

AC 2010-1225: REVISION OF THE MECHANICAL ENGINEERING CURRICULUM AT CHULALONGKORN UNIVERSITY UNDER NEW REGULATIONS AND QUALITY ASSURANCE

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Revision of the Mechanical Engineering Curriculum at Chulalongkorn University under New Regulations And Quality Assurance

Abstract

The new engineering education regulations in Thailand have profound impacts on the flexibility of revision of the mechanical engineering curriculum since they emphasize on course contents and demand a larger credit portion for general education. Hence, the total credits of core courses are forced to decrease, and only slight changes in the curriculum can be made. With new outcome-based demands, the mechanical engineering program committee tailors the revised curriculum by integrating design and experiment skills across course series. The implementation is divided into short and long terms. The short-term procedure involves restructuring and integrating courses for specific competencies while the intensive quality assurance is considered in long term.

I Introduction

Chulalongkorn University was established as the first university in Thailand in 1917 with the Faculty of Engineering as one of the four founding faculties. The Department of Mechanical Engineering, Chulalongkorn University, started offering the undergraduate mechanical engineering program in 1933, the first in Thailand. The program has long been very popular and one of the most selective.

In the last decade, however, there are several changes in the education landscape with a major education reform in Thailand, including the higher education [1]. These changes has been accelerating and posing challenges and opportunities to all concerned and continuously changes in a short timeframe [2]. This situation enormously affects the outlook, administration, finance and many other aspects on the running of a curriculum (Table 1).

Particularly, many revised and new regulations came into effect. To be specific, the structural and operation requirements of an engineering curriculum are mainly regulated by (1) the Commission on Higher Education (CHE), an agency in the Ministry of Education (MoE) and (2) the Council of Engineers (CoE). The main organization that overlooks the educational quality is the Office for National Education Standards and Quality Assessment (ONESQA).

Table 1 Timelines of regulations and changes

Year	Timeline
1999	National Education Act demanded overall education reform in all level [1].
2000	Office for National Education Standards and Quality Assessment (ONESQA) was established [3].
2001	New quality assurance CU-QA 84.1 for teaching units by Chulalongkorn University was introduced [4].
2005	Bachelor Degree Standard by the Commission on Higher Education was revised [5].
2005	Quality assurance for curriculum in Chulalongkorn University was expanded into CU-CQA [6].
2006	New system of undergraduate admission was introduced by the Association of University Presidents of Thailand [7].
2008	Chulalongkorn University Act transformed the public university into an autonomous university, receiving annual block grants from the government [8].
2008	Regulation on Degree Accreditation for Professional Licensing was revised by Council of Engineers [9].
2009	New Thai Qualifications Framework for Higher Education (TQF: HEd) [10] was introduced with guidelines [11] by the Ministry of Education.
2010	The revised system of undergraduate admission took effect [7].

In addition, a new admission system to universities which had been recently started is resulting in the inconsistency of students' quality in last several years [12]. Moreover, the globalization and economic crisis around the world might stimulate a strong competition between engineers from different nationalities in this coming decade such that the Council of Engineers has pushed for the acceptance of Washington Accord. Indeed, there are several considerations on globalization in the draft of the qualifications framework for undergraduate engineering programs [13]. With the introduction of full-fee programs in English within the faculty [14], these programs posed challenges to the subsidized, traditional programs. Therefore, it is very important to carefully revise our curriculum in order to prepare mechanical engineering graduates to be able to compete in this highly competitive era.

With such demands from different organizations, the flexibility in curriculum revision is limited. Meanwhile, the demands for outcome-base attribute and quality are increasingly important. Indeed, the long-term survival of the department as a leader in the field absolutely demands high quality. Coupled with less secured finance and resources, this is certainly very 'interesting times'.

This paper explains an ongoing process and strategies of the Department of Mechanical Engineering, Faculty of Engineering, Chulalongkorn University for the curriculum revision in an attempt to comply with new regulations and quality assurance systems.

II Curriculum Regulations

The Bachelor Degree Standard [5] by Commission on Higher Education has been in effect since 2005. It specifies a minimum of 120 credits which must include at least 30 credits of General Education, an increase of 12 credits from the previous standard, and 84 credits of core courses.

For the Council of Engineers who regulates national engineering program accreditation and professional licensing, the new 2008 regulation [9] still strictly specifies minimum requirements in course contents and credits for science and engineering subjects. In short, the program accreditation is input-based and rigidly relied on the contents. The Council of Engineers has also

participated in the APEC engineer discussions [15] and set up a steering committee on the possible adoption of Washington Accord [16]

In 2009, MoE also announces a Thai Qualifications Framework for Higher Education (TQF: HEd) [10] which further restricts the standard imposed from the Commission on Higher Education [11]. They specify graduate attributes; ethical & moral responsibilities, knowledge, cognitive skills, interpersonal skills & responsibility, and numerical analysis, communication & IT skills. In addition, standards for different disciplines and continuous quality development are also included. This framework has to be further customized for specific disciplines [13].

As a result of the described standard and accreditation requirement, the minimum requirements on the course contents and credits for the present program are clearly specified and based on 3-credit courses as followings.

1. General education (30 credits) – English, social science, humanity, science & technology, multidisciplinary, etc.
2. Basic science (18 credits) – mathematics, physics and chemistry with additional laboratory.
3. Basic engineering (18 credits) – 4 compulsory courses in drawing, mechanics, materials and computer programming and at least 2 courses in thermodynamics, fluid mechanics, mechanics of materials or manufacturing processes.
4. Core engineering (12 credits) – at least 4 courses in mechanics of machinery, machine design, automatic control, vibration, combustion, refrigeration, heat transfer or power plant.

In addition, all first year students must study common subjects together before selecting the program at the start of their second year. Therefore, the mechanical engineering program cannot freely choose courses or modify the course sequence in basic science and engineering. As a result, any curriculum revision might be done under this limitation.

III Quality Assurance

The ONESQA specifies the national standards for education institutes and compares the results from educational institutes nationwide in all levels. Chulalongkorn University responded to the ONESQA quality assurance by upgrading the Office of the Quality Assurance and declaring its more rigorous system CU-QA [4]. This system had been enthusiastically adopted by the Faculty of Engineering [17]. This procedure was further expanded into the CU-CQA, specifically to curriculum development and operation in 2005 [6].

The CU-CQA is a comprehensive system for quality assurance, concerning 1) context, 2) resource and resource management, 3) educational management, and 4) quality enhancement, to enforce every program to meet international standards. CU-CQA also introduces highly detailed quality factors and key indices.

The quality factors are measured in 16 areas with 69 major items under 3 requirement levels of essential, supplementary and beneficial. Areas of quality factors are program objectives, program management, program development & evaluation, teaching resource management, human resource management, environment & safety management, IT, student acceptance, student quality development, teaching & research quality development, classroom environment

management, thesis quality management, graduate & research quality evaluation, continuous development of quality assurance, relationship development with international & national universities, and research based knowledge development.

The 24 key indices measure both input and outcome in 5 areas of applicants, staff, education process, supporting factors and research. Key indices are, for example, course wise evaluation results, graduates' performance satisfaction of employer, total numbers of publications, and amount of research fund.

The university also declares the graduate attributes, the common outcomes for all program [18]. They are:

1. Virtue – honesty & morality, discipline & acceptance of rule of law and social norms, professional ethics, cultured living,
2. Intelligence and scholarship – expertise in field of study, creativity, passion for learning, vision, ability to syntheses & analyses,
3. Skills and profession – proficiency in Thai, English and IT, appropriate personality, management skill, intercultural effectiveness, and
4. Society – responsibility and awareness of role in society, sacrifice for common good.

To reconcile all of these different graduate attribute models as well as attempt to relieve the burden on departments to formulate, interpret and implement processes, the Faculty of Engineering also create their own common graduate attributes to generally conformed to that of TQF, Chulalongkorn University, and Washington Accord. They are concerned in 13 attributes [19] as shown in Table 2.

IV Curriculum Structure and Revision

The general aim of the mechanical engineering program is to ensure students' understanding of theoretical principles, through exercises, experiments and design projects, to provide students with ability and confidence in solving practical problems and designing mechanical systems. The total credit of 2002 mechanical engineering curriculum is 145. Basic Science and Engineering are concentrated in the first two years. The third year is primarily concerned with design and supporting tools. Students are also required to complete a summer internship after the third year. In the final year, the focus is on a one-year senior project together with elective advanced courses.

Compared to the previous curriculum, this 2002 curriculum adopts some of ABET outcomes with strong emphasis on design. To response to this demand, the programs have been recently re-structured by the interaction of the academic disciplines and desired outcomes or competencies. Courses are organized into disciplines by the responsible units – the academic/research divisions within the department, other engineering departments, Faculty of Science, Office of General Education and other faculties. The desired outcomes are grouped into three streams – design, experiment and other skills – such that the integration across disciplines can be considered together by dedicated working groups.

Table 2 Graduate Attributes of the Faculty of Engineering, Chulalongkorn University [19].

<p>1. Knowledge of Science & Engineering</p> <p>1.1 knowledge in mathematics 1.2 knowledge in science 1.3 knowledge in engineering fundamental 1.4 knowledge in engineering specialization 1.5 knowledge in the conceptualization of engineering models</p> <p>2. Application of Science & Engineering Knowledge</p> <p>2.1 apply knowledge in mathematics 2.2 apply knowledge in science 2.3 apply knowledge in engineering fundamental 2.4 apply knowledge in engineering specialization 2.5 apply knowledge in conceptualization of engineering models</p> <p>3. Problem Analysis</p> <p>3.1 identify and formulate complex engineering problems 3.2 analyze and solve complex engineering problems</p> <p>4. Design & Development of Solution</p> <p>4.1 design solutions to meet specified needs with appropriate consideration for safety 4.2 design solutions to meet specified needs with appropriate consideration for public health 4.3 design solutions to meet specified needs with appropriate consideration for culture and society 4.4 design solutions to meet specified needs with appropriate consideration for environment</p> <p>5. Investigation</p> <p>5.1 design experiments to investigate complex engineering problems/designed solutions 5.2 conduct experiments to investigate complex engineering problems/designed solutions 5.3 analyze and interpret data 5.4 synthesize information to provide valid conclusions</p> <p>6. Modern Tool Usage</p> <p>6.1 select appropriate/modern engineering tools, techniques, and resources 6.2 apply appropriate/modern engineering tools, techniques, and resources 6.3 create appropriate/modern engineering tools, techniques, and resources</p> <p>7. Working as an Individual and in Teams</p> <p>7.1 function effectively as an individual 7.2 function effectively as a member in diverse teams 7.3 function effectively as a leader in diverse teams</p>	<p>8. Communication</p> <p>8.1 communicate (listening, speaking, writing, reading) effectively on engineering activities with teams 8.2 communicate (listening, speaking, writing, reading) effectively on engineering activities with an engineering community 8.3 communicate (listening, speaking, writing, reading) effectively on engineering activities with society</p> <p>9. Engineer and Society</p> <p>9.1 demonstrate understanding of safety issues and consequent responsibilities relevant to engineering practice 9.2 demonstrate understanding of public health issues and consequent responsibilities relevant to engineering practice 9.3 demonstrate understanding of cultural and societal issues and consequent responsibilities relevant to engineering practice 9.4 demonstrate understanding of legal issues and consequent responsibilities relevant to engineering practice</p> <p>10. Ethics</p> <p>10.1 have honesty & morality, and sacrifice for common good 10.2 have self-discipline 10.3 accept of rule of law and social norms, professional ethics, and have responsibility and awareness of role in society</p> <p>11. Environment, Sustainability, and Economics</p> <p>11.1 understand an impact of engineering solutions and a responsibility in an environment context 11.2 demonstrate knowledge of and need for sustainable development 11.3 recognize and demonstrate an engineering practice on a sufficient economic principle</p> <p>12. Risk Management</p> <p>12.1 understand of risk and change management in engineering practice 12.2 demonstrate of risk and change management in engineering practice</p> <p>13. Life Long Learning</p> <p>13.1 recognize a need for an ability to engage in independent 13.2 have an ability to engage in independent 13.3 recognize a need for life long learning</p>
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Figure 1 shows the management structure. For each design/experiment/skill outcomes (in rows), the competencies will be built through various courses that are under the responsibility of the various units (in columns). These innermost units are the academic/research divisions that represent mechanical engineering disciplines within the department. Then, the units expand

outwards according to the management structure within the university, i.e. other departments within the Faculty of Engineering, Faculty of Science, Office of the General Education and, lastly, other faculties. All interactions are looked after by the program administration and the quality assurance committees. Current focus is on the courses that are taught by the Department in which it has full control. Meanwhile, other courses can be monitored as well with the assistance of the Faculty of Engineering.

According to the curriculum revision, the process poses some major challenges due to the diverse demands from the previously described regulations and quality assurance procedures. Meanwhile, the department must also keep the graduate attributes in mind for the revised curriculum. The department decided to divide the curriculum revision into short and long term procedures. For short term procedure, the curriculum structures will be revised based on the graduate attributes while tools for program performance evaluation and feedback will be created and implemented in long term.

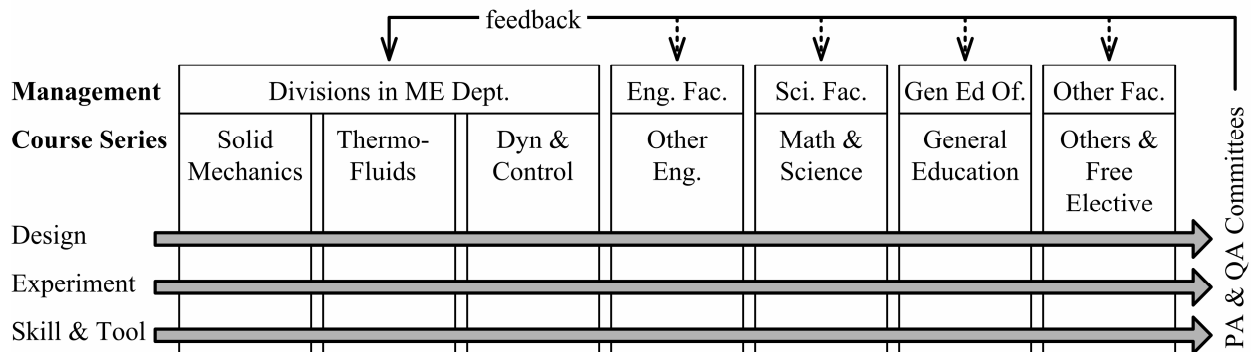


Figure 1 Program management overview

A. Short Term Procedure

Based on survey results and opinions of lecturers regarding the graduate attributes, both design and experiment skills are emphasized in the new curriculum. The major obstacle in the revision is the total credit number. Regarding this issue, the program administrative committee agreed early on that the current total credit number was already very high and the revised values should be kept at 147 or lower.

As mentioned earlier, all first year students must study common basic courses together before selecting the program at the start of the second year. In addition, general education and basic science courses are also taught by other faculties. Being aware of a limitation for the program to directly manage these courses, the Faculty of Engineering designs a common framework of general education, basic science, and basic engineering courses and credits strictly following the requirements from Commission on Higher Education and Council of Engineers for every program as shown in Table 3.

Table 3 Framework of courses and credits arranged by the Faculty of Engineering. The numbers in the bracket are course credits.

General Education (30)	Basic Sc and Math (21)	Basic Engineering (23)	Dept Core Course (> 61)
<ul style="list-style-type: none"> - Social science (3) - Humanity (3) - Science & Tech (3) - Multidiscipline (3) - English (12) - Engineering essentials (ethics, environment, laws, etc.) (6) 	<ul style="list-style-type: none"> - Mathematics (9) - Physics (6) - Chemistry (3) - Physics lab (2) - Chemistry lab (1) 	<ul style="list-style-type: none"> - Drawing (3) - Mechanics* (3) - Material (3) - Programming (3) - Electrical Eng (3) - Internship (2) - Program specific** 	No specific requirement except the senior project course (3) is required.

* The course can be replaced by Statics (3) if a program has Dynamics (3).

** For mechanical engineering program, the program selects two courses (6) from Thermo-dynamics, Fluid mechanics, Mechanics of materials or Manu-facturing processes.

Figure 2 shows a program structure of the new curriculum. Mathematics, basic science, and basic engineering are concentrated in the first two years as in the 2002 curriculum. However, for the third year, both design and experiment are emphasized as their course series are developed in the new curriculum. In the final year, the focus is also back to a one-year group project along with elective advanced courses.

In the first course of the design course series, students learn about design concept, basic mechanical components, standards, and basic assembly. After that, they learn machine element design together with energy thermo-fluid system design. Lastly, both mechanical and thermal-fluid engineering knowledge must be together applied and realized their relationship into a system design project, where in the final stage of the project, every student is encouraged to built and test a designed prototype.

To prepare their ability in building and testing the prototype, students theoretically learn about manufacturing processes, and also have hand-on experience in basic machining and measuring tools in the manufacturing process course as well as experimentation skills in the experiment course series. In the experiment course series, Experiment & Lab I is added in the new curriculum to familiarize students with basic measurement instruments. In Experiment & Lab II, students learn more about uncertainties in experiments, instrument selection, and design of experiment, and also examine a behavior of small mechanical systems. In the last course, they are expected to apply experimentation skills for larger and more complex mechanical systems.

Meanwhile, presentation and writing skills are built in these two course series as well as in English writing and presentation courses. In addition, engineering mathematics and numerical analysis will help students in analyzing, interpreting, and understanding of complex design problems and experimental results.

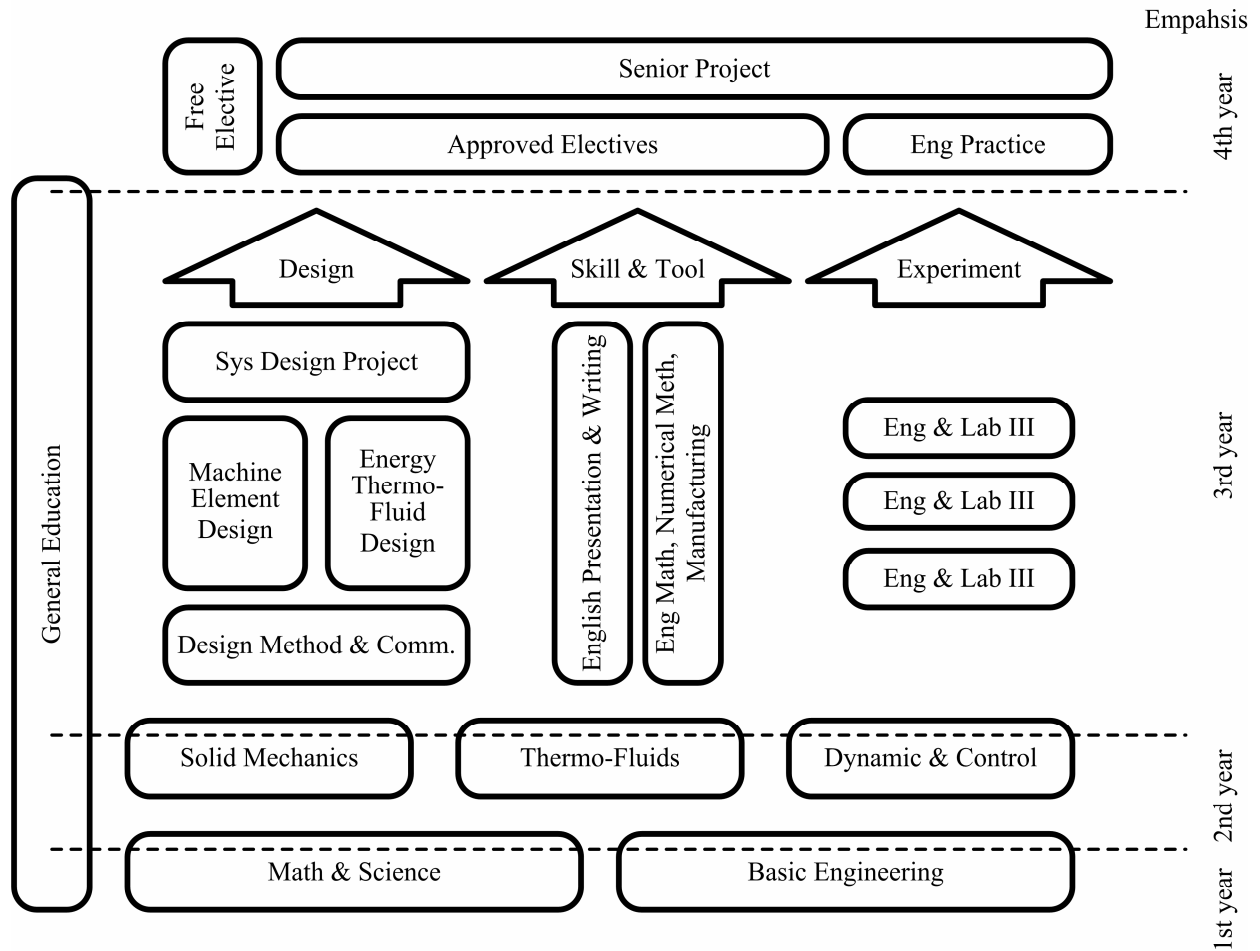


Figure 2 Program structure of the new mechanical engineering curriculum

The total credit of new curriculum is 146. Figure 3 compares the ratios of credit numbers of each course category to the total credit number between the 2002 and the new curriculum. It shows that, with the demands aforementioned, the new curriculum sacrifices the credit numbers of basic engineering & core courses (solid mechanics, dynamics & control, thermo fluids) as well as advanced elective courses (approved & free electives) by about one-fifth from the previous curriculum. These decrements limit the flexibility in tailoring the curriculum to ensure the successful delivery the outcomes, and are mainly a result of the increment in credit numbers of general education courses that are consisted of English, social science, humanity, ethics, environment, laws, and etc. These course and respective desired outcomes should be intensely addressed in the future.

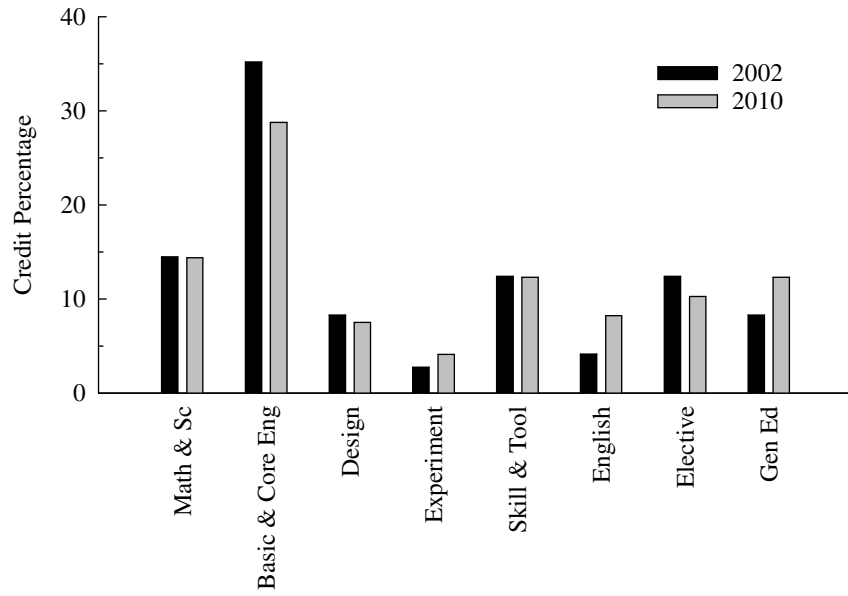


Figure 3 Comparison of percentage of credits between previous and new curriculum.

B. Long Term Procedure

As the program administration and quality assurance committees overlook the program management, outcomes and performances, and give feedbacks to the corresponding groups, it requires a ton of human and financial resources to collect all necessary information. To facilitate this operation, several systems and tools are developed in both university and department levels to gather information for the program administration and quality assurance committees.

In the university level, an on-line assessable evaluation form to monitor course wise quality has been adopted since 2009 by the University in order to reduce time and workload. Topics that are evaluated consist of teaching plan, teaching techniques, analysis & synthesis encouragement, content connection, self-learning, opinion expression encouragement, teaching materials, and students' understanding evaluation. All subjects are evaluated by students at the end of each semester, and the results of course evaluation will be feedback to the program administration and quality assurance committees to individual lecturers.

In the department level, at the beginning of quality assurance system adoption, the evaluation on overall outcome and performance of the program will be heavily relied on the senior project course as the systematic evaluation has already been developed and implemented by course committees for over 5 years. The evaluation emphasizes on students' design process, including their principal understanding in applied fundamental knowledge, teamwork, self-discipline, and presentation & writing skills. However, such evaluation should be expanded to design and experiment course series in the future in order to measure the success of outcomes in each course series.

Furthermore, a tool to examine the graduates' opinions on necessary professional competencies including feedback on the department's course wise quality is also developed and deployed, and

the data processing is still ongoing. The questionnaire consists of competencies related to the graduate attributes including other information such as graduates' job, salary, and general opinions.

Recently, the department also starts the syllabus revision for every course in the mechanical engineering program. This syllabus revision aims to survey a contribution of each course in creating the graduate attributes to students. In addition, all staffs will also be reminded about their duty to deliver some graduate attributes to students through their course subjects.

These mentioned systems and tools will help the program administration and quality assurance committees to monitor the program, and initiate change at least in the department level via the concerned divisions and working groups as well as communicate with the outside groups on other course series. However, it might take few years before all systems and tools work effectively.

V Conclusion

The undergraduate mechanical engineering curriculum at Chulalongkorn University, Thailand, is now being revised to comply with new regulations and quality assurance, demanded by the educational and professional organizations as well as the globalization of engineering education. With the curriculum rigidity from regulations, it is clear that delivery of the desired outcome is not possible without changes in structures and teaching/learning approaches. That is, the only real opening for improvements is in management and educational improvements that are not formally included into the curricula but can be carried out and continuously adapted.

The program management was re-structured by the interaction of the academic disciplines and desired outcomes/competencies such that the design and experiment skills can be integrated across course series. Then, the quality assurance is used to check outcomes and providing feedbacks for continuously adjustments. This development requires very high human and financial resources, making the process very challenging in the current situation. However, the continuous development on curriculum and quality assurance systems is particularly crucial in this highly competitive era.

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