Re-engineering the Electrical Engineering Education for an Innovative Diploma Curriculum at Universiti Teknologi MARA

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Abstract - The revolution looks to ensue after the ICT Revolution will be the Knowledge Revolution, as such human capital development becomes ever more important. Recently, the Faculty of Electrical Engineering of University Teknologi MARA has been revising its Diploma curriculum to realign with the effort of the Malaysian government to standardize the total credit hours and regulate the composition of Humanity-Skill-Theory learning. The revised curriculum is built upon past experience, peer comparison, feedback from users and recipients, and literature on future of Electrical Engineering education. It synergizes disciplines in Electrical Engineering, Mathematics, Science, Computing, Language, Entrepreneurship and Religion/Humanity Science. Curricular innovation are featured by seven key elements – modular program structure, continuity in education, commitment to experiential learning, integration of technology and education, integration of research and education, a compromise of general and specialized education, and disciplinary diversity. This paper addresses the research, design and implementation of these seven elements to bring curricular innovation and improvement. The consequence is a curriculum that optimizes the compromise between the accelerating rate of change in technology innovation and the realistic rate of change of curricular content and scope, and challenges the delivery of Engineers with the attributes of adaptability, flexibility and autonomous capability to learn.

Index Terms - Curriculum design, Diploma, Electrical Engineering education.

INTRODUCTION

The revolution looks to ensue after the Information and Communication Technology (ICT) Revolution and the Industrial Revolution will be the Knowledge Revolution [1], as such human capital becomes ever more important. The quality of education, which provides the impetus to human capital development, is gaining more and more attention worldwide. In meeting this, the government of Malaysia, with the aspiration to become the hub of education excellence, participates directly to improve the quality of teaching and learning across the wide spectrum of its education system with policies such as Malaysia Qualification Framework (MQF) [2], National Education Blueprint (NEB) [3], Industry Incorporated Diploma (IID) [4] and National Education Blueprint (NEB) [5], in the hope to produce a future workforce enriched with creativity and innovation.

Recently, the Faculty of Electrical Engineering (FEE) of University Teknologi MARA (UiTM) has been revising its Diploma curriculum to realign with the concerted effort of the Ministry of Higher Education (MOHE) to standardize the total credit hours of Diploma programs to 90-100 [6] and to regulate the composition of Humanity-Skill-Theory learning in the curriculum. Both of these are aimed to set a standard for Diploma programs in this country, as part of the effort to implement MQF [2].

Besides, the current curriculum has not had a major revision since it was first introduced in 1994 [7]. This curriculum was designed initially for the Department of Electrical Engineering, under the wing of the Faculty of Engineering, which also housed the Department of Civil Engineering and Mechanical Engineering. With its independence to become a Faculty in 1996, the common courses for the three departments became irrelevant. Also, with the conferment of University status in 1999, an upgrade from its former status as an Institute of higher learning, there invokes a shift in the focus for vision and mission of the Faculty [8] and the University [9] to set path towards a World Class University. The current curriculum did not address them.

Then the ICT revolution, in bringing a leap frog technological advancement to Electrical Engineering (EE), makes an impact on education: the emergence of courses with titles unheard of, such as nano-technology, micro-electro-mechanical system, bioinformatics, with intensity unseen before. The current program structure is inflexible to support transients like this.

In view of the aforementioned deficiencies, the current curriculum is revised. The revised curriculum is built upon past experience, peer comparison, feedback from users and
recipients as well as consultation with literature on the future direction of EE education. It synergizes disciplines in Electrical Engineering, Mathematics, Science, Computing, Language, Entrepreneurship and Religion or Humanity Science, to meet the challenge to educate the workforce for tomorrow. Curricular innovation are featured by seven key elements – modular program structure, continuity in education, commitment to experiential learning, integration of technology and education, integration of research and education, a compromise of general and specialized education as well as disciplinary diversity.

This paper addresses the research, design and implementation of these seven key elements to the revised curriculum. It also discusses how these seven key elements are embedded to bring curricular innovation and improvement to the current curriculum. The consequence is a curriculum that instills a balance of attitude-skill-knowledge and facilitates industry-academic partnership, in support of the program outcomes and program education objectives of FEE, derived from the latest vision and mission of the Faculty and hence the University, which in turn, is aligned with the directives from MOHE, and hence the visions of our nation.

METHODOLOGY

The curriculum revision for the FEE embraces a three-part strategy: our current position, our final goals and the best route to the final goals. The currency and relevancy of the existing curriculum (see Figure 1) was reviewed by a committee, comprised of academic staff who have had experience in developing the previous curriculum and also delivering the Diploma and Degree courses. The review was performed by analyzing the existing Diploma curriculum and comparing it with ten other public and private institutions of higher learning to identify our current position.

A list of recommendations summarized from this review was discussed with the users (staff from main, branch and franchise campuses) for unanimous support, and recipients (alumni) to supplement and validate the recommendations. To enhance the definition for our final goals, this list was further scrutinized and adapted with reference to the future direction of EE education as implied in [10-12].

After the review, a new curriculum structure was proposed based on the refined recommendation list and was critically assessed at the Department level as well as Faculty level.

At the Department level, the Outcome Based Education (OBE) analysis was conducted [13]. Each course was designed with course outcomes to specify the level of knowledge, attitude and skill that the students are expected to attain, determined from a previous workshop. The course outcomes for each course and the FEE program outcomes were mapped to match the program education objectives of the Faculty. The committee also worked with the support faculties such as Center of Islamic Thought and Understanding, Academy of Language Studies, Malaysian Entrepreneurship Center, to tailor the course assessment matrix for their courses to the program education objectives of the Faculty.

At the Faculty level, a 2-day workshop was conducted to debate, amend and endorse the content of all the courses common to the different departments. Content of courses specific to a department was left to the jurisdiction of the department concerned.

The revised course syllabus which was endorsed by the Academic Board of FEE was then submitted to the Senate. Upon approval, the revised curriculum was implemented immediately. To ensure the conformity and effectiveness in implementing the revised curriculum, the committee presented details of the revised curriculum to the branch campuses and franchises. At the same time, related issues such as requirement on teaching skills, lecture room,
laboratory space and equipment were also discussed for proper resource planning.

**RESULT AND DISCUSSION**

In order to support the MQF [2], courses offered by the different institutions must be compatible to facilitate the transfer of credit. Courses that are no longer supportive of Diploma and Degree programs and incongruent with peer institutions have been removed. The revised curriculum consists of new courses to provide for the current technology, with total credit hours bounded by the recommended range of MOHE [6]. The credit hour is fixed at 3 for theory courses, 1 for laboratory courses and 2 for semi-laboratory courses.

In terms of percentage, the first two components of the Humanity-Skill-Theory learning model, which can be translated into Attitude-Skill-Knowledge, are found to meet the MOHE requirements (see Table 1). The Theory component, standing at 40-44%, is higher than the requirement. This is necessary to allow continuation to the higher level programs. Unlike others which offer Diploma programs, about 60–70% of our University Diploma graduates proceed to the Degree programs, based on statistic on the student intake for our Faculty.

The revised curriculum accomplishes a learner-centered, competence driven and experientially based curriculum through seven key-elements: modular program structure, continuity in education, commitment to experiential learning, integration of technology and education, integration of research and education, compromise of general and specialized education and disciplinary diversity. The following explains how these seven key-elements are implemented to bring curricular innovation and improvement.

**I. Modular Program Structure**

As compare to the current curriculum structure, the revised curriculum structure (see Figure 2) is more flexible and competent in adapting to the accelerating pace of current technologies.

As shown in Figure 2, each program shares the common courses and yet offers their own elective courses. The common courses include the University courses (English, Religion or Humanity Science, Co-curriculum, Entrepreneurship), General Science courses (Physics, Mathematics), Computing Foundation courses (such as Electrical Engineering Computing, Introduction to C programming) and Electrical Engineering Foundation courses. The former two are to satisfy the University requirement [9] and the Humanity component of the MOHE learning model [6] while the remainders provide engineering knowledge essential to the profession of an assistant electrical engineer.

To create a new program, it is only necessary to replace the elective and laboratory courses specific to develop knowledge and skill specific to that field. Already, two new programs, Diploma in Communication and Computer, are to be proposed to the MOHE. The speed at which these programs are developed is possible with the convenience offered by this new structure.

**TABLE 1**

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>MOHE MODEL (%)</th>
<th>EXISTING CURRICULUM (%)</th>
<th>REVISED CURRICULUM (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HUMANITY</td>
<td>15 - 25</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>SKILL</td>
<td>45 - 65</td>
<td>38</td>
<td>43 - 39</td>
</tr>
<tr>
<td>THEORY</td>
<td>20 - 30</td>
<td>46</td>
<td>40 - 44</td>
</tr>
</tbody>
</table>

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**II. Continuity in Education**

With the conferment of University status, UiTM can now offer Diploma, Degree and Postgraduate programs. The continuity in education programs gives the University a competitive edge. Compared to those with direct entry to other local universities, not only do the students receive...
additional qualification but also course exemption. The consequence is shorter timeframe to graduation and more qualification.

One of the designs of this revision is the adoption of courses at the foundation year of the Degree programs into the Diploma programs [14]. As a result, the University Diploma graduates will enjoy the privilege of course exemption for the foundation year, which constitute one out of a total of three years program, as long as their qualifications contain relevant contents to the Degree program being pursued. Furthermore, the continuity in education also promotes the progressive deepening of knowledge and building up of competencies through the different levels. For example, the basic Control Theory in Diploma provides the foundation for Control System Design in the Degree program.

III. Commitment to Experiential Learning

One of the national concerns related to university education has been the lack of psychomotor skills, or in the context of engineering, the skill to transfer a problem on paper to a solution (using hardware or software). It is found that a major cause of this is the non-committal attitude of students towards non-examinable courses such as laboratory courses. Another factor is that the laboratory experiments are usually conducted in groups, due to the limited number of training units, unintentionally produces many observers than doers.

In order to improve the development of psychomotor skills, the revised curriculum formulates a strategy to counter their attitude by imposing examination for all the laboratory and semi-laboratory courses. The examination is aimed to assess the skill competency level of each individual student. It is believed that this experiential learning strategy will instill confidence and interest in the students to use their own hand to build ideas on their mind [15].

IV. Integration of Technology and Education

There exists a growing dependency on computing in every aspects of EE. Understanding the importance of this, the existing curriculum is revised to integrate teaching with computer software used in the industry. For examples, software for simulation and design of printed circuit board is embedded in Electro-technology; software for signal processing, control system and artificial intelligence is introduced in Electrical Engineering Computing.

Besides computing skill, the revised curriculum also integrates the teaching of technology based courses such as Micro-controller, Programmable Logic Controller, through common courses, while that of industry relevant technologies through elective courses, to better prepare the graduates for the technical work environment.

The integration of computing and technology skills of relevance to EE education will produce graduates with skills relevant to the industry, hence provides a solution to a lack of work-ready graduates [10-11].

V. Integration of Research and Education

Integrating research and education undeniably enriches student learning [16]; this is made possible through final year project. Since this alone is insufficient, the revised curriculum attempts to augment the content of research through electives courses.

To initiate research creativity and innovation through proper delivery method, courses with design elements are selected as electives courses [17]. Examples are Electronic Design, Programmable Logic Controller, Electrical Power Circuit Simulation, PC Hardware and Software, Windows Programming, Computer in Process Control.

A major benefit of this integration is that it will generate interest amongst the students, which will guide them to make rational choices on their Degree program and career [18].

VI. Compromise of General and Specialized Education

The Diploma program offered by the University presents two options to the Diploma holders; continued education or employment. The former would require the breadth of technical knowledge (general curriculum) while the latter the depth of technical knowledge (specialized curriculum). The general curriculum centers on foundation knowledge to springboard to Degree and postgraduate programs. The specialized curriculum focuses on the industry needs and is designed according to the employment market.

In spite of the differences, the revised curriculum compromises the features of the general and specialized curriculum. There are more general courses than specialized courses (see Table 2). This is to ensure the extent of specialization will not narrow the scope of knowledge and educational experience that inhibit adaptation to career choices. The specialized courses are designated to higher semesters (see Table 2) since they are mostly elective courses that are built on general courses. The specialized courses offered have been assessed on their currency and relevancy to the EE community.

VII. Disciplinary Diversity

Exposure to multi-disciplinary courses is one of the ways to enhance the creativity of the students and broaden their educational experience. This could lead to innovative approach in looking for solution to problems in their core discipline.

Realizing the importance of this to adapting to the fast evolving technology, the inter-disciplinary approach is introduced, as an initial attempt, through assimilation of University, General Science and Entrepreneurship courses, in the current curriculum. The revised curriculum augments the diversity in disciplines through elective courses. Furthermore, the pre-requisites of elective courses are removed to encourage cross-disciplinary learning. For example, PC Hardware and Software is not only offered to those with major in Computer, it is opened to all students in the Faculty. Furthermore, the flexibility of the revised curriculum structure allows non-EE courses (soft skill) to be
included as elective courses, where and when appropriate. This is in preparation to develop engineering innovators and managers for future global marketplace that demand development of full human potential through exposure of engineers to other relevant paradigms, such as business, human communication, profession, political [19] and others.

**TABLE 2**

<table>
<thead>
<tr>
<th></th>
<th>SEMESTER 1 (%)</th>
<th>SEMESTER 2 (%)</th>
<th>SEMESTER 3 (%)</th>
<th>SEMESTER 4 (%)</th>
<th>SEMESTER 5 (%)</th>
<th>SEMESTER 6 (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNIVERSITY</td>
<td>30.4</td>
<td>30.4</td>
<td>31.8</td>
<td>0</td>
<td>12.5</td>
<td>0</td>
<td>17.1</td>
</tr>
<tr>
<td>GENERAL SCIENCE</td>
<td>52.2</td>
<td>17.4</td>
<td>18.2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14.3</td>
</tr>
<tr>
<td>COMPUTING FOUNDATION</td>
<td>0</td>
<td>17.4</td>
<td>0</td>
<td>17.4</td>
<td>0</td>
<td>0</td>
<td>5.7</td>
</tr>
<tr>
<td>ELECTRICAL ENGINEERING</td>
<td>17.4</td>
<td>34.8</td>
<td>50</td>
<td>82.6</td>
<td>33.3</td>
<td>16</td>
<td>38.6</td>
</tr>
<tr>
<td>FOUNDATION</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>54.2</td>
<td>84</td>
<td>24.3</td>
</tr>
</tbody>
</table>

**CONCLUSION**

Traditionally, it is enough for students from a competent Electrical Engineering curriculum to have the adaptability and flexibility in applying theoretical principles. In the future, as cultural and geographical differences diminishes through globalization, it is necessary to extend this adaptability and flexibility to the human and societal aspects. With this awareness, the revised curriculum is built upon past experience, peer comparison, feedback from users and recipients as well as literature on the future of Electrical Engineering education. It synergizes disciplines in Electrical Engineering, Mathematics, Science, Computing, Language, Entrepreneurship and Religion or humanity Science. Curricular innovation are attributed by seven key elements – modular program structure, continuity in education, commitment to experiential learning, integration of technology and education, integration of research and education, a compromise of general and specialized education as well as disciplinary diversity. The consequence is a curriculum that optimizes the compromise between the accelerating rate of change in technology innovation and realistic rate of change of curricular content and scope. All in all, it supports the latest vision and mission of the Faculty and hence the University, which in turn, is aligned with the directives from Ministry of Higher Education, and hence visions of our nation, that is to deliver Engineers with the attributes of adaptability, flexibility and autonomous capability to learn, in preparation of the workforce for tomorrow.

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