Improving Engineering Programs at Kuwait University Through Continuous Assessment: Preliminary Results

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Abstract

The initial stages of the implementation of continuous assessment plans for the engineering programs at Kuwait University have been completed. Assessment is conducted at the course and program levels through direct and indirect measurements, and the results are being used for improvement. Although it is still early to evaluate the complete impact of the assessment process on student learning, preliminary results have been helpful in identifying issues that warrant immediate attention. It is expected that through this process the college and its programs will be able to improve curricula as well as other services that they provide to their constituents.

Introduction

The College of Engineering and Petroleum at Kuwait University, in line with its efforts to improve and maintain the quality of engineering education offered by its programs, has established a continuous assessment process based on the new ABET Engineering Criteria 2000 (EC 2000) [1]. This paper presents the thus far experiences in implementing the assessment process and in using the results for improvement. The process includes a structured methodology for establishing educational objectives and outcomes at the program and course levels, development of required assessment instruments, identification of key institutional practices that need to be aligned, and training programs to help instill the mindset of the new criteria in all concerned parties[2-4]. The process has been in place for the last two academic years and it is producing results. At the course level, faculty are re-examining the course outcomes to ensure higher levels of student learning based on Bloom's Taxonomy[5], and that they can be easily and accurately assessed. Teaching delivery and assessment is thus better aligned with the objectives and outcomes of the courses. In other words, in planning a course delivery, the contents and course objectives, instructional methods used, and assessment, are considered as a system that works in a cyclic improvement process[6]. At the program level, the content of all courses and other activities are being re-examined to ensure that the program objectives and outcomes are thoroughly addressed resulting in a coherent curriculum. Specifically task groups at the college level have been formed to study in depth the teaching practices and content with regard to major design experience, communication skills, and laboratory pedagogy, because of clear evidence from all constituents indicating the need for improvements. The following sections include sample results of direct and indirect measurements of program outcomes as well as corrective actions proposed to improve the program.

Program Assessment – Direct Measurements

At the course level, instructors individually perform the initial assessment. The main assessment tool used is the Instructor Class Evaluation Form[7]. This form reports the grade distribution as well as the assessment of program outcomes served by the course. The instructors evaluate student performance relative to what is normally expected from them at their level according to the following scale:

1 Students' performance was very weak
2 Students' performance was unsatisfactory
3 Students' performance was barely acceptable
4 Students' performance met expectations
5 Students' performance exceeded expectations

The instructors are asked to provide feedback on the course content and outcomes, instructional and assessment methods. They also comment on the achievement of program outcomes and indicate any deficiencies observed. Depending on the nature of the course, in addition to sample student work submitted as evidence, instructors use specific tools, such as team evaluation form, written report evaluation form, etc. to document their assessment. Teaching area groups perform the second assessment at the course level. Each group evaluates the assessment results for the courses in their area to ensure the achievement of course objectives. In addition, they provide feedback to the undergraduate program committee for program level assessment[4].

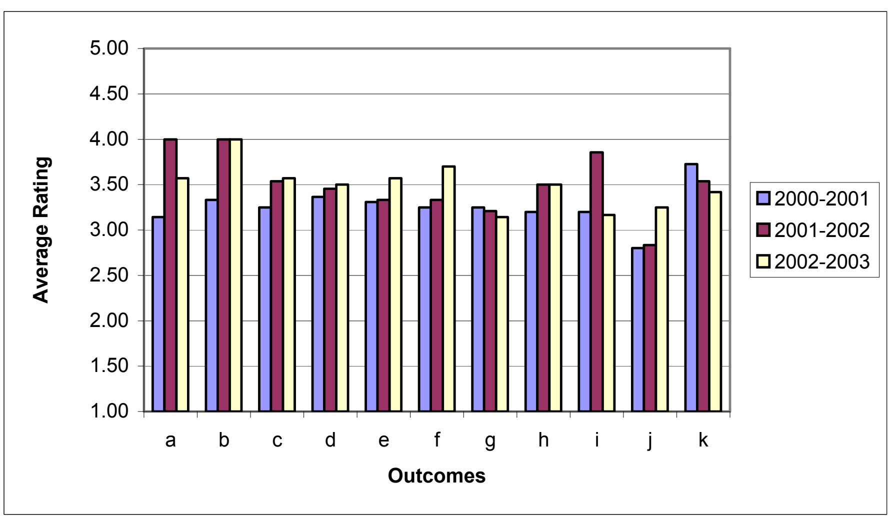

Figure 1: Direct measurements of program outcomes through course assessment

Figure 1 shows the average ratings from the instructors' evaluation of senior level courses offered by the Mechanical Engineering Program for the last three academic years. Note that the program outcomes assessed are essentially parallel to those required by Criterion 3 of ABET EC2000 given later in Table 1. As can be seen from the figure, student performance for most outcomes is rated as "acceptable", which indicates that the faculty are not completely satisfied with the student performance. It is important that care must be taken in interpreting the results since we are still in the early stages of implementing the assessment process, and faculty expectations and interpretations may not be consistent. Although there are improvements in course design and instruction over the last few years, more work is needed to standardize the whole process so that more reliable direct assessment can be obtained.

Program Assessment – Indirect Measurements

At the program level, in addition to the direct measurements provided by the faculty through course assessments, several surveys are conducted periodically to provide feedback from various constituents of the program[7]. All graduating students are required to complete an on-line exit survey as part of their graduation requirements. The exit survey is arranged into several parts covering different aspects of student life at the college such as achievement of program outcomes, quality of learning environment and support services. The students are also asked about their future plans. On the average about 250 students complete the survey every year. For comparison purposes the results are tabulated for the whole college as well as for individual programs. Figure 2 shows the comparison of the students' responses on the outcomes of the Mechanical Engineering Program over the last three academic years. The rating scale is from 5-very well prepared to 1-not prepared. On the average students consider themselves to be well-prepared on most of the ABET Criterion 3 outcomes, with the exception of the outcomes related to impact of engineering solutions, knowledge of contemporary issues, and life-long learning. Some improvements in students' ratings are evident in the areas of design, teamwork, communication skills, understanding of ethical responsibilities, and the use of modern engineering tools. This is expected since much emphasis is placed nowadays on these skills. When asked about their future plans, about 35% of the students indicated that they prefer working in the public sector, 35% in the private sector, about 20 % showed interest in graduate education, and about 10% had an interest in establishing their own business.

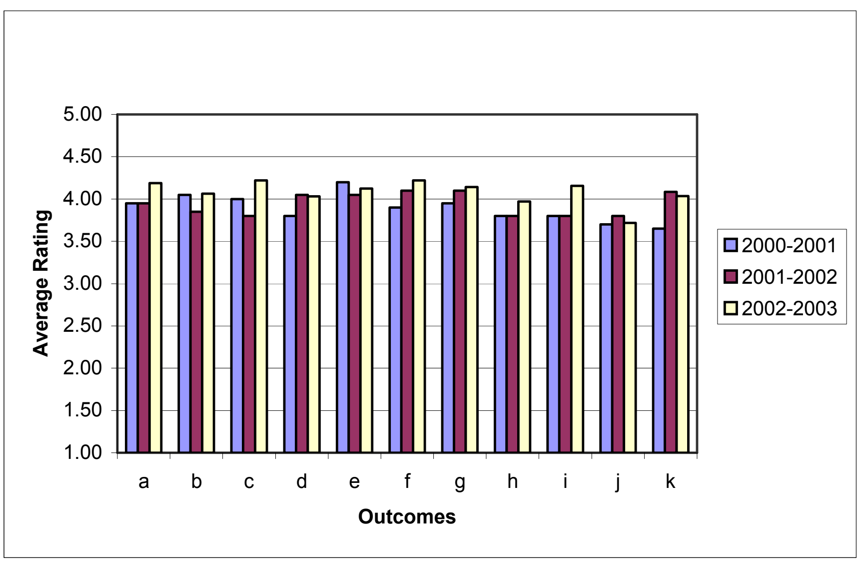

Figure 2: Indirect measurements of program outcomes through exit survey

Another indirect measurement is through an alumni survey, which is conducted every three years. The first survey was conducted in May 2003. This survey solicits opinions and suggestions from the college graduates. Respondents include some recent graduates as well as some with more than 15 years of experience. They are asked to rate and comment about the

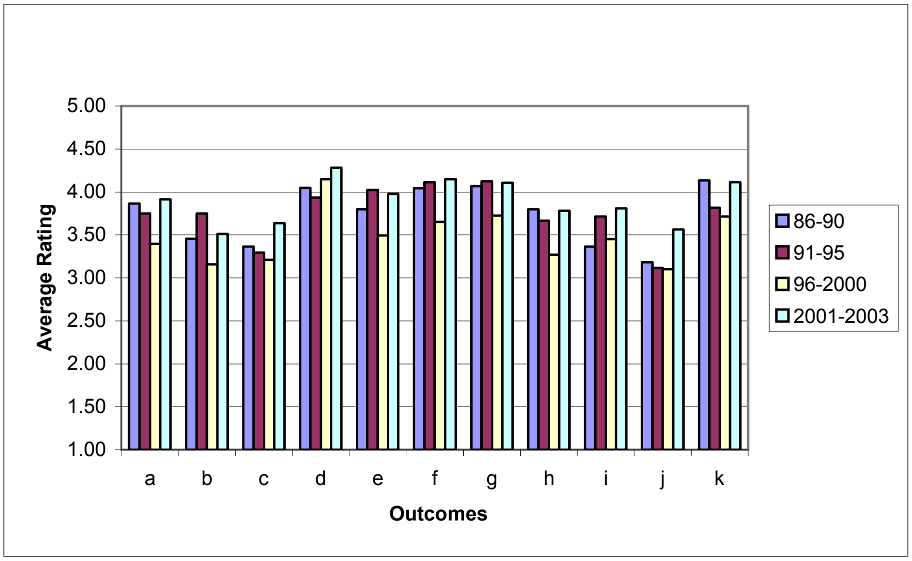

Figure 3: Importance of program outcomes according to alumni

importance of the program outcomes to their employment (5 - extremely important to 1 - not important) as well as their level of preparation (5 - very well prepared to 1 – not prepared) during their college education with respect to the same outcomes. Figure 3 shows that all outcomes are considered as important to very important for the careers of the alumni. It is worth noting that the areas related to teamwork, problem solving, professional and ethical responsibility, communication skills and the use of modern tools received relatively higher ratings, which reflects the trends in the workplace requirements. Figure 4 clearly shows the varying levels of satisfaction of graduates with respect to their preparation in the college. The data is stratified with five-year increments (nominal duration for graduation). The college graduates prior to 1995 consider themselves not prepared for most of the outcomes. Significant improvements in the level of satisfaction of the graduates after 1995 is due to the efforts of the college to improve design education and its integration in the programs. Furthermore, in the latter years, there has been an increased awareness of, and emphasis on certain outcomes such as teamwork, communication skills, professional and ethical responsibilities.

Finally, as another indirect measurement, an employer survey is conducted every four years. The first employer survey was conducted in Fall 2001. Among other issues, the employers are asked to rate and comment about the importance of the program outcomes in relation to their requirements (5 - extremely important to 1 - not important) as well as the capabilities of the college graduates (5 - very strong to 1 – poor) with respect to the same outcomes. As shown in Figure 5, the employers rate all the outcomes as important or very important. Similar to the alumni response, teamwork, problem solving, professional and ethical responsibility, communication skills and the use of modern tools also received relatively higher ratings from the employers. Employers rated the college graduates above average with respect to all outcomes. However, college graduates' communication skills received relatively low ratings indicating a need for improvement in this area.

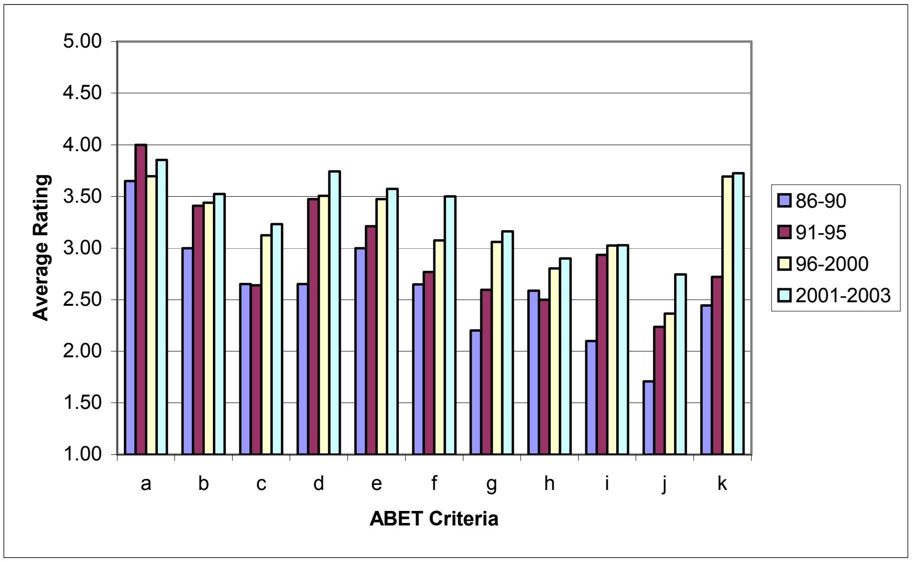

Figure 4: Indirect measurements of program outcomes through alumni survey

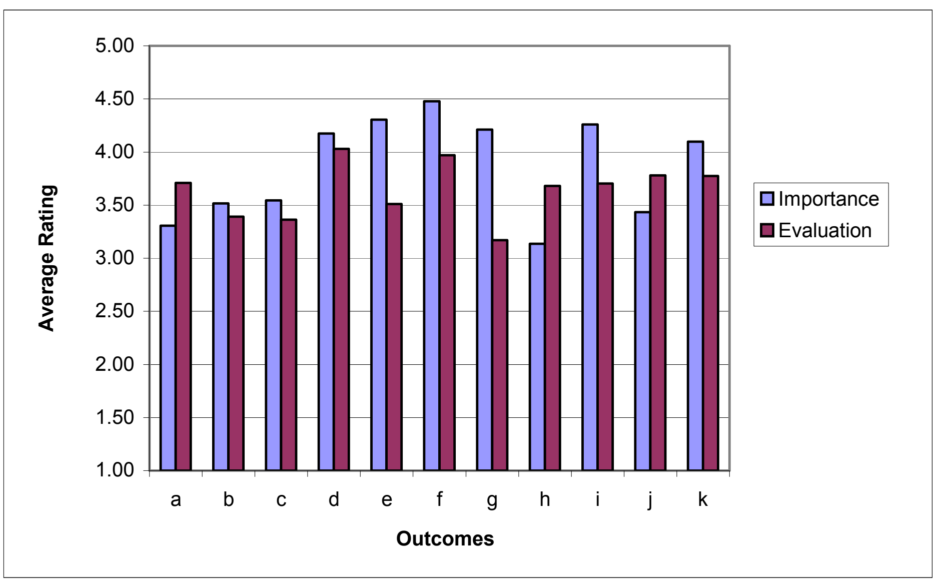

Figure 5: Importance and evaluation of program outcomes according to employers

Formulation of Corrective Actions

In order to complete the feedback loop in the assessment process, corrective actions must be formulated and implemented. The first corrective action taken is the revision of the assessment process itself starting with the program educational objectives and outcomes. Originally, the faculty with minimum involvement of other constituents drafted these objectives, which mostly referred to the abilities of the graduating students. With feedback from constituents such as students, employers and alumni, a new set of educational objectives was developed. These are statements describing the expected accomplishments of graduates during the first few years after graduation and they are:

1. To provide the necessary foundation for entry level engineering positions in the public and private sectors or for advanced studies, by a thorough instruction in the engineering sciences and design.

2. To provide an integrated experience to develop skills for responsible teamwork, effective communication and life-long learning needed to prepare the graduates for successful careers.

3. To provide a broad education necessary for responsible citizenship, including an understanding of ethical and professional responsibility, and the impact of engineering solutions to society and the environment.

The three objectives together address the needs of all constituencies. Although, all the objectives are student centered, one may conclude that the first objective is intended to address the needs of the students specifically. With the education they receive at the college, they should be able to find a job of their choice or continue their education. The second objective is intended to address the requirements of the workplace for capable and productive employees. The last objective addresses the needs of the society at large for responsible citizenship.

Program outcomes, which are the statements that describe what students are expected to know and are able to do by the time of their graduation, were also revised. The program outcomes and their relationship to educational objectives are given in Table 1. Achievement of all program outcomes indicates that the graduates are equipped to achieve the program educational objectives. With the exception of the last one, the outcomes are essentially parallel to those listed under Criterion 3 of ABET EC2000 and to those specified in the program criteria. The last outcome is developed to address the needs of the constituencies since both the employers and the alumni expressed a strong interest in these areas. All the outcomes are developed into a) outcome attributes, which are directly measurable through course assessment, b) practices to address the outcome attributes, and c) assessment methods and tools[8]. Currently, work is underway to revise the course outcomes based on the revised assessment plan and the appropriate levels of learning according to Bloom's Taxonomy.

Further, at the college level, three sub-committees of the College Undergraduate Program Committee (UPC) were formed to study in depth the teaching practices and content with regard to major design experience, communication skills, and laboratory pedagogy, because of clear evidence from all constituents indicating the need for improvements in these areas. The subcommittees have submitted their final reports at the end of May 2003. Based on these findings, a detailed strategic plan for the identified focus areas has been drafted. The plan includes objectives, strategies to achieve these objectives, and the action items required to implement the strategies. The plan also includes the parties responsible for individual actions, timelines, milestones and metrics as appropriate. The outline of the plan is given below.

Table 1 : Relationship Between Program Educational Objectives and Outcomes

	Program Outcomes	Educational Objectives		
		1	2	3
a	An ability to apply fundamentals of mathematics, science, and engineering science in modeling and analyzing engineering systems.	✓		
b	An ability to design and conduct laboratory experiments, and analyze and interpret experimental data.	✓		
c	An ability to design and realize both thermal and mechanical systems, components, or processes to meet desired needs.	✓	✓	✓
d	An ability to function as effective members or leaders in teams.	✓	✓	✓
e	An ability to identify, formulate, and solve engineering problems.	✓	✓	
f	An ability to identify and critically analyze ethical issues that arise in various situations, and respond according to the codes of ethics of the profession.			✓
g	An ability to communicate effectively in oral and written form.		✓	
h	An awareness of the impact of engineering solutions on safety, health, welfare, and the well being of the society and the environment.			✓
i	An ability to acquire new knowledge independently, and a recognition of life-long learning as a necessity for progress in the profession.	✓	✓	✓
j	An awareness of emerging technologies in local and global context, and involvement in discussions of contemporary issues related to society.		✓	✓
k	An ability to utilize state-of-the art hardware and software tools for problem solving and design that are necessary for engineering practice.	✓	✓	
l	A proficiency in the areas of Mechanical Engineering that are important to Kuwait and the region, such as the design, analysis and maintenance of machinery, refrigeration, air-conditioning and desalination systems.	✓	✓	

Outline of the strategic plan

Objective 1: Improve teaching and learning in laboratory courses

Strategy A: Develop a comprehensive assessment plan for lab courses

Action 1: Develop generic objectives/outcomes for Lab courses
Responsibility: Vice-dean Academic Affairs, Office of Academic Assessment (OAA)
Milestones: Generic objectives published by Fall 2004

Action 2: Revise syllabi of Lab courses including detailed outcomes
Responsibility: Departmental UPC
Metric: Revised syllabi published, Fall 2004

Action 3: Assess the effectiveness of Lab courses
Responsibility: Departmental Assessment Coordinators, Teaching Area Groups, OAA

Timeline: Ongoing
Metric: Degree of achievement of Lab objectives as measured by student/faculty surveys

Strategy B: Improve teaching capabilities of lab instructors

Action 1: Develop and offer workshops for faculty and TA's
Responsibility: Vice-dean for Academic Affairs
Milestones: First workshop to be offered in Spring 2004, then every year
Metric: Number of instructors participated, workshop evaluation

Action 2: Clarify the roles of Lab instructors
Responsibility: Vice-dean for Academic Affairs, Dept. Chairs
Milestone: Guidelines published by Fall 2004

Action 3: Encourage and monitor full attendance of Lab engineers during lab classes
Responsibility: Administrative Affairs, Chief engineers, Faculty
Timeline: Ongoing
Metric: Full attendance achieved as demonstrated by attendance reports

Action 4: Recognize Laboratory teaching load
Responsibility: Dean, Dept. Chairs
Milestone: Guidelines for teaching load for faculty and engineers specified, Spring 2004

Strategy C: Maintain and upgrade lab facilities

Action 1: Implement a plan for maintenance and upgrade of Labs
Responsibility: Dept. Chairs
Timeline: Ongoing
Metric: Satisfaction of faculty and students as measured by surveys

Action 2: Enforce safety regulations
Responsibility: Safety committee
Milestone: Safety folder distributed to all labs Spring 2004
Metric: Reduction in number of accidents, injuries

Objective 2: Ensure a meaningful major design experience for all graduating students

Strategy A: Review and revise curriculum for design courses

Action 1: Introduce corner-stone design courses in all programs
Responsibility: Vice-dean for Academic Affairs
Milestones: New major sheets include these courses, end of Fall 2004

Action 2: Investigate feasibility of a two-semester sequence for capstone design course
Responsibility: Vice-Dean Academic Affairs
Milestones: Decision whether to extend the course to two terms, Fall 2004

Action 3: Revise course outcomes to ensure that the design experience includes some overlooked elements of design (e.g., safety, ethics, life-cycle economics)
Responsibility: Vice-Dean for Academic Affairs, Dept. UPC
Milestones: Revised course descriptions by Fall 2004

Strategy B: Improve teaching and learning in design courses

Action 1: Develop and offer training workshops for concerned faculty and staff; also encourage and facilitate participation in design teaching workshops
Responsibility: Vice-Dean Academic Affairs
Milestone: Offer first workshop in Spring 2004, then every year
Metric: Number of faculty participated, workshop evaluations, mission reports

Action 2: Encourage and facilitate multi-disciplinary teaching
Responsibility: Dean, Vice-Dean for Academic Affairs
Milestones: Framework established, by-laws/policies issued by Spring 2005
Metric: Number of faculty participating in co-teaching

Action 3: Encourage and facilitate industry-sponsored projects
Responsibility: Dept. Chairs
Timeline: Ongoing
Metric: Number of industry-sponsored projects

Action 4: Encourage and facilitate co-teaching by practicing engineers
Responsibility: Dept. Chairs
Timeline: Ongoing
Metric: Number of seconded instructors from industry

Action 5: Recognize the importance of teaching the capstone design course and encourage more faculty participation
Responsibility: Dept. Chairs
Milestones: New incentives established, Fall 2004
Metric: Number of faculty teaching these courses

Action 6: Provide qualified technical personnel in design and manufacturing
Responsibility: Dean, Administrative Affairs, Chairs
Timeline: Ongoing
Metric: Faculty satisfaction of the staff as measured by surveys

Action 7: Establish and enforce formal guidelines for technical reports
Responsibility: Vice-Dean for Academic Affairs, faculty
Milestones: Report template issued and adopted by departments, Fall 2004

Action 8: Establish learning factory to improve design teaching
Responsibility: Vice-Dean for Academic Affairs
Milestones: Learning factory established (including some rapid prototyping equipment), Fall 2005

Action 9: Encourage and facilitate industrial sabbaticals/summer employments in industry
Responsibility: Dean
Milestones: Frameworks established, Spring 2005
Metric: Number of sabbaticals, summer works in industry

Objective 3: Improve written and oral communication skills of students

Strategy A: Increase opportunities for students to practice and improve their communication skills

Action 1: Enforce instruction in English
Responsibility: Dean, Chairs
Timeline: Ongoing
Metric: Percentage of instruction in English as measured by surveys

Action 2: Review and revise course outcomes to ensure sufficient opportunities for developing and assessing communication skills throughout the curriculum
Responsibility: UPC, OAA
Milestone: Revised assessment plans including detailed course outcomes, Fall 2004

Action 3: Provide feedback regarding English usage and grammar in student work
Responsibility: Faculty, Dept. Chairs
Timeline: Ongoing
Metric: Evidence of grading and feedback on sample student works, completed assessment tools

Strategy B: Review and revise curriculum with respect to English courses

Action 1: Reinstate English 098 Remedial course (investigate increasing contact hours/week to 20)
Responsibility: Dean, Vice-Dean for Academic Affairs
Milestones: Feasibility study by Fall 2004, Draft proposal by Spring 2005, ENGL-98 reinstated instead of ENGL 090 by Fall 2005

Action 2: Revise course outcomes for ENGL 123 (Intermediate Writing) and ENGL 221 (Technical Writing)
Responsibility: Vice-dean for Academic Affairs
Milestone: New course descriptions including oral presentation skills published, Fall 2004

Strategy C: Provide an adequate infrastructure for Language preparation

Action 1: Establish Engineering English Language Unit
Responsibility: Dean
Timeline: Feasibility study by Fall 2004, Draft proposal by Spring 2005, the unit established by Fall 2005

Action 2: Limit enrollment in English courses to 15 students/section
Responsibility: Vice-dean for Student Affairs
Milestone: Limits enforced by Fall 2004
Metric: Maximum, and average number of students registered in English courses

Action 4: Study the feasibility of a preparatory year in English
Responsibility: Vice-Dean for Academic Affairs
Milestone: Feasibility study by Fall 2004, Draft proposal by Spring 2005

Strategy D: Revise admission requirements to improve English proficiency of incoming students

Action 1: Institute a minimum acceptable equivalent GPA with the entrance exam for admission
Responsibility: Vice-dean for Student Affairs
Milestones: Feasibility study by Spring 2004, Draft proposal by Fall 2004, Change implemented by Fall 2005
Metric: Number of students not requiring remedial English

Action 2: Investigate the feasibility of requiring a certain TOEFL score for specifying majors
Responsibility: Vice-dean for Student Affairs
Milestones: Feasibility study by Fall 2004, Draft proposal by Spring 2005
Proposal implemented for certain programs in Fall 2005

Strategy E: Establish a liaison with High Schools

Action 1: Contact and coordinate with English program administrators
Responsibility: Vice-Dean for Student Affairs
Milestone: Initial contacts established, Fall 2004

Summary and Conclusions

The experience gained in implementing a continuous assessment process at the College of Engineering and Petroleum at Kuwait University has been presented. Program assessment results presented include data from courses as well as surveys. Corrective actions have been identified to address key issues such as the assessment process itself, design skills, laboratory experience and written and oral communication skills. At present, there is not clear evidence with regard to improvement of student learning, but there is a definite change in curricular content, classroom activities and assessment practices that the students are experiencing. It is expected that within the next three-year assessment cycle, improvements in student learning will be evident as well. This will be reflected in direct as well as in indirect measurements resulting in higher average ratings (well prepared and above).

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