Adopted Techniques Towards ABET EC2000 Accreditation at the American University of Beirut

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Abstract

The Faculty of Engineering and Architecture at the American University of Beirut recognized the need to institutionalize quality assurance, whereby on-going mechanisms for outcomes assessment and quality improvement would be built into the educational system. A committee of faculty members from the different departments was formed to investigate how best to introduce quality assurance into the educational system that can lead to ABET EC2000 certification.

The vision and mission statements of the Faculty of Engineering and Architecture (FEA) were articulated and the educational objectives and outcomes were formulated for each of the four undergraduate programs offered in Civil Engineering, Electrical Engineering, Computer and Communications Engineering, and Mechanical Engineering.

Teaching methodologies and the effectiveness of student learning were investigated in the light of techniques that address student learning styles and co-operative learning. The Index of Learning Styles by Felder/Silverman, still in beta version at the time, was adopted on the basis that it is suitable for engineering students and no training is required to evaluate the results. The results of the questionnaire should lead to more adequate catering for student learning preferences.

A comprehensive list of possible assessment tools of program and courses educational outcomes was prepared based on the adopted techniques in already accredited programs in other universities. A typical course syllabus of a multi-disciplinary nature was developed in light of EC 2000. The course objectives were tied to program objectives, and course outcomes were correlated to the course objectives while catering for program outcomes. A course articulation matrix was developed to assist in designing and formalizing the breakdown of learning objectives into detailed contents correlated to in-class and out-of-class activities delivering certain desired levels of learning as defined in Bloom's Taxonomy. In addition, a course learning assessment matrix was developed to assess the achievement level of course learning outcomes correlated to the specific activities that contributed to the development of the competencies. The matrix could also be used as an end-of-term course appraisal for students to fill out.

Two multidisciplinary first year courses entitled "Introduction to Engineering I & II," were introduced which aim at exposing the students to the general nature of engineering, to the

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engineering design process through reverse engineering and through design and build project, and to teamwork. The necessary professional skills of leadership, innovation, and engineering ethics are highly stressed in these courses. Extensive outlines of these courses, objectives, articulation matrix and learning assessment matrix were prepared.

I. Introduction

The underlying philosophy of EC 2000 is that each engineering program must have clearly stated educational objectives that are consistent with the mission of the institution and are based on the needs of the program's various constituencies (e.g., students, faculty, alumni, and employers). The educational objectives are translated into program educational outcomes reflecting the acquired skills of graduates. Continuous assessment is needed to demonstrate that the outcomes are being measured, and to provide evidence that the results of the assessment are being applied for further development and improvement of the program. The ultimate goal of the Faculty of Engineering and Architecture (FEA) at the American University of Beirut (AUB) is to institutionalize quality assurance as an ongoing process for continuous improvement in pursuit of excellence.

The desire and ability to engage in life-long learning has assumed such importance in recent years so as to be singled out as a separate educational outcome in EC 2000. Life-long learning has two sides to it:

- A thorough understanding of fundamental principles and concepts. These are not only largely time-invariant but would also provide a solid foundation for future learning.
- The ability to learn on one's own. It has been said that a goal of university education should be to teach students how to teach themselves, for a truly educated individual never stops learning. In pedagogical terms, this entails a shift from teacher-centered to student-centered learning [2].

At FEA-AUB, a need was felt to institutionalize quality assurance, i.e., to have built into our educational process on-going mechanisms for quality assessment and quality improvement. Hence, the need for a quality education system in which quality is monitored and improved on a continuing basis, as opposed to our current state in which evidence of quality is not systematically collected, is anecdotal at best, and is seldom used for further improvement of the program. A committee of faculty members from the different departments was formed during the fall semester, 1997-1998, to investigate how best to introduce quality assurance into our educational process. After much deliberation, the committee recommended compliance with EC 2000 because it is specifically intended for engineering education, and compliance would pave the way for ABET accreditation of our programs. Then the Total Quality Management (TQM) Committee was formed at the start of the spring semester 1997-1998 to act as a study group to research and prepare position papers on certain main topics so that the FEA Academic Committee and the Faculty can act effectively and expeditiously when they consider revision of our curricula and our teaching philosophy and methodology. Some of the work of the TQM Committee during the spring semester, 1997-1998, and the following academic year of 1998-1999, is presented in this paper.

The Committee felt that the least that can be done at the dawn of a new century is to take a hard look at what we are doing and see how it can be improved in the light of the needs of our constituencies, our judgment, experience and that of others. The success of our programs in the past does not necessarily mean that they will remain adequate for the changing needs of the future. We need to consider education, as not merely confined to the classroom and the laboratory, but as a total system that encompasses in-class activities, out-of-class learning experiences, peer-to-peer student interaction, faculty-student relations, and the school activities and environment as a whole.

The main issues considered by the TQM Committee and included in this paper are: Faculty Vision and Mission statements, programs' educational objectives and outcomes; teaching methodologies and the effectiveness of co-operative learning; proposed programs' and courses' outcomes assessment methodologies and tools; developed course syllabus in light of EC 2000; and recommendation of two multidisciplinary first year engineering courses entitled "Introduction to Engineering I" and " Introduction to Engineering II", which aim at exposing the students to the general nature of engineering, the engineering design process, and teamwork. The Committee eventually recommended a first common year for all incoming engineering students.

II. The Development of AUB-FEA Vision and Mission, Programs' Educational Objectives and Outcomes

The first task of the TQM Committee was to articulate the Vision and Mission statements of the Faculty and to formulate prototypical educational objectives and outcomes. The Vision and Mission statements were adopted by the Faculty in February, 1998. The three engineering departments subsequently approved educational objectives and outcomes for each of the four undergraduate programs they offer: Civil Engineering, Electrical Engineering, Computer and Communications Engineering, and Mechanical Engineering. As mentioned in the first paragraph above, programs' educational objectives should address the outcomes specified by EC 2000, based on the needs of programs' constituencies. Accordingly, guidelines were prepared for the formation of External Advisory Boards to review and discuss matters pertaining to the various FEA undergraduate programs, as well as research activities and professional development of the FEA departments.

A. Vision Statement

The Faculty of Engineering and Architecture (FEA) will enhance its status as a world-class professional school that attracts eminently qualified faculty of international caliber and outstanding students from the region. The FEA will contribute to the development of Lebanon and the region by providing education of the highest quality, promoting basic and applied research of international standing by its faculty and students, and rendering educational and professional services.

B. Mission Statement

The Faculty of Engineering and Architecture (FEA) is a leading professional school in the Middle East. Its mission is to offer American-style educational programs of the highest standard, to promote research, creative, and scholarly activities by its faculty and students, and to provide services to the community at large, with special consideration to the needs and circumstances of Lebanon and the region. The FEA prepares its students, in a challenging and intellectually stimulating environment that undergoes continuous improvement, for life-long learning, innovation, and leadership in their chosen careers and empowers them for a richer personal and professional life.

C. Prototypical Educational Objectives

The following objectives have been suggested by the Committee to the various departments in FEA as a starting point in developing educational objectives for the various programs offered:

"The Bachelor's degree programs of the Faculty of Engineering and Architecture (FEA) rigorously prepare the graduate for life-long learning and professional advancement in a broad range of career choices. The Master's degree programs emphasize research experience and the acquisition of specialized skills, on a full-time basis, or part-time allowing concurrent professional practice. The curricula adopt, whenever appropriate, an integrative, multidisciplinary, and multifunctional approach that underscores the environmental, social, economic, and management aspects. An ample selection of elective courses provides flexibility that accommodates particular interests of students."

"Comprehensive professional preparation is combined with a liberal education that enriches the mind and spirit, broadens the outlook of students, fosters an understanding and appreciation of diversity, and places professional work in its proper humanistic and philosophical perspectives."

"More specifically, the educational objectives of the undergraduate FEA programs are:
1. to impart a sound understanding of fundamental principles and concepts while conveying state-of-the-art knowledge and maintaining a proper balance between theory and practice;
2. to develop mathematical, scientific, and computational skills relevant to engineering practice;
3. to train students in analysis and synthesis when formulating and solving engineering problems;
4. to teach students how to design and conduct experiments for engineering applications and use statistical methods for the analysis and interpretation of data;
5. to motivate students to think independently, critically and creatively;
6. to cultivate the skills pertinent to the engineering design process, including the investigation of open-ended problems, consideration of realistic constraints and alternative solutions, implementation, and evaluation;
7. to foster interactive skills for effective communication and teamwork; and
8. to instill in students an appreciation of leadership qualities, professionalism, and ethics."

D. Prototypical FEA Program Outcomes

The educational programs' outcomes have been adopted from ABET EC-2000 ((a) through (k)) [1], and an outcome (l) has been added by the Committee as a recommendation for the various FEA programs. Outcome (l) states that the graduates should demonstrate "some experience in engineering practice and undergraduate research". A correlation matrix of the prototypical FEA program educational objectives and outcomes was developed and is shown in Table I.

TABLE I. Prototypical FEA Program Educational Objectives
and Outcomes Correlation Matrix

	PROGRAM OUTCOMES											
PROGRAM OBJECTIVES	a	b	c	d	e	F	g	h	i	J	k	l
1	●	●	●		●			◗	●	◗	◗	◗
2	●	●	●		●			)	●		●	◗
3	◗	●	●		●	◗		)	●		)	◗
4	)	●	◗		)	◗			◗		◗	◗
5		●	◗		●		◗	◗	●	◗	)	●
6	)	●	●	)	●	◗	◗	◗	●	)	◗	◗
7		)	◗	●		◗	●					●
8		)	)	◗		●	●	◗	◗	)	)	●

Strongly correlated	●	Weakly correlated	)
Moderately	◗	Not correlated	Blank

III. Effective Teaching, Learning, And Advising

Teaching methodologies and the effectiveness of student learning and involvement in courses were investigated in the light of catering to different student learning styles and co-operative learning. The positive impact of student-faculty relations was studied. The TQM Committee stressed the benefits of cooperative learning in a student-centered learning environment, and considered ways for implementing cooperative learning in courses. Student advising goals were set and the mechanisms to achieve these goals were considered by the Committee. The positive impact of student-faculty relations was also emphasized.

A. Index of Learning Styles (Felder - Silverman Model)

The Index of Learning Styles by Felder/Silverman, still in beta version at the time, was adopted on the basis that it is specifically intended for engineering students and no training is required to assess the results [2,3]. Students whose learning styles are compatible with the teaching style of a course instructor tend to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject than do their counterparts who experience learning/teaching style mismatches. It is expected that the results of the questionnaire will lead to a better understanding of student learning preferences. The information will help students study more effectively and guide teachers for improved teaching techniques and enhanced student learning. In addition, student advising will better address the academic needs of students.

The dichotomous learning style dimensions of the Felder/Silverman model divide learning styles into five categories of sensing/intuitive learners, visual/verbal learners, inductive/deductive learners, active/reflective learners, and sequential/global learners. These categories are on a continuum and not either/or type [2]. A student's preference on a given scale (e.g., for inductive or deductive presentation Inductive/Deductive reasoning was not tested. Hence another example should be used) may be strong, moderate, or almost non-existent, may change with time, and may vary from one subject or learning environment to another.

The Index of Learning Styles questionnaire was administered to all new first-year students (300 students in four departments) in October 1998. Figures 1a and 1b show a typical distribution of the test score for the computer and communication engineering students. The results of the questionnaire have shown a bias of these students towards visual/sensing learning style in contrast to verbal/intuitive learning style. But the students were almost equally divided as sequential/active learners verses global/reflective learners (there seems to be a clear bias towards sequential as opposed to global learning). The results were sent to advisors and students with an instruction sheet explaining the model dimensions and instructional methods that are appropriate for each learning style.

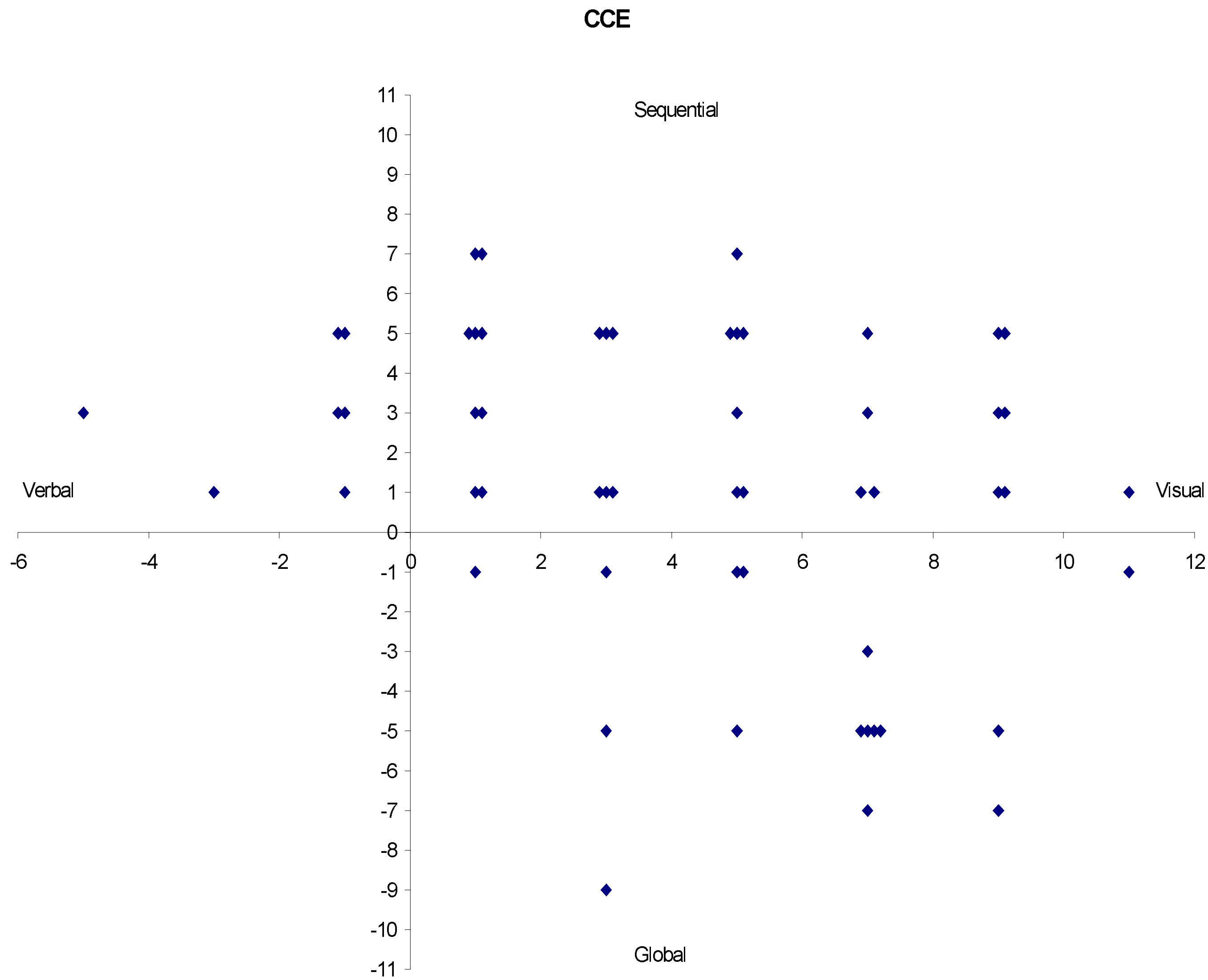
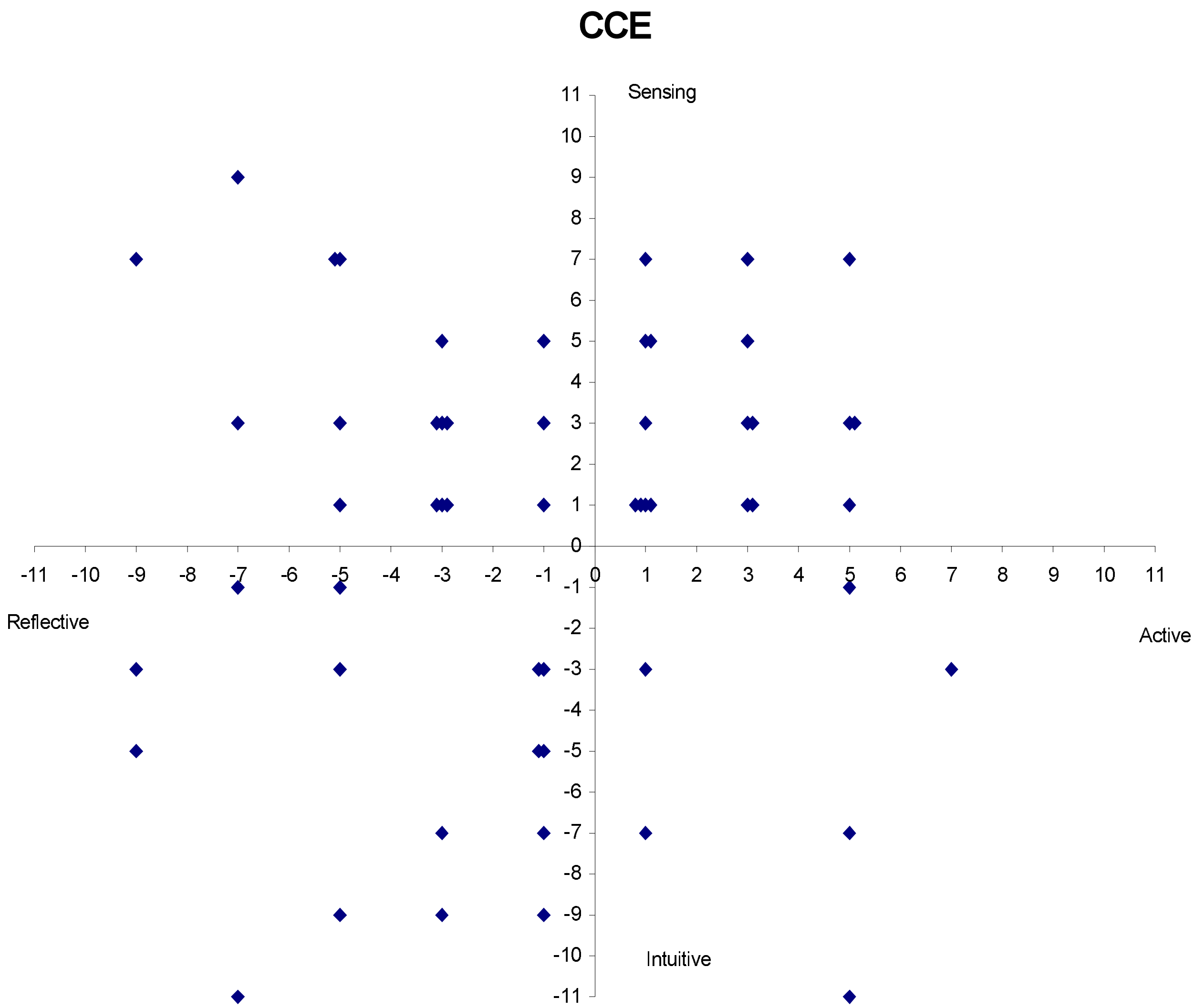

CCE
Sequential
Global
Verbal
Visual
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-6
-4
-2
0
2
4
6
8
10
12

Figure 1a

Figure 1(a, b): Felder/Silverman model questionnaire results to incoming computer and communication engineering students.



B. Cooperative and Student-Centered Learning

Research shows that students learn more by cooperating than they do by competing and working individually [4, 5]. When companies fill out surveys asking them what skills they want their employees to have, teamwork skills are usually ranked first or second. These are good motives to start implementing cooperative learning in and out of class. Today in US colleges and universities, many professors are placing a renewed emphasis on teaching quality. They no longer see their students as empty or passive vessels, but as active constructors, discoverers, and transformers of knowledge. Professors want to develop students' talents and abilities so that they can function in real-world professional environments. Student-Centered learning (SCL) is a broad approach that includes such techniques as:

1. Substituting active learning experiences for passive lecturing,
2. Augmenting in-class activities with out-of-class learning assignments,
3. Assigning open-ended problems and problems requiring critical thinking that cannot be solved by following text examples,
4. Involving students in simulations and role-plays, and
5. Using self-paced and/or cooperative (team-based) learning.

On a broader note, class time should be spent only on the most critically important and conceptually difficult parts of the course, leaving the students to cover the rest for themselves. The many hours saved in class time should be more than sufficient for all active learning exercises. In cooperative learning situations there is a positive interdependence among students' goal attainments; students perceive that they can reach their learning goals if and only if the other students in the learning group also reach their goals [4-7]. Cooperative learning may occur in or out of class. In-class exercises, which may take anywhere from 30 seconds to an entire class period, may involve answering or generating questions, explaining observations, working through derivations, solving problems, summarizing lecture material, trouble-shooting, and brainstorming. Out-of-class activities include carrying out experiments or research studies, completing problem sets or design projects, writing reports, and preparing class presentations. The research clearly indicates that cooperation, compared with competitive and individualistic efforts, typically results in (a) higher achievement and greater productivity, (b) more caring, supportive, and committed relationships, and (c) greater psychological health, social competence, and self-esteem.

The TQM committee has prepared a position paper that was presented to FEA faculty members to show the benefits of the student-centered learning environment and the procedures and mechanisms for implementing cooperative learning through a wide list of in-class and out-of-class activities.

C. Faculty-Student Relations

The period of undergraduate study is when most students begin to form their system of values that shapes their views on life, society, morality, ethics, and interpersonal relationships. Positive faculty-student interaction can have a major, beneficial, and lasting influence on students. Faculty-student interaction, particularly the informal, outside-the-classroom kind, is considered an essential ingredient of any good liberal education environment. The fostering of this interaction is very much part of the responsibilities of a true educator.

Channels fostering formal as well as informal interaction between students and faculty fall in two domains: academic and extra-curricular. Within the former, in-class interaction and advising are the main components.

C.1. Advising Programs

Objectives

- To assist students in making responsible, informed decisions and to help them seek answers to questions that are important to them as they develop intellectually and educationally. In particular, students will be counseled on career and job opportunities that are compatible with their potential, interests, and goals.
- Create a favorable student environment through:
  1. Schedule building and program planning to select elective courses based on the advisee's interests, strengths, and weaknesses.
  2. Performance evaluation to monitor students' progress through periodic performance evaluation to discuss their performance and progress.
  3. Problem solving to provide encouragement, sympathetic understanding, and treatment of students as individuals. A seminar is organized by the Faculty during the first two weeks of each academic year to discuss and inform students how to deal with issues such as time management, efficient study techniques, proper prioritizing, and stress reduction.

C.2. Students' Interaction Outside the Classroom

Encouragement of students' interaction could be through extra-curricular activities with focal areas such as *personal development*, *education*, *industrial interaction*, and *outreach*. Addressing these issues will lead to a healthy environment that nourishes a plethora of social and educational activities such as field trips, lecture series, visits to engineering practices, mentoring programs, film series, receptions, and competitions. Such activities create a great sense of spirit within each program, and actually enhance the academic side of things. In addition to the Student Representative Committee (SRC), the involvement of the students in the affair of the university should be initiated through various ad hoc committees. The role and objectives of these committees may be formulated according to each program/department's mission and educational objectives. These modes of expression are very valuable to shape the students into active social individuals and to stimulate dialogue. The involvement of the students should also not be limited to local organizations. Faculty members need to invite and guide students to join student chapters of professional societies, promoting earlier on the sense of professionalism. The student body is an important creative force that is hardly exploited for the betterment of the educational environment at AUB. In short, we need to involve our students in the leadership of the Faculty. This process will help create a shared vision of the Faculty, promote wide ownership; and champion organizational change.

IV. Outcomes Assessment-Based Course Syllabus:

A comprehensive list of possible instruments for assessing the level of achievement in meeting the course as well as program educational outcomes, was prepared by the TQM Committee based on the adopted tools in already accredited programs in the US [8-10]. Furthermore, the Committee investigated the advantages of introducing the Fundamentals of Engineering (FE) exam [11] as a valid program outcomes' assessment tool. The learning outcomes system assesses student achievement of learning objectives at three levels: the course level, the curriculum level, and the program outcomes level. In this paper, the focus will be on assessment at the course level, where a simple mechanism has been developed for course activities' articulation and outcome assessment.

On the course level. Professors accumulate a lot of data about individual student performance. These data will be useful in improving individual courses only if they are detailed enough to indicate why students are failing to meet minimum requirements. Failure can indicate a number of things. The teaching approach may not be compatible with students' learning style. The learning objectives may not be appropriate. And/or prerequisite courses may not be preparing students to perform at the next level. Measuring the level of achievement in meeting a course educational objectives is no more restricted to exams that test simply the students' knowledge (in the sense Bloom's taxonomy) of a course. In line with the desired shift to move away from a teacher-centered to a student-centered educational environment, course assessment tools must be designed to encourage active learning, emphasizing in-depth understanding along with applications of knowledge. The tendency is to develop **performance-based** assessment tools that require students to perform different tasks rather than simply answer questions. The multiplicity of tasks is required to offer validity to the assessment measure of the level of achievement of each individual educational course objective. Furthermore, it is important to understand that these measuring tools are not conceived of as a separate entity from the course instruction. On the contrary, the success of these measuring tools lies in relation to the capacity to integrate them in the instructional activity that exists along a continuum (from the theoretical to the practical pole). The central idea is that even a conventional multiple choice item can be rethought and tailored to address the multiple cognitive level of students by:

a) Focusing these questions on application-level or higher-level thinking skills (this is often easily done if several items are linked to a brief, textual paragraph or data set),
b) Modifying the normal response to include a written justification statement (this allows a glimpse into student reasoning),
c) Designing distracters that target specific, common student misconceptions.

Additionally, open-ended questions that require students to write a short essay-type answer, complete or design a concept map, manipulate data on a chart or graph, or prepare a sketch related to real-world science applications have been used in traditional exams by many science teachers. In this respect, each of the possible measuring tools listed below needs to be tailored to emerge seamlessly from the learning objectives of the course.

A typical course of a multi-disciplinary nature (Automatic Controls) was reviewed in light of the above. The course objectives were tied to both program objectives and outcomes as shown in Table II. A course articulation matrix was developed, as shown in Table III, to assist in designing and formalizing the breakdown of learning objectives into detailed contents correlated to in-class and out-of-class activities delivering certain desired levels of learning as defined in Bloom's Taxonomy. In addition, a course learning assessment matrix was developed, as shown in Table IV, to assess the achievement level of course learning outcomes correlated to the specific activities that contributed to the development of the competencies. The matrix could also be used as an end-of-term course appraisal for students to fill out. From the course learning assessment matrix, the instructor will be able to rate the relevance of any course activity to students' learning and redesign the course accordingly. The course learning assessment matrix simplifies the assessment process into a single table that replaces the course competency matrix, learning checklists and the course activity impact matrix which were discussed by Anderson et al [12], and McNeil and Bellamy [13].

Assessment tools were:

- Exams (Midterm and Final)
- Computer Simulation Assignments
- Simulation Group Project
- Porfolio (exams, simulation homework, and project)
- Presentation.

TABLE II - Automatic Controls Outline

Catalog Description	EE 073 / ME 102 Automatic Controls Credits: 3 Prerequisite: AS 045 Application of Analytical Methods in Engineering This course seeks to impart in students a sound understanding of fundamental principles in control engineering, based on both analog and digital technologies. The course includes: Mathematical Modeling of Linear Continuous and Discrete Time Invariant Single Input - Single Output Dynamical Systems. Transfer Functions and Block Diagrams, Performance Specifications, Analysis and Design of Closed Loop Analog and Digital (computer based) Control Systems.
Textbooks:	1. Ogata, K., Modern Control Engineering, Third Edition, Prentice Hall, 1997. 2. Franklin, G., Powell, J., and Workman, M., Digital Control and Dynamic Systems, 2nd Edition, Addison Wesley, 1992.
Prerequisite by Topic	1. Physics: Dynamics 2. Mathematics: Calculus, Differential Equations, Matrices, Laplace and Z Transforms 3. Computer Simulation skills using Matlab, LabView, or similar packages
Objectives: *Correlate to CCE Program Objectives 1,2,3,4,7.*	1. To introduce students to the general field of control engineering, based on both analog and digital technologies. 2. To develop in students mathematical, scientific, and computational skills relevant to control systems. 3. To teach students analysis techniques when formulating and solving control problems. 4. To cultivate skills pertinent to the control engineering design, synthesis, and the investigation of open-ended problems while considering realistic specifications and constraints, alternative control strategies, implementation, and evaluation of analog and digital control systems. 5. To foster effective interaction skills for peer and multidisciplinary teamwork and communication.
Topics	See the Course Articulation Matrix in Table III
Learning Outcomes	Outcome 1 (Correlated to Course Objective 1): Students are knowledgeable in the field of control engineering and the dynamical systems classification and components, based on both analog and digital technologies. *Caters to Program's outcome (a)* Outcome 2 (Correlated to Course Objective 2): Students will demonstrate an ability to apply Laplace and Z transforms, Transfer Functions, Discretization Techniques, Modelling, and Computer Simulation of Dynamical Systems in control engineering. *Caters to Program's outcome (a)* Outcome 3 (Correlated to Course Objective 3): Students will demonstrate an ability to apply Routh's (continuous) and Jury's (discrete) stability tests, and Root-Locus. In addition students will utilize Frequency response, Polar, and Bode Plots in the analysis of both continuous and discrete control systems. *Caters to Program's outcome (e)* Outcome 4 (Correlated to Course Objective 4): Students will demonstrate an ability to Design continuous and discrete controllers using (Root-locus, Frequency response, PID, Pole Placement with state feedback) meeting transient and steady state performance specifications of first and second order dynamical systems. *Caters to Program's outcomes (c ,k)* Outcome 5 (Correlated to Course Objective 4): Students will demonstrate an ability to consider realistic constraints, alternative control strategies, implementation, and evaluation of analog and digital control systems' design. *Caters to Program's outcome (c ,k)* Outcome 6 (Correlated to Course Objective 5): Students will demonstrate an ability to interact and communicate effectively with peers and multidisciplinary teams. *Caters to Program's outcome (d, g)*

TABLE III Course Articulation Matrix

The purpose of the course articulation matrix is to assist instructors in organizing the contents of the course in a detailed list (leftmost column) and generate in-of-class and out-of-class activities (upper row) that correlate to course subjects and deliver a certain level of learning based on Bloom's Taxonomy (matrix entrees).

LEARNING OBJECTIVES	**LEARNING LEVEL**	**Course Activities IN CLASS**	Preparing and Taking Tests	scenarios on computer (demos)	active learning exercises	listen to lectures	group presentations	**OUT OF CLASS**	practice using MATLAB	computer simulation H.W.	**group project**	establish multi disciplinary team	model real life dynamical system	translate performance specs	design alternative controllers	simulate controlled system	compare and choose solution	prepare technical report/presentation
1.Intro to the Field of Control																		
1.1 general concepts	K		K		K	K												
1.2 control system components	K		K		K	K									K			
1.3 classification of dynamical systems	K		K		K	K								K	K			
1.4 open vs. closed loop control	K		K		K	K									K			
2. Math, Scientific, Comput Skills																		
2.1 Laplace and Z transforms, Properties	Ap		Ap		Ap	C												
2.2 Cont. / Discrete Transfer Functions	Ap		Ap		Ap	C							Ap		Ap			
2.3 Discretization Techniques	Ap		Ap	C	Ap	C			Ap	Ap			Ap		Ap	C		
2.4 Modelling and Simulation	Ap			Ap	Ap	Ap	Ap		Ap	Ap			Ap			Ap		
3. Analysis in control																		
3.1 Routh's / Jury's Stability Tests	Ap		Ap		Ap	Ap												
3.2 Root Locus Stability	Ap		Ap		Ap	Ap			Ap	Ap					Ap		Ap	
3.3 Frequency Response, Bode Plots	An		An	An	An	An			An	An			An	An	An		An	
4. Control design Process (SPECS)																		
4.1 Transient and Steady States specs	C		C	C	C	C			C	C			C	C	C	C	C	
4.2 Controller design strategy	An				An	An							An	An	An		An	
4.3 Design using root locus	S		S	S	S	S			S	S			S		S		S	
4.4 Design using Frequency Response (Bode)	S		S	S	S	S			S	S			S		S		S	
4.5 Design using PID rules / Tuning	S		S	S	S	S			S	S			S		S		S	
4.6 Design Pole Placement with State Feedback	S		S	S	S	S			S	S			S		S		S	
4.7 Sampling effects	An			An	An	An			An	An			An		An	An	An	
4.8 Software and Hardware Technologies	K			K	K	K	K		K	K			K	K	K	K	K	
5. Teamwork and Communicaton																		
5.1 Multi Disciplinary teams (EE, ME)																		
5.2 Team Dynamics																		
5.3 Team communication																		

Level of Learning Legend **K**nowledge **C**omprehension **Ap**plication **An**alysis **S**ysnthesis

Course Articulation Matrix EE 073 / ME 102 Automatic Controls 9/30/1998

TABLE IV Course Learning Assessment Matrix

The purpose of the course learning assessment matrix is to assist students in assessing the achievement level (matrix entrees: weak, medium, or strong) of the course outcomes (upper row) based on the contributions of course activities (left most column).

COURSE ACTIVITIES	COURSE OUTCOMES	**(1)** Students demonstrate konwledge in the control field	**(2)** Students demonstrate ability to apply Laplace and Z transforms, transfer functions, modelling, discretization and simulation.	**(3)** Students demonstrate ability to apply Routh, Jury and Root Locus, as well as, Utilize Frequency Response, Polar, and Bode Plots in the Analysis of Systems.	**(4)** Students demonstrate ability to design controllers using Root-Locus, Frequency Response, PID, Pole Placement to meet transient and steady state specs of 1st and 2nd order systems.	**(5)** Students demonstrate ability to consider constraints, alternative control strategies, implementation, and evaluation of analog and digital contro systems design.	**(6)** Students demonstrate ability to interact and communicate effectively with peers and multidisciplinary teams.	ACTIVITY IMPACT
IN CLASS								
Prepare and take Exams								
Attend in class computer demos								
Listen to lectures								
Participate in class exercises								
Participate in class presentations								
OUT of CLASS								
Practice Matlab out of class								
Prepare computer simulation homework								
Course Project								
Establish multi-disciplinary team								
Model real life dynamical system								
Translate perfomance specifications								
Design alternative controllers								
Simulate controlled system								
Compare and choose a control solution								
Prepare technical report/presentation								
LEARNING OUTCOMES								

EE 073 / ME 102Automatic Controls. Course Learning Assessment Matrix

9/30/98

VI- Recommended First Year Engineering Courses:

Engineering is a profession that requires knowledge of basic sciences, mathematics, and design methodologies. All of these knowledge areas combine to allow engineers to understand how systems interact, how they can be designed and improved. Incoming first-year students generally have a narrowly conceived notion of a particular engineering discipline they intend to ‘specialize’ in. They do not appreciate the multidisciplinary nature of real-life engineering problems and the realistic constraints that are placed on engineering designs in terms of a diversity of constraints that could include manufacturability, safety, reliability, and cost, as well as environmental, social, ethical, and esthetic considerations. Moreover, engineering students should experience very early in their education the thrill of tackling engineering problems. Accordingly, two new courses are suggested: Introduction to Engineering I and II, whose objectives may be stated as follows:

- To present engineering as an integrated approach to practical problem solving and not as a set of disjointed disciplines.
- To introduce students to engineering design as a creative decision-making process which involves formulation of specifications to meet desired needs, consideration of alternative solutions and realistic constraints, testing and evaluation.
- To impress upon students the importance of mathematics, basic sciences, and theory to engineering solutions.
- To inculcate in students the relevance of a broad general education to understanding the societal and global impact of engineering.
- To cultivate in students from the very beginning leadership qualities, effective teamwork and communication skills.

An added benefit of the course would be to enable students to make a more informed decision about the engineering major they wish to pursue, assuming that they would at least be given the opportunity to request a change of major at the end of a first common year. Moreover, the courses will allow students to become familiar at an early stage with the facilities and resources (library, software, laboratories) available in the Faculty.

The courses will be primarily based on projects undertaken by teams of students, supplemented by lectures that guide students in their projects and introduce them to design methodologies. The first course, Introduction to Engineering I, introduces design through reverse engineering of familiar items [14], and the second course, Introduction to Engineering II, introduces a project that could be open-ended, could utilize universal construction sets (such as Lego and Meccano). Teams will be required to report periodically on their progress through group presentations to the whole class. The catalog of data and courses’ objectives for both courses are given in Table V.

Table V. Catalog Description of the Courses Introduction to Engineering I and II

Course Name	**Catalog data**	**Course Objectives**
Introduction to Engineering I	The course seeks to expose students to a realistic view of various disciplines and phases of engineering, build their interpersonal and communication skills, and give them insight about engineering concepts and creative design principles through reverse engineering. Overview of engineering as a profession, ethics in engineering, and human relations. Acquisition of information. Reverse engineering of an artifact. Self regulation and time management. The art of self-learning.	1. To provide students with a broad overview of the engineering profession and present engineering as an integrated approach to practical problem solving. 2. To stimulate students' ethical imagination and help them deal effectively with ambiguity and disagreement about ethical matters, and become familiar with professional value systems and codes. 3. To introduce students to engineering design as a creative decision-making process. 4. To foster effective interaction skills for peer and multidisciplinary teamwork and communication. 5. To develop in students the art of self-learning. 6. To train students to self regulate their activities and prepare checklists, schedules and plans. 7. To introduce students to the human side of engineering and means of resolving conflicts.
Introduction to Engineering II	The course seeks to introduce students to the creative process of identifying needs and then devising practical solutions to fill those needs, and give them insight of design principles and realization process through designing, building, testing and evaluating of an engineering product. Teamwork experience and communication skills are highly stressed. Acquisition and management of resources, Design and build project. Creativity and innovation. Cost-benefit tradeoffs. Leadership principles and leadership in engineering	1. To introduce students to engineering design as a creative decision-making process. 2. To foster effective interaction skills for peer and multidisciplinary teamwork and communication with emphasis on the shared responsibility among team members. 3. To familiarize students with facilities and resources for information retrieval. 4. To enable students to self regulate their activities and prepare checklists, schedules and plans. 5. To introduce students to techniques for creative thinking. 6. To enable students to understand leadership principles and leadership tools for innovation.

VI- Recommendations

The work of the TQM committee has resulted in setting the FEA vision and mission, programs' educational objectives and outcomes. The current teaching methodologies at FEA and the effectiveness of student learning have been evaluated and several recommendations have been adopted to improve the learning process through an outcome-based learning assessment. A typical course outline format including objectives and outcomes in light of ABET EC 2000 have been proposed with articulation and learning assessment matrices. Two multidisciplinary first year engineering courses entitled "Introduction to Engineering I" and " Introduction to

Engineering II", aiming at exposing the students to the general nature of engineering, the engineering design process, and teamwork have been introduced. The Committee eventually recommended a first common year for all incoming engineering students irrespective of their major. The work is continuing to restructure all the engineering programs in the light of the TQM recommendations and provide means for a successful implementation of these recommendations. Academic year 1999-2000 is crucial in reviewing all of FEA undergraduate curricula to accommodate the guidelines of ABET-EC2000 criteria. Implementation will start in the Fall of 2000-2001. The quality journey in engineering education is a continuous improvement process.

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