

Developing electrical engineering education program assessment process at UAE University *

QA Memon [†] and A Harb

Electrical Engineering Department, UAE University, Al-Ain, United Arab Emirates

SUMMARY: *As the shape of industries within the United Arab Emirates (UAE) changes, it changes the job market and its expectations along the way. Electrical engineering education program assessment developed at the College of Engineering, at UAE University, is approaching its maturity level after a rigorous 10 years of efforts to develop an evolving program assessment process towards ABET accreditation in general, and industrial expectations in particular. This paper describes the program assessment process, along with its various component tools used to generate confidence in its effectiveness for continuous evolution of the program. It is shown how knowledge levels are measured, and skills and competencies of students are determined in order to improve the implementation of the program assessment. Finally, a software program application is developed to automate this cyclic process to reduce tiring paper work per outcome per term, and per program each year for periodic subjective assessment by program constituencies. This development has encouraged the faculty responsible for the program to focus on the program assessment process for its effective use in meeting expectations of UAE industry, in general.*

1 BACKGROUND

The universities in different countries follow their own curriculum development philosophies and processes with the intention of producing “environment-ready” engineers. The Accreditation Board for Engineering and Technology’s (ABET) criteria was introduced to rationalise the various curriculum development processes followed by different universities in the US. The ABET’s requirement for accredited programs to implement outcomes-based assessment models has stimulated the growth of formalised assessment of programs within the engineering and engineering technology communities. The ABET plan contains the specifics of a structured process, which validates that students are achieving the goals and objectives of the program via direct and indirect measurements.

Recent transformations in engineering education accreditation have shifted emphasis to focus on the documentation of student learning outcomes. The ABET Engineering Criteria 2000 (EC2000) demands that engineering programs show evidence of at least 11 skills in their students. Only five of these skills

relate to a student’s technical abilities. The remaining six define what have been called “soft” skills, and it is this shift in emphasis that carries significant impact on technical communication programs and pedagogy. To meet these criteria, the engineering institutions actively promote student development in knowledge, skills and behaviour in these areas, and measure the effectiveness of relevant instruction. Measuring student behaviour in these areas and showing positive change as a result of the time spent in the educational program creates a major challenge for educators (Culver et al, 2005). In essence, EC2000 has redefined both who is responsible for developing students’ communication skills and for documenting evidence of student learning outcomes (Williams, 2000).

Outcome-based education (OBE) is the paradigm shift resulting from the failure of traditional education to adapt to evolving demands of the local industry. This is due to the lack of respective focus in the education process. Traditional education narrowly focused on the content and produced students with varying degrees of achievement levels. Thus this model did not produce learners, which could perform effectively in the work place. OBE is a methodology of curriculum design and teaching that focuses on what students can actually do after they are taught. Thus, the OBE’s instructional planning process is a reverse of that associated with traditional educational planning. The desired outcome is determined first,

* Paper D08-047 submitted 11/11/08; accepted for publication after review and revision 23/09/09.

† Corresponding author A/Prof Qurban Memon can be contacted at qurban.memon@uaeu.ac.ae.

and then the curriculum, instructional materials and assessments are designed around to support and facilitate the intended outcome. Outcome-based assessment is the culminating part of OBE.

Currently, it is understood that a systematic process must be in place to assess the achievement of both the program outcomes (at graduation) and the program educational objectives (a number of years after the graduates left the program). The process needs to be ongoing to ensure the continuous improvement of each program with input from constituencies, process focus, outcome and assessment linked to objectives (Mourtos, 2006; Enderle et al, 2003). This requires that the program administration should deploy a continuous assessment process that provides meaningful input to future program development and allows the institution to strengthen its educational effectiveness (Stephanchick & Karim, 1999).

2 RELATED WORK

A number of methodologies have been developed in engineering programs preparing for accreditation under ABET criteria EC2000. Many of the commonly promoted assessment activities, such as exit interviews and employer interviews, require many years before trends can be established (Withington, 1999). Withington (1999) suggested methods to shorten the cycle time of assessment and produce documented progress in achieving educational objectives. Some of the works in literature have addressed students' perspective in engineering education (Schmidt et al, 2007). The main idea put forth by Schmidt et al (2007) was to open a dialogue with students on their instructional needs and challenges, and to determine how to conduct this process. Haag et al (2003) described the methodology used and the results obtained in the systematic web and literature search for instructional and assessment materials addressing EC2000 program outcomes. In another study, Koehn (2006) investigated the level at which the understanding of students for various subjects has been enhanced by involving students in projects associated with their curriculum and related studies, and suggested that knowledge and skills gained by students are greatly enhanced and complement the criterion required for accreditation. Heinze et al (2002) described development of several innovative tools to automate the processes of assessment and evaluation of outcomes of engineering college and individual ABET engineering programs. These tools depict quantitative information that is automatically plotted and users can view most recent results displayed relative to historical trends. A sustainable set of assessment tools have also been reported (Ahlgen & Palladino, 2000) to measure achievement of stated objectives and outcomes related to ABET EC2000 criterion. Ferguson et al (2007) described a project-based experiential learning experience, and

explained the process of establishing and validating learning objectives assessment systems, for which an assessment system is developed for measuring achievement of learning objectives.

As an example for ABET accreditation in the US, a number of research works have been published that described successful implementation of ABET accreditation process and how continually changes are being made within that process (DeLyser & Hamstad, 2000; Schachterle, 1999). A number of engineering institutions outside the US have received substantial equivalency with the accredited US engineering programs with respect to EC2000 criterion, for example in Germany (Julliard et al, 2001). An effort to create competency related to engineering technology programs is required (Earnest, 2005) to help in the development of the competency-based curriculum. The respective authors exercised this attempt to usher in some level of rationalisation of Indian technical education system. Yahya (2007) described the issues in engineering accreditation of programs in developing countries, where global accreditation standards are sought at the expense of local considerations in engineering programs, and thus accreditation criteria is satisfied only partially.

The Department of Electrical Engineering (EE) at UAE University has embraced the general philosophy of OBE, and has engaged in an ongoing assessment process put forth to establish and review the program's education objectives (long-term objectives) and outcomes (at the time of graduation) by utilising a set of tools that do direct and indirect measurement of program assessment components. In the next section, the program assessment process and its components adopted at the EE department of UAE University are described. This paper discusses components and assessment tools, implementation of an application developed at EE department, along with assessment results for comparison purposes. In section 6, conclusions are presented.

3 PROGRAM ASSESSMENT PROCESS

The program outcomes that have been established as goals of the EE program follow closely the ABET (2007) required outcomes. Achievement of these outcomes in the context of an EE program would meet the program objectives. Thus, the EE program is specifically designed to provide the graduates with the knowledge and skills needed to succeed in today's workplace and in advanced studies. The desired outcomes of the EE program that have been set based on educational objectives require that every student graduating from this program should demonstrate the following abilities (ABET, 2007):

- a) Ability to apply knowledge of mathematics, statistics, science and engineering principles. The mathematics knowledge includes linear algebra,

vector algebra, partial differential equations, complex analysis, and probability and random processes.

- b) Ability to design and conduct experiments safely, as well as to analyse and interpret data.
- c) Ability to design electrical components, systems or processes to meet desired specifications and imposed constraints.
- d) Ability to work in teams, including multidisciplinary teams.
- e) Ability to identify, formulate and solve problems encountered in the practice of EE.
- f) Understanding of professional and ethical responsibility.
- g) Ability to communicate effectively orally and in writing.
- h) Ability to understand the impact of engineering solutions in a global and societal context.
- i) Recognition of the need for and an ability to engage in life-long learning.
- j) Knowledge of contemporary issues.
- k) Ability to use the techniques, skills and modern engineering tools necessary for EE practice.

The program educational objectives based on the mission of UAE University are shown in table 1. The mapping between educational objectives and related program outcomes is not done directly.

Table 1: EE educational objectives.

Educational objectives
1. Graduates should have adequate skills, including problem solving, analysis, design and hands-on experience, necessary for successful careers in industry or for pursuing graduate studies.
2. Graduates take pride in their profession and are aware of ethical work conduct, as well as environmental and societal implications of engineering solutions.
3. Graduates should be self-confident and have necessary communication skills and attitude to become teamwork leaders.
4. Graduates should be able to develop and update their knowledge and skills in order to keep up with rapidly evolving technologies.

The program educational objectives do affect determination of program outcomes as these outcomes reflect achievement of program objectives. The level of achievement of program educational objectives is determined through input from program constituencies enabled by rational and subjective assessment of program outcomes. Thus, the Department of EE has established an assessment process that is executed for continuous improvement of the undergraduate program and the department’s educational operations. This process can be visualised as shown in figure 1.

In fact, the program assessment report consists of two parts: annual report prepared by the assessment committee and the input from academic advisory body from its previous visit, ie.

$$PA[j] = W_1AR[j] + W_2I_{ABET}[j - 1] \tag{1}$$

where PA , AR and I_{ABET} stand for program assessment, annual report and input from ABET, respectively. The term j indicates current year, and W_1 and W_2 are assigned weights based on a particular criteria set by the EE departmental council during that year. There exists a dependency between W_1 and W_2 in cases when there are corrective measures to be taken based on ABET comments on the assessment process. This, in turn, depends on how well stakeholders’ opinion has been incorporated at various levels of the assessment process. In short, it can be said that the

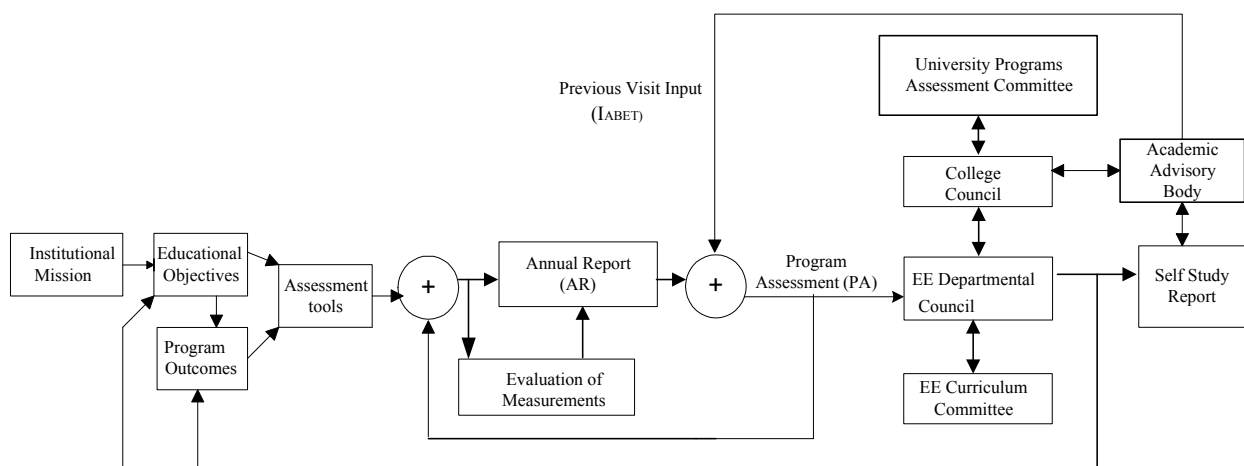


Figure 1: EE program assessment for continuous improvement.

annual report combines ABET feedback to generate program assessment, where as the annual report is prepared using previous program assessment combined with assessment measurement results obtained by various tools in the current year and from at least previous one year. This can be written as:

$$AR [j] = PA [j-1] + \frac{1}{N} \sum_k T_k [i] + \frac{1}{N} \sum_k T_k [i+1] + \frac{1}{N} \sum_k T_k [i+2] + \dots \quad (2)$$

where $T_k[i]$ stands for measurement result using specific tool i for the measurement k , and N stands for number of measurements considered for averaging. The assessments are measured twice per year (ie. once per each term of the year), and thus term k typically may range from 1 through 4, so N would equal 4 in this case. The various tools (ie. direct and indirect approaches) are implemented to assess the program outcomes. The annual program assessment followed by its local (university, college and department) evaluation and the input from the (external) accreditation body set the benchmark performance limits of the program assessment. These two components form the (bottom) two feedback paths in figure 1. In fact, there exists another outer loop that refines the program educational objectives set by its constituencies. These loops can be seen clearly in figure 2. The averaging methods are used to generate confidence in the assessment process: ensemble averaging over a number of quantitative assessments within a term (and the same holds for student and instructor assessments, respectively); time averaging of similar assessments over a number of years.

The continuous improvement of program assessment requires that respective feedback be used to refine educational objectives and corresponding program outcomes together with improvement of corresponding tools of assessment. The (local) college evaluation is generated within the same year, followed by input from the academic advisory body during the respective visit made to the college after self study report is prepared.

4 ASSESSMENT VEHICLES

Successful achievement of the EE program at UAE University is determined by ensuring that its graduates achieve the program outcomes and program educational objectives. As shown in figure 1, assessment tools are developed using program educational objectives and outcomes. The achievement of the objectives and outcomes is monitored and assessed using the following tools:

- curriculum quantitative assessment
- capstone course (graduation project)
- exit exam
- student exit interview survey
- internship survey
- alumni survey
- employer survey.

There also exists two industrial advisory boards – one at departmental level, and the other at the college – to evaluate educational objectives, program outcomes, annual program assessment and various assessment tools. Additionally, a college

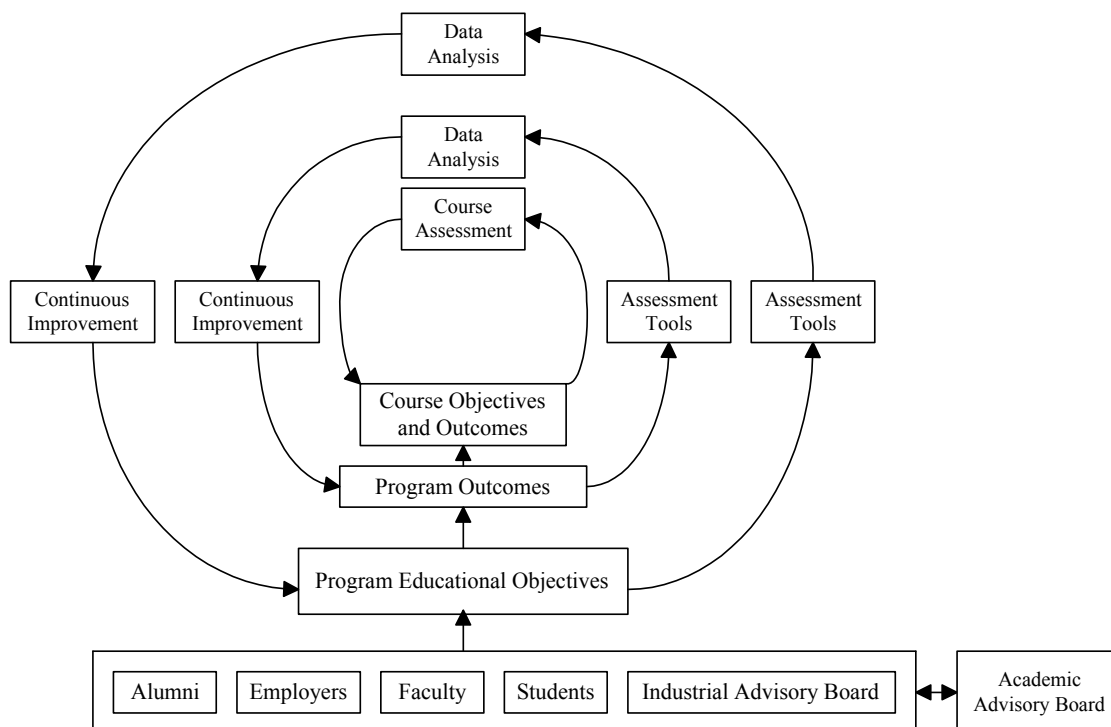


Figure 2: Continuous improvement loops for the program.

academic advisory board exists to provide input on the assessment process. These tools and advisory boards help in direct and indirect measurement of the assessment process.

In case of curriculum quantitative assessment, the EE Programs Assessment Committee selects a set of courses (the most relevant for the targeted outcome) related to each program outcome to be assessed during that semester. Curriculum assessment is done collectively with the participation of all faculty members of the EE department. The curriculum assessment process involves three performance measures: Student assessment (S), faculty assessment (F) and quantitative assessment (Q). The qualitative data collected from the instructor and student assessment of course surveys on the outcomes of each course is analysed and mapped to the corresponding program outcomes. Then the average of all courses (related to each outcome) is calculated to obtain the program outcome achievements (using individual terms in equation (2)).

Some of the program outcomes like multidisciplinary teams (*d*), ethical responsibility (*f*), communication skills (*g*), social impact (*h*), life-long learning (*i*) and contemporary issues (*j*) are best assessed qualitatively through the capstone course, internship and extra curriculum activities. The strong participation in the IEEE student branch, for example, gives a good indication on the tendency of the students towards life-long learning and keeping up to date with contemporary issues. The other factor is participation (attendance and organisation) of students in extra curriculum activities (such as open day, activities day, workshops, field trips, seminars, etc). Effectively, the extra curricular activity where students meet people from different disciplines and different environments and participate in discussion has direct impact on outcomes *d, f, g, h* and *j*. During the last few years,

the EE department at UAE University is continuously organising such events to usher in such values in students to reflect respective skills.

Generally, it is argued that the relatively longer duration in industrial training helps in job placements later. The College of Engineering at UAE University requires its students to conduct internships or industrial training after students have finished their third year of engineering education. The duration of this training, with UAE University being the only university in the region, amounts to 16 weeks (equivalent to a normal semester) at specialisation-specific industries. This extensive training (prior to a capstone project) is an indicator of how program curriculum contributes in improvement of program outcomes *d, f, g, h, i* and *j*. This type of activity conducted twice a year is measured through an internship survey accumulated over a number of students before being included in program assessment.

In an alumni survey, an attempt is made to measure success by directly asking the alumni for their opinion of how well they are fulfilling the objectives. Similarly, in an employer survey the employers who employ our graduates are directly asked for their opinion about skills of our graduates and how well our graduates are fulfilling the program objectives. As regards to the exit interview, this interview form is developed in order to poll the opinion of graduating EE students on the EE program outcomes, and the way they feel the program has helped them acquire the skills and abilities stipulated in the ABET criteria 3.

The items assessed using various tools and respective constituent bodies are shown in table 2. These assessment tools utilise information from faculty, students (present and graduates) and industry (employer, internship supervisors). The assessment data are used to improve the curriculum and the

Table 2: Assessment tools, items, and administrative bodies.

No.	Assessment tool/advisory boards	Items assessed	Administered by
1	Curriculum assessment	Program outcomes	EE assessment committee
2	Alumni survey	Program outcomes, educational objectives	Dean’s office, EE department
3	Employer survey	Program outcomes, educational objectives	Dean’s office, EE department
4	Capstone course, internship survey	Program outcomes	Industrial Training & Graduation Project Unit (ITGPU)
5	Exit exam	Program outcomes	ITGPU
6	Student exit interview survey	Program outcomes	EE assessment committee
7	College industrial advisory board	Program educational objectives	College board
8	College academic advisory board	Program outcomes, educational objectives	College board
9	EE industrial advisory board	Program outcomes, educational objectives	EE department chairman

courses. It is also used by the faculty to update the outcomes and performance measures.

5 ASSESSMENT PROCESS IMPLEMENTATION

As the program assessment process is cyclic and requires extensive manual calculations per outcome per term, and per program each year, these turn out to be tiring and involve a lot of paper work. The objectives of this research work included a development of an application that not only automates the calculations within the loops of the process, but exhibits flexibility at the same time to embed on-going changes within the assessment process. In order to implement this, a program was written to embed two inner loops (using equations (1) and (2), and as in figure 2) that include course assessment and program assessment cycles. The innermost loop (in figure 2) includes all assessment (quizzes, labs, project, exams, etc.) grades per each course – this exercise reflects individual terms without sum and divider N in equation (2). The course grades are mapped to outcomes so the quantitative assessment of the course is directly obtained. The score of each outcome is calculated based on the weighted averaging of all assessment elements mapped to the specific outcome – the element being a quiz (small) or a question within an assessment (eg. progress exam, mid-term, final, etc.). The weight comes from the weight of the question within the assessment and from the weight of that exam out of total. The final score is normalised to 100. Once the faculty (F) and student (S) assessments are included in the system, the outcomes data for all courses are available.

The second loop (in figure 2) deals with program outcomes. First, clusters of courses for each outcome

are developed based on a respective (higher weighted) targeted outcome. The primary objective of this clustering is to remove unnecessary calculations done due to the insignificant impact of the majority of the courses for a particular course outcome, since each course may not target all program outcomes with the same weight. This simplifies the calculations, without much difference. It also helps in reducing the course assessment load on each faculty each term, and the same for the assessment committee. The sample clusters are shown in figure 3. For example, in the cluster related to outcome A, there are six courses. When we examine the course outcomes (COs) of each course, we found that Signals & Systems maps to outcomes A by 88% of its COs, Random Signals and Fundamentals of Microelectronic Devices by 83%, Engineering Electromagnetics by 82%, and Electric Circuits-I and Electric Energy Conversion by 50%. Thus, the courses mapped to program outcome A by less than 25% were not added to the cluster. It was thus concluded that a 25% threshold would be used for course mappings in order to be included in the cluster.

Next, for instructor and student inputs and for the quantitative results, the score of a specific outcome is calculated based on the weighted averaging. The weight comes from the number of credit hours associated with each course. The output is a comparative result showing all outcome scores from the three performance measures (ie. Q, S and F). Thus, average scores of Q, S and F per outcome are calculated and results may be shown in comparison graphs, for final subjective assessment by constituencies. As an example, the sample results from assessment process in years 2005 through 2007 are shown in figures 4 and 5, and tables 3 to 5. Figure 4 and tables 3 and 4 show satisfactory

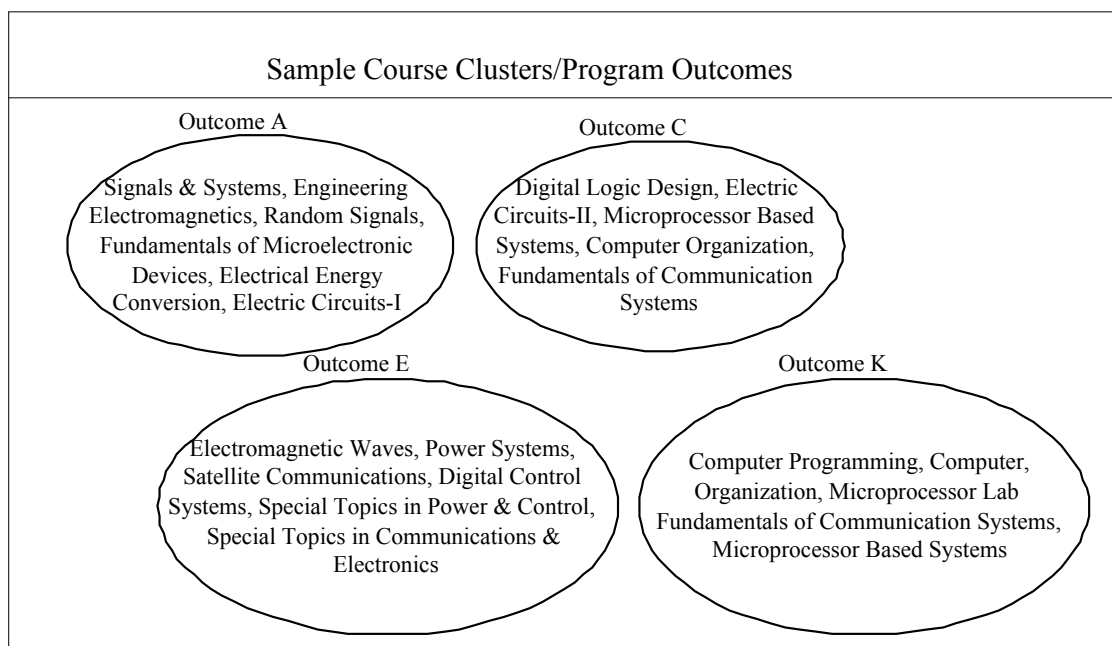


Figure 3: Sample course clusters.

outcome measurement on a scale of 1-5, where 5 is the highest value. The satisfactory measurement is currently scaled at 2.5 on the scale of 1-5, set by EE Departmental Council with recommendations from the industrial advisory board. The little discrepancy found in exit exam column (shown as a measurement value of 1 in table 4) was later investigated and found out to be based on the quality of questions asked in the exit exam, as most of the students forget the technical details of each subject or a course topic learned two or three years earlier than they take the exit exam. The exit exam is currently under revision to balance out this discrepancy.

To further elaborate measurements, table 5 shows a summary of satisfactory results for a typical program outcome *b* for years 2005 through 2008. The comparison of student assessments using different performance measures is shown in figure 5 and table 6, where it can be observed that there are large outcome assessment discrepancies between the student assessment, and quantitative assessment. Figure 5 and table 6 show the percentage of deviation between Q and S, and is calculated as $100*(S-Q)/Q$. This was investigated and later found out to be

caused by non-seriousness of students while filling out such survey forms. It was therefore reminded to respective course instructors by EE Departmental Council to explain to students the importance of filling student assessment forms and how those respective outcomes scores are evaluated. This activity has been termed as continuous, and is to be activated by the instructor at the start and the end of course delivery before respective assessment is completed by students.

A program report (based on equation (1)) is planned each academic year for evaluating the program outcomes and objectives. The report includes among others, the results of corrective action from last year, the assessment results analysis, observations and recommendations. The evaluation of this report together with corresponding feedback based on program assessment results and effectiveness of the tools drives the inner loops to start continuous improvement in assessment process. Additionally, cyclic feedback to the departmental curriculum committee ensures respective changes in program curriculum. A self-study report is generated to show continuous program assessment and is based on the

Table 3: Comparison of the curriculum quantitative assessment in years 2005 through 2007.

Outcome	2005	2006	2007
A	4.20	4.50	3.51
B	4.00	4.10	4.63
C	4.00	4.00	3.33
D		5.00	
E	3.80	3.90	3.49
F	3.60	4.30	
G	3.60	4.30	5.00
H	3.90	4.90	
I	4.00	4.20	4.50
J	3.60	4.40	
K	4.00	4.20	3.85

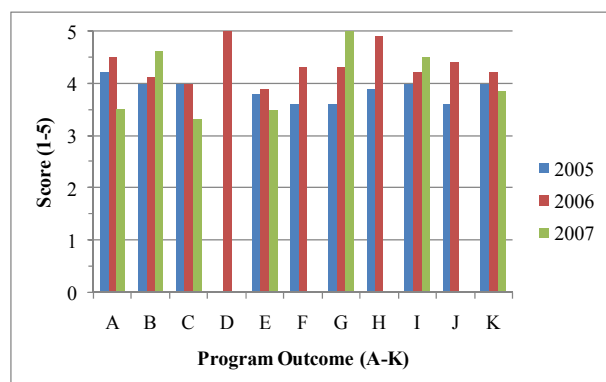


Figure 4: Comparison of the curriculum quantitative assessment in years 2005 through 2007.

Table 4: Other assessment tools detailed data (scale 1-5) for Spring and Fall 2007.

Tools ABET	Capstone course (GP)	Industrial training	Exit exam	Exit interview
A	5	3.8	1	4.42
B	4	3.5	1	4.00
C	4.5	3.3	2.5	4.67
D	5	3.3		2.67
E	4.5	3.4	1	4.50
F	5	4.2		4.53
G	5	4.3		4.53
H	4.5	3.3		2.89
I	5	3.8		3.84
J	4	3.5		4.00
K	4.5	3.8	3	4.59

Table 5: Summary of outcome *b* results for years 2005-2008.

Assessment tool	2005	2006	2007	2008	Average
Exit interview	3.13	3.98	4.00	3.96	3.77
GP	4.02	3.50	4.00	5.00	4.13
Alumni survey	3.60	3.50		3.84	3.65
Employer survey	3.50			3.44	3.47
Internship survey	3.30	3.30	3.50	3.07	3.29

Table 6: Comparison of the student response deviation with respect to the curriculum quantitative assessment in years 2005 through 2007.

Outcome	2005	2006	2007
A	-4.76	-11.11	12.24
B	-2.50	-7.32	-25.11
C	-2.50	-5.00	20.95
D			
E	2.63	0.00	8.03
F	8.33	4.65	
G	8.33	2.33	-22.80
H	15.38	-24.49	
I	10.00	4.76	-11.00
J	19.44	-13.64	
K	-5.00	-7.14	0.52

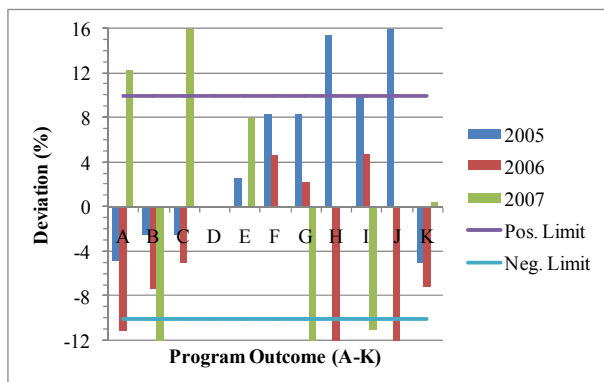


Figure 5: Comparison of the student response deviation with respect to the curriculum quantitative assessment in years 2005 through 2007.

average of assessments done over a period of time. This report duly addresses continual feedbacks received from academic advisory body, and thus forms the outermost loop within the process to evolve educational objectives, program outcomes and assessment tools accordingly.

6 DISCUSSIONS AND CONCLUSIONS

The main components of EE program assessment at UAE University have been described with emphasis on how and which tools are used to achieve targeted outcomes. Some of the outcomes are easily determined like quantitative assessment from curriculum delivery during the year, and others through exit exam, capstone course and internship surveys, etc. In total, seven assessment tools are used to measure outcomes, with frequency of two measurements per year for program report (inner loop). The frequency of feedback (in outer loop) available for self-study report is four to six years, depending upon the accreditation cycle. Looking at figures 4 and 5, and tables 3 to 5, it

is clear that the student performance is above 2.5 (on the scale of 1-5) benchmark set by the assessment process and the curriculum delivery is in line with the expectation of its constituencies. It can be inferred that the assessment data available for the program (as shown in figures 4 and 5, and tables 3 to 5) suggest satisfactory evolution of the education process to meet changing demands of the local industry, in general.

The current state of the program is such that the program has gone through two major revisions to reflect trends set by its constituent bodies and earned substantial equivalency by the ABET accreditation body. As the industrial outlook of UAE is changing at a faster pace than expected, so is the face of the job market. The difficulties still faced are in the alumni and employer surveys; in fact in getting a good number of these surveys to ensure confidence while comparing targeted results. Since these two surveys map the quality of a graduate to current requirements of the local industry, therefore a rigorous activity is being planned to get sufficient number of corresponding samples to evolve the curriculum and its assessment to reflect market needs. In fact, the curriculum setting to conform to industrial expectations is expected to undergo restructuring (in the near future) to reflect this ongoing process, once significant number of market and alumni surveys are compiled and assessed by the program constituencies.

REFERENCES

- ABET, 2007, *Criteria for accrediting engineering programs*, Engineering Accreditation Commission, www.abet.org/Linked Documents-UPDATE/Criteria and PP/E001 07-08 EAC Criteria 11-15-06.pdf.
- Ahlgen, D. J. & Palladino, J. L. 2000, "Developing assessment tools for ABET EC2000", *Proceedings of the 30th Annual Conference on Frontiers in Education*, Vol. 1, Kansas City, MO, pp. T1A/17-T1A/22.
- Culver, R., McGrann, R. & Lehmann, G. 2005, "Preparing students for ABET a-k", *Proceedings of the 35th Annual Conference on Frontiers in Education*, Indianapolis, IN., pp. T2C-15.
- DeLyser, R. R. & Hamstad, M. A. 2000, "Outcomes based assessment and a successful ABET 2000 accreditation at the University of Denver", *Proceedings of the 30th Annual Conference on Frontiers in Education*, Vol. 1, Kansas City, MO, pp. T1A/1-T1A/6.
- Earnest, J. 2005, "ABET engineering technology criteria and competency based engineering education", *Proceedings of the 35th Annual Conference on Frontiers in Education*, Indianapolis, IN, pp. F2D-7.
- Enderle, J., Gassert, J., Blanchard, S., King, P., Beasley, D., Hale, P. J. & Aldridge, D. 2003, "The ABC's of

- Preparing for ABET", *IEEE Engineering in Medicine and Biology Magazine*, Vol. 22, No. 4, pp. 122-132.
- Ferguson, D., George, S. & Huyek, M. 2007, "Work in Progress – Continuous Process Improvement in Attainment of Learning Objectives", *Proceedings of the 37th Annual Conference on Frontiers in Education – Global Engineering: Knowledge without Borders, Opportunities without Passports*, Milwaukee, WI, pp. S2G-1-S2G-2.
- Haag, S., Caso, R., Fowler, E., Pimmel, R. & Morley, P. 2003, "A systematic Web and literature search for instructional and assessment materials addressing EC 2000 program outcomes", *Proceedings of the 33rd Annual Conference on Frontiers in Education*, Vol. 1, Boulder, CO., pp. T4B-T19.
- Heinze, L. R., Gregory, J. M. & Bagert, D. J. 2002, "Web-based automated assessment for ABET programs", *Proceedings of the 32nd Annual Conference on Frontiers in Education*, Vol. 1, Boston, MA, pp. T1B-23-T1B-27.
- Julliard, Y., Meinecke, C. & Schwab, A. J. 2001, "Applying ABET Engineering Criteria 2000 to a German Electrical Engineering program", *Proceedings of International Symposium on Technology and Society*, Stamford, CT., pp. 226-231.
- Koehn, E. 2006, "Engineering Experience and Competitions Implement ABET Criteria", *Journal of Professional Issues in Engineering and Practice*, Vol. 132, No. 2, pp. 138-144.
- Mourtos, N. J. 2006, "Workshop Program Educational Objectives and Outcomes: How to Design a Sustainable, Systematic Process for Continuous Improvement", *Proceedings of the 36th Annual Conference on Frontiers in Education*, San Diego, CA., pp. 1-2.
- Schachterle, L. 1999, "Outcomes Assessment and Accreditation in US Engineering Formation", *European Journal of Engineering Education*, Vol. 24, No. 2, pp. 121-131.
- Schmidt, K. J., Burgan, S. & Alletag, A. 2007, "Teaching Engineering: The Student's Perspective", *Proceedings of the 37th Annual Conference on Frontiers in Education – Global Engineering: Knowledge without Borders, Opportunities without Passports*, Milwaukee, WI, pp. S3C-1-S3C-6.
- Stephanchick, P. & Karim, A. 1999, "Outcomes-based program assessment: a practical approach", *Proceedings of the 29th Annual Conference on Frontiers in Education*, Vol. 3, San Juan, Puerto Rico, pp. 13D1/2-13D1/6.
- Williams, J. M. 2000, "Transformations in technical communication pedagogy: engineering, writing, and the ABET Engineering Criteria 2000", *Proceedings of the 2000 Joint IEEE International Professional Communication Conference and 18th Annual Conference on Computer Documentation*, Cambridge, MA., pp. 75-79.
- Withington, J. P. 1999, "Short-cycle assessment techniques for ABET Criteria 2000 compliance", *Proceedings of the 29th Annual Conference on Frontiers in Education*, Vol. 1, San Juan, Puerto Rico, pp. 11B1/14-11B1/17.
- Yahya, A. H. 2007, "Engineering Accreditation: A Developing Nation Perspective", *Proceedings of the 37th Annual Conference on Frontiers in Education – Global Engineering: Knowledge without Borders, Opportunities without Passports*, Milwaukee, WI, pp. T3E-13-T3E-18.



QURBAN MEMON

Qurban A. Memon received his Masters and PhD degrees from Department of Electrical Engineering, University of Florida, Gainesville, USA, and Department of Electrical and Computer Engineering, University of Central Florida, Orlando, USA, in 1993 and 1996, respectively. Currently, he is Associate Professor at Electrical Engineering Department of UAE University, Al-Ain, UAE. He carries professional experience of over 13 years. He has more than 60 research publications to his credit in refereed international journals and conferences. His research interests include networks and digital systems..



ADNAN HARB

Adnan Harb received his Master in Applied Sciences (M,Sc.A.) and PhD both from the Electrical Engineering Department of École Polytechnique de Montréal in 1995 and 2004, respectively. He has worked for the Swiss Federal Institute of Technology (Lausanne, Switzerland) as a research assistant, for Pultronics as an analogue design engineer, for Canadian Revenue Agency as a scientific advisor, for ST Microelectronics as a senior analogue design engineer, and for Diablo technologies as a high-speed IC custom layout design engineer. He joined UAE University in 2004, where he is currently an assistant professor of Electrical Engineering. He has published more than 20 papers in the field of circuit design and biomedical applications. His research interests include analogue and mixed signal integrated signal design, and biomedical engineering.