu is the first university to reform the structure of EE and CE related departments and to integrate these departments into a College of Electrical and Information Engineering. Many universities follow the same pattern to form their new college of Electrical and Information Engineering (EIE). This structure reformation expects to gain the advantage of resource integration. Because of this new structure, many colleges of EIE start to consider an integrated electrical and computer engineering (ECE) curriculum. They try to set up a structure so that students in the EIE college would be more flexible and effective to decide their learning profiles and to receive inter-discipline in EE and CE.

The trend of technology development has shown that the fields of EE and CE grow fast and will involve in many disciplines. The related industries require students being trained with a wider and deeper background courses so that they can catch up the rapid change and face the challenge in the future. Of course, ECE curriculum must be adapted to the trend of technology. In Taiwan, the Ministry of Education had played a supervisory role in monitoring the curricula of universities for a long time. That means the universities just follow the guide given by the Ministry of Education. The faculty members in a department may not pay too much attention to design their own curriculum. Instead, a committee organized by the Ministry of Education was assigned to review the curricula and suggest a list of course requirements every certain years. In the recent years, this situation has changed and the universities become more active in designing their own curricula. However, EE and CE are still in different departments and the curricula for these two fields are separately designed.

In order to investigate the problems in current EE and CE curricula, the Ministry of Education initiated a project for the evaluating the current curricula and planning the integration of EE and CE curricula. A group of senior professors from several major universities in Taiwan was invited to join in this project. It provided an occasion to think about EE and CE education for the future and to communicate with professors, leading researchers,

industrial representatives for finding their needs and comments. This study group met frequently to survey the literatures, to visit universities, to review the existing curricula, to define the course contents, and to come out a draft of sample ECE curriculum. The final report of this study is a set of documents to give suggestions to the Ministry of Education as well as the universities.

2. Studies on EE and CE Curricula

The works concerning the reformation of ECE curricula or the improvement of some particular courses can be found the certain journals, such as IEEE Transactions on Education, IEEE Computer, IEEE Communication Magazine, IEEE Proceedings, etc.. Many EE and CE curricular reformation studies have appeared in last ten years. Their viewpoints can be summarized as follows [1-7];

(1) beginning the engineering courses in the freshman year,
(2) stressing writing and oral communication skills,
(3) industry-university collaborating in funding instructional laboratories,
(4) focusing on fundamental skills and knowledge,
(5) well-coordinating core courses,
(6) promoting the use of advanced technology in education, and
(7) incorporating CAD into the curriculum.

Among those studies, the new curriculum implemented by Carnegie Mellon University (CMU) in 1991 is an impressive one [2]. In this implementation, a minimum core of required courses and a relatively large fraction of free electives are proposed. The breadth and depth requirement has been emphasized also. Recently, a special issue on ECE education was published in Proceedings of the IEEE. In this special issue, the co-editors, F. T. Ulaby and S. W. Director, give an introductory note and raise five questions related to the future of ECE education [8]. They encourage readers to think about some problems. They include the impact of using Internet and CD in delivery of education off campus, the survival of traditional classroom style of teaching, the replacement of hardware-based laboratory by computer simulation, and the major curricular shifts in the next decade. This informative note does give some guides for planning the ECE curricula for the future.

In Taiwan, we face other problems. At first, the curricula in the universities are quite similar because most of them follow the guide provided by the Ministry of Education. The course requirement is around 140 credits for most of EE and CE departments. Usually, there are about 30 credits in general education. The departmental requirement is ranged from 40 to 80 credits. In order to guide students in some specific fields, several tracks are designed to constrain the electives. These well-organized elective courses are ranged from 15 to 60 credits. Under this course structure, students have no much room to select their interested courses. A typical example of EE curriculum is as follows;

General education	30 credits
Departmental requirements	70 credits
Constrained electives	27 credits
Free electives	15 credits
Total	142 credits

In addition to the course requirements, we also find some particular phenomena in the our universities.

(1) Many core courses start from sophomore year. It gives a heavy load to those students who can not adapt well in their freshman year. A student may take more than 22 credits of courses in a semester. This heavy load may cause frustration and non-efficiency in learning.
(2) In the senior year, students put a lot of efforts to prepare for the entrance examinations to graduate schools. Many students take easy courses in senior year. That implies the four-year courses have been squeezed into two years, i.e. the sophomore and the junior years.
(3) Most of courses are lectures. The laboratory courses are not paid too much attention by teachers and students. Some laboratory materials are out of date in the viewpoint of today's technology.
(4) Some core courses are required to take in a sequence of semesters, such as Electronics I, Electronics II and Electronics III. Some students may be blocked by the pre-requisite courses in several semesters and get frustration in their learning.

3. Sample EE&CE Curriculum

In this project, we come out a sample curriculum of integrated discipline of EE and CE for undergraduates. It attempts to give a new concept of EE and CE education in the future. Each individual university can take this sample curriculum as a reference for designing its own EE and CE curricula. The principal ideas of this curricular design are highlighted as follows;

(1) To present new concept and new methodology in teaching EE and CE courses so that the students are more flexible and effective in learning.
(2) To provide students more freedom in course selection but ensure their professional training so that the students can adapt to the trend of technological change.
(3) To design the courses in a sequence of incremental levels so that the students can easily get into the courses in elementary levels and appreciate the courses in advanced levels.
(4) To encourage teachers refining their teaching materials and writing their own textbooks so that the curriculum reformation can be realized in practice.

Based on the above consensus, a sample curriculum is designed. The content of this sample curriculum is summarized as follows.

(1) The course requirement for undergraduates is 134 credits. This number is higher than those commonly recognized 128 credits in US, but has been reduced from 140 in current curricula.
(2) The courses for general education are 28 credits. They are the languages, Chinese literatures, humanities, social sciences, and arts. More emphasis will be on the courses related to the intelligent properties, the skill of communication in speech and writing, and the impact of electronic and computer industries to the society and human behavior.
(3) The basic requirement is 35 credits. It emphasizes the training in mathematics and computer skills. In fact only 23 of them are solely required. These are Calculus (6 credits), Physics and its Lab. (4 credits), Programming and Computer Science (6 credits), Linear Algebra (3 credits) and probability (3 credits). A special course talking about engineers' ethics is also included, i.e. Ethics for Engineers (1 credit). The mathematics courses for engineering or for computer science are options. They are Differential equations (3 credits), Complex variables (3 credits), Discrete mathematics (3 credits), and data structure (3 credits). Besides, students are required to take courses of 6 credits from other departments, such as Mathematics, Physics, Chemistry, Life Science, and Economics. This design attempts to give students the exposure to the fundamental of sciences and mathematics.
(4) The core requirement is 18 credits. Its common part includes Practice topics on ECE (2 credits), Logic design and its Lab. (4 credits), and Design project (3 credits). For EE major, Circuits (3 credits), Elecromagnetics I (3 credits) and Electronics I (3 credits) are required. For CE major, the requirements are Algorithms (3 credits), Computer Architecture (3 credits) and Operating systems (3 credits). All the core requirement courses are elementary level courses.
(5) The courses for breadth and depth requirements are organized in four categories; i.e. Applied Physics, Systems, Circuits/Hardware, and Computers. Many required courses in the current curricula have been moved into these four categories. Typically, the courses of Electronics II and Electromagnetics II are no longer put in a solely required list. The courses in these four categories are advanced level courses. In this breadth and depth requirement, students are required to take at least 30 credits from these four categories. The selected courses should cover at least two categories and include at least 3 laboratory courses each with 2 credits.
(6) Free-electives are 23 credits.

This proposed sample curriculum has echoed the desire of increasing freedom in course selection and condensing the sequential courses. The fundamental knowledge in mathematics and basic skills in using computers are emphasized. For those courses of departmental requirement, we can find that the solely required courses are 23 credits in basic requirement and 9 credits in core requirement. This is a big reduction from the current curricula in our universities. Students have freedom to select courses in the basic requirement, the core requirement and the breadth and depth requirement. The total number of credits is 134. We do not intend to reduce this number in the meantime because we do not expect to change the current status too much. The other reason is that the workload of a course in Taiwan is quite different from that in US. This sample curriculum provides a framework for course reformation. Universities can learn the concept of our design and select what they need to plan their own curricula.

4. Discussions

The curricular reformation always needs the support from teachers. The infra-structure of our teaching programs and teacher evaluation systems will be other facts to influence the implementation of new curricula. At first, we need to evaluate the flexibility of unifying the EE and CE departments into a single department even though this is obvious in US. If EE and CE can not be integrated or cooperated in some sense, an integrated ECE curriculum would be impossible. A proper approach is to promote a concept of joint teaching program in freshman and sophomore years. Students are assigned to the departments in junior and senior years. Second, we should pay more attention to the teaching works. For many years, the teaching work has been disregarded because of the pressure on research works. Some incentives should be provided to encourage teachers to write textbooks or use multimedia technique in preparing their course contents and presentation. Finally, the trend of distant learning may change the learning habits in student body and also the teaching methods and materials. We need to face this impact on the education in the future.

Acknowledgement

This project was sponsored by the Ministry of Education, Taiwan, ROC. The authors would like to thank all the invited professors who have devoted into this study and contributed a lot to this report. They are Kim-Joan Chen, Liang-Gee Chen, Chien-Ching Chiu, Cheng-Hsin Ho, Tsai-Ming Hsieh, Ching-Chi Hsu, Ching-Hsiang Hsu, Chao-Chang Hwang, Chien-Wei Jen, Min-Cheng Liang, Yuen-Chung Lee, Chan-Nan Lu, Ying-Yu Tzou, Yi-Wen Wang, and Yung-Ho Wang. The gratitude is also given to Professor Young-Long Lin, advisor to the Ministry of Education, for his advice and assistance in making the project available.

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