Redesigning the Philippine Mechanical Engineering Program To Promote Regional Development

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Abstract

The Philippine Commission on Higher Education (CHED) through its Task Force in Mechanical Engineering reviews and revises the mechanical engineering program every five years. In 2005 the task force with membership representing the academe, industry, government and professional societies underwent a two-day seminar-workshop on DACUM (Developing A Curriculum) process that equipped them with its concepts and principles. They had applied them in the identification of basic engineering competency standard and specific mechanical engineering competency standard. Given CHED's regulatory orientation in enforcing the minimum requirements for a standard mechanical engineering curriculum, the task force designed a new curriculum that reduced CHED's requirements to the barest minimum. This gives schools offering mechanical engineering program the free-hand and flexibility to offer a twelve-unit or more of elective courses which are needed by new mechanical engineering students of a particular region in the Philippines that will promote its industrial development. For example, regions located near the coastline which are depending largely on its fishing industry would require mechanical engineering graduates with adequate knowledge and background in refrigeration and food processing and canning, while regions which are agricultural-based would need mechanical engineers with adequate knowledge and sufficient skills in mechanical design and may be in agricultural mechatronics. Likewise, highly industrialized cities would need mechanical engineers with concentration in manufacturing, mechatronics and controls engineering. Furthermore, the new mechanical engineering program includes a senior design project that would address the specific needs of the communities where the schools are located.

Introduction

Designing and revising a curriculum is not an easy task especially when the parties involved such as the academia, government, industry and professional societies with their competing interests are involved. Through the commendable initiative of the Philippines Commission on Higher Education (CHED), we have been equipped with the concept and principles of DACUM (Developing A CUrriculuM) process and have gone through the experience of applying them in the identification of basic engineering competency standard and those that apply specific to the Mechanical Engineering (ME) program.

In contrast to the outcome-based criteria for engineering education in some countries, CHED's regulatory orientation enforces a set of minimum requirements for a standard curriculum. Through the CHED's Technical Panel for Engineering, Technology and Architecture (TPETA) Task Force in Mechanical Engineering (of which the authors are members), a new curriculum was designed which reduced the requirements to the barest minimum. This allows schools offering ME program the free-hand to offer a twelve-unit or more of elective courses which are deemed important and relevant for the practice of emerging mechanical engineers of a particular region in the Philippines to contribute in its industrial growth and development. This paper presents the DACUM process and its application to the revision of the existing ME curriculum and two models of ME curriculum that made use of the twelve-unit elective courses to introduce a major or concentration.

The DACUM Process

DACUM was derived from the phrase "Developing A Curriculum" and DACUM approach was created in July 1968 in British Columbia, Canada. It is a competency – based approach to curriculum development and places the emphasis on the learners gaining ability to meet specific objectives formulated according to a set of standards.

According to Mancebo[1], DACUM is based on three assumptions as follows:

1. Expert workers can define and describe their job more accurately than anyone else.
2. Any job can be effectively described in terms of the tasks that successful workers in that occupation perform.
3. In order to be performed correctly, all tasks demand certain knowledge and attitudes from workers.

The DACUM process consists of four components namely: (1) the selection of workshop participants, (2) the DACUM workshop, (3) data analysis and (4) the development of the course. This process is illustrated in Appendix A.

The participants in the workshop should be experts in their respective areas of specialization, articulate and forward thinking. In the Philippines, revision of the mechanical engineering curriculum is done by a Technical Panel composed of people from the academe, industry, professional organization and the board of mechanical engineering. This group meet and discuss the contents of the present mechanical engineering curriculum and innovate the curriculum incorporating the feedbacks coming from the industry, the requirements of the board of mechanical engineering and the requirements set the Commission on Higher Education.

The DACUM workshop brings together all these experts and provides a forum for consultation and negotiation of training goals. The workshop includes the general introduction and orientation of the process, agreement on the span of positions to be analyzed, identification of the process – based duties and responsibilities of the position and identification of the general areas of competencies through task analysis.

The data generated during the workshop are then analyzed in terms of estimating the time required to teach each of the courses identified to meet the competencies. After which the topics to be taught is developed within the area of competencies by the group and once ratified, the syllabi are then prepared.

Applying the DACUM Process to ME Curriculum Revision[2]

The initial step to develop the mechanical engineering curriculum using the DACUM process was to establish the profile of duties and responsibilities of an engineer in general. Several duties were identified during the workshop, which includes:

1. Conceptual Design
2. Research
3. Project Planning
4. Technology Innovation
5. Systems Development
6. Supervision of Personnel, Project and Operation

Under each of these categories, specific tasks were identified and the competencies required to perform these tasks were listed. The list of basic engineering courses was identified based on these.

The process was repeated to establish the profile of duties and competencies specific to a mechanical engineer. The tasks to be performed were identified based on the three major functions being carried out by a mechanical engineer namely research and development, technology innovation, and management. The competencies required to perform such tasks were then listed.

After all the competencies required to accomplish the tasks were identified, the courses needed to develop such competencies were listed. Reference was made with the existing minimum requirements set by the technical panel for mechanical engineering education.

Competencies for this area include understanding the principles of mathematics, determining appropriate engineering principles and techniques as applied to the concept design, developing proficiency in computational and multi- dimensional simulation skills and others. Appendices B1, B2, and B3 show the competencies identified for the areas on research and development, technology innovation, and management.

Identification of Courses for the ME Curriculum

The existing requirements set by the Task Force in Mechanical Engineering was reviewed vis-à-vis the competencies identified. Almost all of the courses presently offered were retained except for the reduction in some units. The number of units saved was allotted for new courses, specifically elective courses, which will address the needs of the locality in which the school is located.

The following specific objectives which were primarily based on ABET Criteria[3] were formulated in coming up with the new ME curriculum that will provide quality education for global competitiveness:

1. Develop ability to apply knowledge of mathematics, science and engineering.
2. Develop ability to design and conduct experiments, as well as to analyze and interpret data.
3. Develop ability to design a system, component or process to meet the desired need.
4. Develop ability to function on multi – disciplinary team.
5. Develop ability to identify, formulate and solve engineering problems.
6. Develop an understanding of professional and ethical responsibility.
7. Develop ability to communicate effectively.
8. Develop an understanding of the impact of engineering solutions in a global and societal context.
9. Develop ability to use techniques, skills and modern engineering tools necessary for Mechanical Engineering practice.

The changes made in the existing ME curriculum are summarized as follows:

1. The allotted credit units to traditional courses such as machine design, power plant design and industrial plant design courses are reduced to the barest minimum

2. The number of units allotted for electives courses is increased to twelve units. These courses may be utilized to introduce a major or concentration relevant to the industrial needs of the region where the school is located to promote regional development.

3. The schools are strongly encouraged to offer an on-the-job training course or practicum to expose the students to the real-world activities in mechanical engineering.

4. The program includes a two-semester design project or research project to relate theories to some practical applications. A project with a strong social impact, that is, addressing some problems in the community is strongly encouraged.

The summary of the proposed courses for the new mechanical engineering is shown in Appendix C. It should be noted that the total number of units (195 units) for the curriculum of Bachelor of Science in Mechanical Engineering is not changed.

Introducing Concentrations in the ME Program To Promote Regional Development

The redesigned ME curriculum has been presented for public hearing to various sectors and regions in the Philippines prior to its proposed implementation in the academic year 2006-2007. Two schools offering ME namely- De La Salle University- Manila and Mapua Institute of Technology have prepared their curricula utilizing the twelve-unit elective courses for their major or concentration such as mechatronics engineering and HVAC&R System Design, respectively. These schools are located in Manila, the capital of the Philippines and a highly industrialized city in the National Capital Region. Mechatronics engineering and HVAC and R System Design applications in various industries found in the metropolitan area will definitely contribute to region's further development. The ME curricula designed by these schools will serve as models for other schools in the Philippines in redesigning their ME curricula..

Mechatronics Concentration in the Mechanical Engineering Program of De La Salle University – Manila[4]

Studying the manner of mechatronics education in the mechanical engineering programs offered in two American universities provides the DLSU-Manila ME Department a model to consider in developing its own mechatronics focus. Instilling a design-oriented mindset among engineering students early in their academic career will not only enable them to further appreciate any preparatory courses they may have taken, but will also stoke the fire of their curiosity for the more complex engineering courses to come. Also, in-depth knowledge of the foundation courses for mechatronics field prior to the mechatronics course proper makes the students spend less time learning the integration of sensors, actuators, and controllers into systems. Finally, the interdisciplinary nature of mechatronics must be reflected in the design of the mechanical engineering curriculum, the delivery of some of the courses, and the design and set-up of the laboratory facilities.

The ME curriculum is revised with these points in mind. A one-unit orientation course is introduced in the first year to give the students an overview of the mechanical engineering profession and an inkling of engineering design (with emphasis on mechatronics design) at the conceptual level.. In addition to the existing courses in the curriculum which comprise the mechatronics thread such as advance engineering mathematics, numerical methods, computer programming, and basic electrical circuits and electronics circuits, the new courses introduced include lecture and laboratory courses in controls engineering, digital electronics, and mechatronics. The mechanical vibrations course previously offered in the final term is made a prerequisite to the controls course to aid the student's understanding of system dynamics. The thrust of the mechatronics course will be more focused on the design of integrated mechatronics systems.

The laboratory facilities are being assessed and evaluated whether the existing equipment are sufficient to complement the enriched mechatronics course content. Additional instrument equipment, tools, sensors and actuators are to be procured to facilitate mechatronics systems design and fabrication. Some of the applications of mechatronics engineering are already introduced in the design of fuzzy-logic controller of a micro-hydro power plant installed in the northern region of the Philippines as part of the Department's community extension project. Currently, mechatronics-related undergraduate research projects are pursued in the areas of thermo-fluids engineering and power engineering.

HVAC and R System Design Concentration in the ME Program of the Mapua Institute of Technology[5]

The Heating, Ventilating, Air-Conditioning and Refrigerating (HVAC and R) System Design concentration in the ME program of the Mapua Institute of Technology has its primary objective the students' understanding of the fundamentals of air-conditioning and refrigeration systems, their components and accessories including the electrical components of such systems, and the students' applications of such knowledge in their design or research project. The twelve-unit elective courses utilized for the HVAC and R concentration include seven courses.

1. Fundamentals of Heating and Cooling Loads**.** The course aims to develop an understanding of heat transfer principles and their applications in calculating the heating and cooling loads of a building.

2. Fundamentals of HVAC Systems. The course aims to develop an understanding of the the HVAC systems function in controlling temperature, moisture content, air quality, and air circulation in a conditioned space.

3. Fundamentals of Refrigeration. The course aims to develop an understanding of the principles of refrigeration and their applications to refrigeration systems.

4. Fundamentals of Water System Design. The course aims to develop an understanding of the basic concepts of hydronic system operation and design including piping systems, pipe materials and fittings, centrifugal pumps, terminal units, expansion tanks and water chillers.

5. Fundamentals of Air System Design. The course aims to develop an understanding of the fundamentals of air movement, the components of air distribution systems, considerations of human comfort, load and occupancy demand, and how codes and standards affect the design of air systems.

6. Fundamentals of Electrical Systems and Building Electrical Energy Use. The course aims to develop an understanding of the basic principles of electricity, the electric components and systems used in HVAC and the role of the electric utility and how it affects building electrical systems. It includes familiarization with the *Philippine Electrical Code.*

7. Fundamentals of HVAC Control Systems. The course aims to develop an understanding of the various types of controls as applied to HVAC systems including electric controls, pneumatic controls, self-powered controls, analog electronic controls and digital controls.

When redesigning the ME curriculum, therefore, the school must consider the major industries and products in the region to align their elective courses to the needs of such industries. The Philippines, which is basically an agro-industrial country, is divided into sixteen regions. Each region has identified its major products and industries. All regions produce same kind of agricultural products and are engaged therefore in food processing the mountain regions have mineral resources and forest products. The coastal regions have aquaculture and mass transportation operation. Other major industries include machineries, milling, handicrafts, textiles and garments, energy and tourism.

Conclusion

The DACUM process is a very useful tool in developing / redesigning a more innovative mechanical engineering curriculum. Here, the courses introduced are based on the competencies required to perform the identified tasks / duties of a mechanical engineer.

With the participation of the various stakeholder in mechanical engineering education such as the industry, academia, government, and professional societies in the DACUM process, there is no doubt that their concerns are taken into consideration in redesigning the Philippine mechanical engineering program. The challenge is for each school to be creative in the implementation of the new mechanical engineering curriculum such as the identification of concentration/major that is in line with the thrust of the regional industrial development plan; the formation of industry –academe linkages that will provide opportunities for practicum/ on-the-job training of the students; and, partnership with the local communities to undertake design project or research project that will have a strong social impact especially among the marginalized people in such communities

Perhaps if these things are accomplished, mechanical engineering education and practice in the Philippines have not only contributed in promoting the economic development of the different regions in the country but have also significantly contributed in the improvement of the human condition and enhancement of the human spirit especially of the poor Filipinos.

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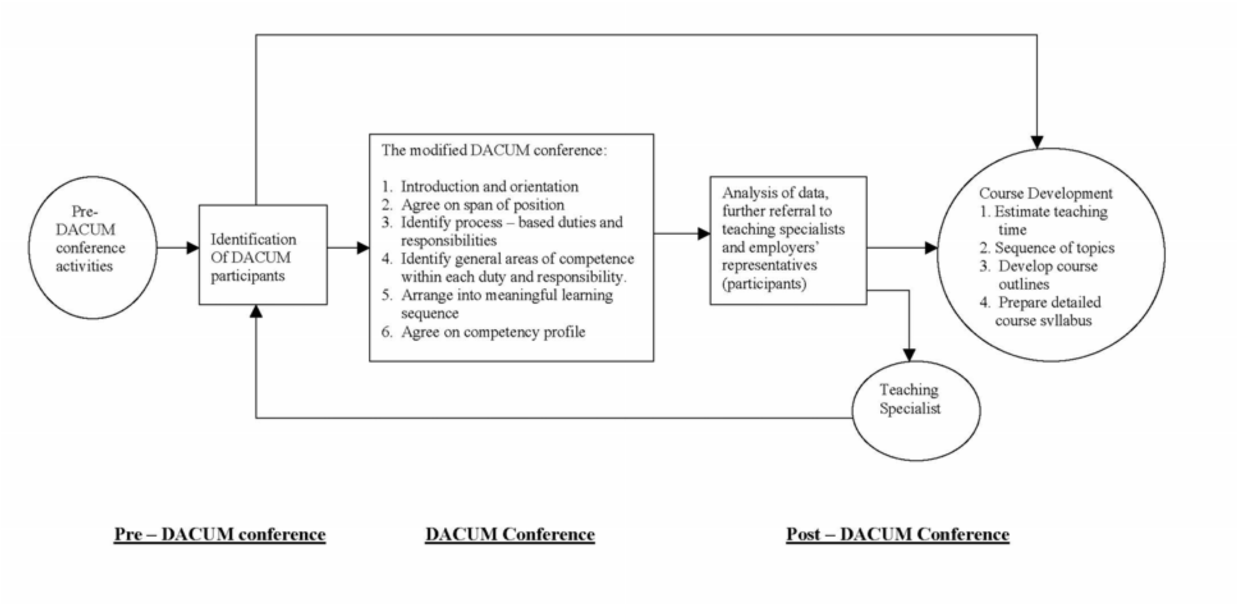
APPENDIX A

Process Flow of the Various Components of the DACUM Approach to Curriculum Development (Mancebo 1994)



APPENDIX B1

Profile of Duties and Competencies of a Mechanical Engineer
Research and Development

DUTIES	COMPETENCIES				
Apply knowledge of mathematics and engineering principles.	Understand the principles of mathematics, natural, physical, and applied sciences.	Determine the appropriate engineering principles and technique application to the concept design.	Develop proficiency in computational and multi – dimensional modeling/simulation skills in the defined knowledge areas.	Develop the ability to use techniques, skills and medium tools such as computer software necessary for engineering practice.	
Conceptualizes, designs, plans and implements machines, products and services for the benefit of the consumers.	Understand engineering concepts and invention applied in the course.	Know design subjects, product development, kinematics, strength of materials and engineering mechanics.	Able to explain existing engineering plans.	Acquire an in – depth understanding of the principles and needs of engineering design	
Generate technical specification and standards.	Conduct research for the international application of the conceptual design being developed.	Familiarize with the engineering standards.	Able to translate custom desired needs into engineering solution terms.		
Conduct scientific research.	Understand the research process & apply the principles of mathematics, physical, natural, and applied sciences	Collect, evaluate, assess, and transform data into meaningful and useful information.	Design and conduct experiments, analyze and interpret data, document and disseminate results.	Analyze and validate data and write technical reports.	Function in multi – disciplinary teams.

APPENDIX B2

Profile of Duties and Competencies of a Mechanical Engineer
Technology Innovation

DUTIES	COMPETENCIES				
Translate relevant information into product and / or service requirements.	Analyze statistics and product / services or system information.	Analyze competitive advantage.	Apply radical or incremental technological innovation.	Exercise critical / lateral thinking.	
Knowledge of contemporary issues and technological trend and IPR	Understand the technology life cycle.	Acquire information on the product from different sources on the same industry.	Observe rules on intellectual property rights.	Diagnose product system failure or deficiency characteristic.	
Create prototypes.	Understand the principles of technological innovation.	Adopt engineering inter – disciplinary requirements and prototypes.	Identify technical system contradiction and resolve them.	Interpret product design in terms of improvement, changes, etc.	Enhance creativity.
Apply technology transfer and facilitate innovation.	Know appropriate technologies.	Understand process of technological transfer.	Establish feedback mechanism.	Demonstrate technology leadership.	Seek interface between industry and academe.
Identify and implement best practices	Be aware of industry practices.	Know ethical and legal standards and practices,	Conduct bench markings.	Apply learning and skills to Mechanical Engineering practice.	

APPENDIX B3

Profile of Duties and Competencies of a Mechanical Engineer
Management

DUTIES	COMPETENCIES			
Evaluate technical system issues.	Understand the work process and purpose.	Develop and assess periodic test performance and monitoring of system.	Document evaluated issues.	Understand the impact of engineering solutions in a global and societal context.
Mechanical Engineering systems analysis and design	Review mechanical engineering systems operations.	Define mechanical engineering system performance and parameters.	Develop mechanical engineering systems design.	Document data design.
Mechanical Engineering Systems Integration	Comprehend different mechanical subsystems.	Recognize inter – relating subsystems.	Harmonize subsystems.	Ensure that the integrated systems developed are operational.
Communicate effectively and efficiently.	Demonstrate verbal, written and other form of communication.	Communicate proficiently the technical report writing and documentation.	Demonstrate the art of public speaking as presenter, facilitator, mentor and trainer.	Create strategies for information dissemination.
Understanding engineering business / organization	Understand the basic concepts, tools and areas of application of business management, with emphasis on operation and project management.	Supervise and monitor the performance of project milestones and operational targets.		
Understanding ethical practices	Recognize the principles of ethics.	Be able to practice high moral standards in all undertakings.	Promote social responsibility.	Develop concern for the environment.
Understand human behavior and develop strategies. Supervises a team	Understand organizational culture and situational leadership.	Be an effective team player.	Facilitate change management in the organization.	Coach, counsel and motivate peers and subordinates.

APPENDIX C

Proposed Bachelor of Science in Mechanical Engineering (BSME) Curriculum

The proposed BSME program has a total of 195 credit units comprising of the general education, technical, professional, allied and technical elective courses. The following table gives a summary of the course credit units distribution of the different courses:

Classification / Field / Course	Minimum Lecture Hours	Minimum Laboratory Hours	Minimum Credit Units
I. **Non – Technical Courses** (includes Languages, Humanities\ and Social Sciences courses)	**39**	**0**	**39**
II**. Mathematics Courses**	**28**	**0**	**28**
III. **Natural / Physical Sciences Courses**	**9**	**9**	**12**
IV. **Basic Engineering Sciences**			
Engineering Drawing	0	3	1
Computer Fundamentals	0	6	2
Computer – Aided Drafting	0	3	1
Statics of Rigid Bodies	3	0	3
Dynamics of Rigid Bodies	2	0	2
Mechanics of Deformed Bodies	3	0	3
Engineering Economy	3	0	3
Engineering Management	3	0	3
Environmental & Safety Engineering	3	0	3
Sub Total	**17**	**12**	**21**
V. **Allied Engineering Courses**			
Basic Electrical Engineering	2	3	3
Basic Electronics	2	3	3
DC and AC Machinery	3	3	4
Sub Total	**7**	**9**	**10**
VI. **Fundamental of Mechanical Engineering Courses**			
Fluid Mechanics	3	0	3
Machine Elements 1	2	3	3
Machine Elements 2	2	3	3
Materials Engineering	3	3	4
Thermodynamics 1	3	0	3
Thermodynamics	3	0	3
Combustion Engineering	2	0	2
Heat and Mass Transfer	2	0	2
M.E. Laboratory 1	0	6	2
M.E. Laboratory 2	0	6	2
Industrial Processes	2	0	2
Safety Engineering 2	2	0	2
Workshop Theory and Practice	0	6	2
Machine Shop Theory	0	6	2
Instrumentation and Control Engineering	2	3	3
Fluid machinery	3	0	3
Refrigeration Systems	3	0	3
Air conditioning and Ventilation	2	3	3
Vibration Engineering	2	0	2
Sub Total	**36**	**39**	**49**

VII. **Professional Mechanical Engineering Courses**			
Machine Design 1	3	0	3
Machine Design 2	3	0	3
M.E. Laboratory 3	0	6	2
Industrial Plant Engineering	3	0	3
Power Plant Engineering	4	3	5
M.E. Laws, Ethics, Codes and Standards	3	0	3
Sub Total	**16**	**9**	**19**
VIII. **Others**			
Methods of Research	3	0	3
Technical Electives	12	0	12
Plant Visit / OJT (On-the-Job Training)	0	6	2
Sub Total	**15**	**6**	**17**
Grand Total	**166**	**84**	**195**
Non – Academic Courses			14