A Proposed Procedure to Assess Students Learning Based on Criterion 3 of EC 2000

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Abstract –A systematic procedure for the assessment of EC criterion 3 is proposed. The procedure is based on relating the technical requirements of criterion 3 to the knowledge and skills acquired by each student. A Top-down analysis is required to transform the qualitative technical requirements of criterion 3 to a set of quantitative measures of skills and knowledge. This set can be measured through different methods of evaluation. The results of evaluation are used to go up using bottom-up approach to see if the final goals are achieved or not. Comparison with the desired outcome of the engineering education will be used to evaluate the success of each student to achieve the goals of engineering education. The new procedure should produce an education profile which will augment the A, B, C, D and F grades or GPA of each student. A student's education profile will consist of three files that describe the technical requirements of criterion 3. The first file covers mathematics, physics and basic science part of the education profile, the second file covers the basic engineering part of education, and the third file covers the gained knowledge and skills of the students' engineering field of specialty. Each file gives the required skills and knowledge of the student, and the percentage of skills and knowledge each student achieved during college. The paper discusses the top-down and bottom up concepts, and explains the details utilizing functional block diagram representation of the engineering education system. Non-technical and humanities aspects of criterion 3 should be included in a fourth file and will not be discussed in this paper.

Keywords: Assessment, criterion 3 of EC 2000, grading system, and student's education profile.

CRITERION 3 OF EC 2000

The new ABET EC 2000 is composed of eight criteria that emphasize quality and professional preparation [ASEE Professional Books, 1 and web site, 2]. This paper focuses on criterion 3 of EC 2000. This criterion requires that engineering programs must demonstrate that their graduates have:

(a) An ability to apply knowledge of mathematics, science, and engineering
(b) An ability to design and conduct experiment as well as to analyze and interpret data;
(c) An ability to design a system, component, or process to meet desired needs;
(d) An ability to function on multidisciplinary teams;
(e) An ability to identify, to formulate, and to solve engineering problems;
(f) An understanding of professional and ethical responsibility;
(g) An ability to communicate effectively;
(h) The broad education necessary to understand the impact of engineering solutions in a global/societal context;
(i) A recognition of the need for and an ability to engage in lifelong learning;
(j) Knowledge of contemporary issues; and
(k) The ability to use techniques, skills, and modern engineering tools necessary for engineering practice.

The assessment based on criterion 3 poses a fundamental challenge which is how to devise agreeable measures to evaluate students' learning. EC 2000 criterion 3 can divided into non-technical requirements (d, f, g, h, i &j) and technical requirements. In theory, it is possible to have agreeable learning objectives that reflect the technical requirements [Ronald, 3]. Measuring the qualitative non-technical requirements is a fundamental problem. This

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paper suggests a systematic procedure to create an education profile of each student to show the degree of students' achievements of the technical requirements of EC 2000 criterion 3.

The assessment of engineering education using the ABET new criteria needs developing a comprehensive procedure to evaluate students' learning to augment the A, B, C, D & F grading system [Terenzini, 4, Hoey, 5, Stadler, 6 and Withington, 7]. The author is not aware of any reliable assessments procedure to assess students learning based on EC 2000. Assessment is one of the most challenges facing the implementation of EC 2000 [Fromm, 8 and Splitt, 9].

THE PROBLEM OF ASSESSMENT OF TECHNICAL REQUIREMENTS

Technical requirements of criterion 3 reflect holism requirements while the practice of teaching, in classrooms and labs to cover courseware in a specific period, follows a reductionism approach. In this approach an engineering program is reduced to courses, each course is composed of topics, and each topic is composed of a series of teaching activities. Classical methods of tests, quizzes, and exams examine the ability of students to know each course as dissected topics. The main problem to assess students' learning based on criterion 3 requires devising reliable tests to relate the results of reductionism teaching and testing to the holisms requirements of criterion 3. A reliable test should not depend on the instructor or the students. Also, it should assess students learning of the entire objectives of each course.

The author conducted an experimental investigation to show the difficulty of creating systematic and reliable tests to assess the students learning. The tests were designed to assess the technical requirements only of criterion 3 of EC 2000 using letter grading system and the traditional reductionism engineering teaching approach. The two subjects selected for the test were aeromechanics (AENG 340) and control theory (AENG 460). The entire class was asked to solve two sets of problems; the first set was the textbook problems. The other set was the same problems but rewritten to focus on skills and concepts required to solve the same problems. Tests were conducted for the Aeromechanics course for three years: Fall 2001, 2002, 2003, and the Control theory course for three years: Spring 2002, 2003, 2004. The number of students in the class was small (6-8 students). There were no meaningful changes in grades based on type 1 and type 2 questions in the above mentioned two subjects.

The findings suggest that, classroom and lab activities are only one factor to control students learning and there are other factors. A faculty member's method of instruction may not be effective if not consistent with other faculty. Most end of the book questions, tests, exams, and quizzes have similar structure and the students are used to certain type of questions and they focus on a memorized pattern of questions and answers. Also, students' habits of study, distraction of social environments, students' role models, high school background, and students' motivation and attitudes toward learning can not be neglected. Faculty willingness to change their teaching habits, time allowed to faculty to improve are other factors. For conclusive results a larger samples of students from different institutions are requirements. In addition to that, tests must be repeated by faculty from different departments, for different subjects. Also, the same tests must be conducted by different faculty from the same department teaching the same subject.

TOWARD A SYSTEMATIC ASSESSMENT OF STUDENTS' LEARNING

The main aim of the systematic assessment is to relate the technical requirements of criterion 3 to the knowledge and skills gained during the years of engineering study. Engineering education system is intended to achieve specific goals. The first step in designing an educational system is to determine the final outcomes expected. Then education subsystems are designed to achieve that end. In designing an engineering curriculum these goals must be defined clearly and implemented. If the goals are clear and well defined, polices to achieve these goals can be established, curriculum and education technology can be developed. Also, methods of instructions are selected and methods for evaluation and assessment are adopted. EC 2000 criterion 3 gives an example of learning goals of engineering education.

The goals of engineering education are expressed in qualitative statements. Qualitative and quantitative measures are needed to measure the success of the education system to achieve its goals. Instructors use courseware to transform the qualitative goals to quantitative objectives. Tests and exams are employed to evaluate the achievement of courseware objectives. Since the assessment process evaluates students' skills and knowledge a connection theory is required to link the skills and knowledge to the requirements of criterion 3.

Questions

There are words in the literature of engineering education that need to be defined accurately. These definitions are necessary to specify some quantitative procedures to measure the success of engineering education. For reliable assessment of the achievement of the education system clear distinction and usage of these words is necessary. For successful results some questions about education terminology need specific answers.

- What are the distinctive differences between goals, objectives, deliverables, requirements, and outcomes of engineering education?
- What are the differences between skills and abilities?
- What are the relations between curriculum, courseware, syllabus and textbooks?
- How to relate the above terms to EC 2000 criterion 3?
- What are the correlations between general qualitative description of goals and deliverables and the quantitative description of course objectives?
- What is the correlation between the goals of engineering education and university mission and objectives?
- What is the correlation between the goals of engineering education and the college's mission and objectives?
- What is the correlation between the goals of engineering education and departmental mission and objectives?
- What is the correlation between the goals of engineering education and curriculum objectives?
- What is the correlation between the goals of engineering education and course objectives?

A systematic approach is needed to help us understand the differences between these words and the role of each in the education system.

A SUGGESTED CONTROL SYSTEM APPROACH

A control system approach is utilized to represent the engineering education system. Figure 1 shows a functional block diagram representation of the educational system.

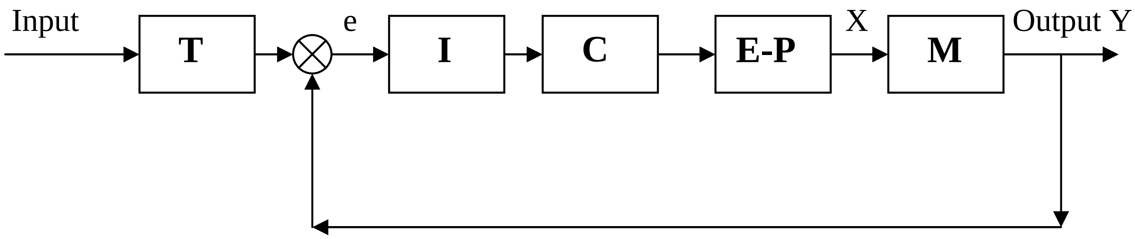

Figure 1. Block Diagram of the Education System

The input to the system is the goals of the desired engineering education system. The goals cover three dimensions of engineering education. These dimensions are mathematics, physics & basic sciences, engineering, and humanities. The goals are expressed using qualitative statements. Criteria 3 (a)-(k) is an example.

Block T, in figure 1, represents the process of transforming the general qualitative goals to a quantitative matrix of skills and knowledge bases. The comparison node in the figure compares the actual skills and knowledge base with the desired skills and knowledge. The deviation error, **e** in the figure, is used by the identification process (block **I** in the figure) to pinpoints the sources of deviation. Block **C** in the figure is the controller. Faculty and administrators are the main elements of this block. The controller issues a control policy for the correction to improve the performance. The correction policy is the input to education processes (Block **E-P**). Correction policy will work to change all or parts of the education processes. The main elements of **E-P** are curriculum, facilities, students, and instructors. The output of the **E-P** block is the learning state of the student **X,** which gives the important aspects of students' learning. Here **X** represents students' study habits, skills, abilities, and attitude towards learning and motivation. The measurement block **M** is responsible to produce quantitative measures of skills and knowledge **Y** gained during the learning process.

Curriculum

The goals of engineering education as outlined above are general and qualitative. It describes the qualities of the end product, i.e. the future engineer of the system shown in figure 1. General goals must be transformed into abilities, skills, characters, and knowledge bases that can be observed and measured. Teaching and learning process should produce the necessary skills and engineering knowledge. The main underlying hypothesis is that the skills and knowledge gained in the learning process produce an engineer with the desired qualities. Faculty, administrators and curriculum are responsible to produce the above skills in an engineering program.

Generally speaking, a curriculum is a systematic plan to enhance leaning and to achieve certain goals. It should be designed to produce engineers with specific knowledge and skills. The curriculum can be defined, from systems viewpoint, as an interactive feedback dynamic process to enhance learning and to achieve specific goals. The main interacting elements of the curriculum are ***objectives***, ***content,*** ***instruction techniques*** and ***evaluation methods.***

Objectives of the curriculum are derived from the goals of engineering education. Thinking of the end product of engineering education is an essential step to design the engineering curriculum. Goals as expressed in form of knowledge, skills, thinking habits and knowledge are cultivated in the labs and classrooms. Knowledge and skills should cover mathematics & physics, humanities or social studies and engineering. Skills include mathematical skills, physics skills, analytical skills, experimental skills, computational skills, design skills, scientific method skills and communication skills. Communication skills deal with the speaking, technical writing, reading, and small group communication to solve problems. Engineering knowledge is divided into two categories: 1) Engineering fundamentals, that focuses on the basic engineering concepts and principles that all engineers need to learn, 2) Engineering knowledge for a specialized field of engineering. Examples are aerospace, electrical, mechanical, chemical, civil, etc.

Content is the medium through which students will gain skills and knowledge. Content is manifested in the courses and syllabi. Courses use textbooks, handouts, on-line materials web pages, etc. Each course must have certain objectives that must be related to the goals of engineering education.

The instruction method is the main vehicle to achieve the learning goals. Switching from teaching to learning is a cornerstone in instructional techniques. Student-centered rather than teacher-centered class and lab activities are important to achieve the goals. Teacher’s role should be changed to the role of an educator and should work in the lab or classroom as a movie director. Instead of memorizing different formulae, students should be aware of the nature and assumptions behind each formula. They should be trained to select the proper formula for the given problem and know how and when to apply it. Instead of memorizing knowledge, students should be trained to collect information and produce knowledge. This will help to create the sense of discovery in the minds of students.

Evaluation should measure the success to achieve the curriculum objectives and the goals of engineering education. It must show the weak points that need correction. Different formats of evaluation includes interviews, questions, quizzes, tests, examination, projects, presentation should be designed to cover all aspects of the goals and objectives. An evaluation bank should be created, for various methods of evaluation, to cover all the aspects of each course. A question bank, using different format and styles should be designed and automated to measure the performance of student’s knowledge and skills in every engineering field.

Closing the Loop

The education process takes time to produce results (the output Y). The outcome Y must be as close as possible to the goals (the input) of the education system. Quantitative as well as qualitative measures must be used to define what "close" means. A learning process to produce graduates with the desired abilities needs different cognitive processes. An engineering program takes almost four years. During these years the output, at any time Y, is the partial achievements of the desired goals.

To produce the expected engineer and to achieve the engineering education goals, a systematic dynamic feedback procedure is required. Closing the loop is based on a top-down/bottom-up iterative cycle. The top-down part of the cycle is the process by which the general goals of engineering education are transformed to specific objectives related to the knowledge and skills required for the future engineer. Quantitative measures of knowledge and skills must be derived from the qualitative goals of engineering education. Engineering courses are designed to teach students knowledge and to sharpen their skills. Instruction techniques are used to transfer knowledge to students efficiently, and to train students to acquire skills. The bottom-up part of the iterative cycle uses the results of the process to find how close each student is to the goals of the education.

TOP-DOWN AND BOTTOM-UP ITERATIVE CYCLE

The top-down process is the process starting from the general qualitative goals to the minor details of course objectives, skills and knowledge. This reductionism is very important to specify the knowledge and skills required at different levels of engineering education. An iterative scheme is required to correlate the goals of engineering educations to the objectives of the curriculum and the courseware. Also, the correlation between the goals of the university to those of the college and finally to the objectives of the departments are essential in the evaluation scheme. The branching from the general goals of engineering educations to the details of knowledge and skills is an indispensable process for the assessment based EC 2000 criteria. The most important task is to relate students' skills, abilities and knowledge to the qualitative goals of education. In this respect there are few essential questions:

- How to relate students' critical thinking, creative thinking, and problem solving abilities to the objectives of courses quantitatively? And how to measure it?
- How to relate multidisciplinary abilities, ability to learn how to learn, life-long learning, how to think correctly, leadership, teamwork, time management (efficient use of time), holistic and serial thinking, parallel and sequential working, and taking decisions to the course objectives? And how to measure it?
- What are the basic skills and knowledge required to achieve the above qualitative goals?

The bottom-up process is the reverse process to discover the resulting goals based on the achievement of students. To do that we need to measure the skills and knowledge from the minor details, of tests, quizzes, interviews, projects, assignments, handworks, presentations, etc., and go up in a synthetic process to discover the emergent qualitative goals of the department, the college, and the university.

STUDENT'S EDUCATION PROFILE

This paper proposes a procedure to measure the degree of success of engineering education as reflected through students learning to achieve Engineering Criterion 3. The new procedure should produce an educational profile which will augment the A, B, C, D and F grades or GPA of each student. The education profile of each student will consist of four files. The first file covers mathematics, physics and basic sciences, the second and third files cover the engineering part of education, and the fourth file covers the humanities aspect of engineering education. Each file describes the required skills and knowledge of the expected graduate, and the percentage of skills and knowledge each student achieved during college.

Tasks to Produce Student's Education Profile

The tasks required to achieve the above proposal are:

1) Define the goals of engineering education in terms of the qualifications of the desired engineer.
2) Divide these qualifications in terms of basic engineering, student field of specific engineering, mathematics , physics & basic sciences and humanities
3) Outline the knowledge and skills needed in each of the above categories.
4) Transform the qualitative goals of education into sets of desired skills and knowledge for each category,
5) Express the desired skills and knowledge in form of a matrix of performance objectives,
6) Develop the curriculum and course structure to reflect the above
7) Design various methods to measure the acquired skills and knowledge of each student through the education process,
8) Create an evaluation bank with all measures required to cover the performance objectives of specific field of engineering education.
9) Use the above bank to create an automated procedure to measure students' achievements and to create an education profile for each student.
10) Develop a feedback mechanism to review the above points every year.
11) Relate the detailed skills and knowledge to (a)-(k) criterion 3 EC 2000.

EXAMPLE FROM AN AEROSPACE ENGINEERING PROGRAM

An example from the Aerospace Engineering Department at Tuskegee university is presented to show our effort to relate the goals of engineering to course objectives, to knowledge and skills, and then to (a) – (k) of criterion 3.

TOP/DOWN STRUCTURE: DESIGN PHASE

Hierarchy of education goals, course objectives, knowledge and skills

The following are the steps showing the top-down , goal-objective structure of aerospace engineering.

I. Goals of the college of engineering as derived from the college mission statement

- Prepare individuals for a full, satisfying and competitive career in an era when society demands comprehensive solutions to environmental and technological problems.
- Prepare professionals with the ability to apply technology for the benefit of society.
- Develop professionals with an appreciation for the humanistic (social, psychological and physical) aspects of a building problem, as well as other factors such as health, safety, welfare and economic feasibility.

II. Goals of the aerospace engineering department as derived from the department mission statement

Produce graduates of superior technical, professional and scientific background in aerospace engineering, who can perform effectively and embrace education as a lifelong endeavor.

III. Objectives of aerospace engineering curriculum as derived from the department goals

- Prepare our graduates with skills necessary to begin entry-level professional work in aerospace engineering or to continue graduate studies.
- Prepare our graduates for successful engineering careers.
- Provide an understanding of complexities of engineering and its importance to society.

- Produce graduates that are proficient in the use of computer and software packages.

IV. Knowledge and skills of an aerospace engineer

Courseware of aerospace engineering should produce students with specific skills and knowledge. Table 1 gives a simplified incomplete example of the mathematics, physics & sciences items. Table 2 gives another sample of the items of the basic engineering skills and knowledge. Table 3 gives an example of the certain items of the aerospace engineering profile. A forth table for humanities must be added. Exhaustive tables are required for a comprehensive assessment.

Table1. Mathematics, physics & basic sciences

Knowledge	Concepts	Elementary Skills	Higher level skills/abilities
I. Mathematics Arithmetic's Algebra Calculus Vectors Linear algebra Differential equations Special function Transformation II. Physics Mechanics Thermal fluids waves	 Function, polynomial, continuity, differentiability, solution, Linear/nonlinear identities	Scalar operations , associative , commutative, distributive laws, polynomial, series, sequence Limits, Differentiation, integration Quadrature, limits, Fourier, Laplace transforms Matrix and vector operations	Problem solving Team working Critical thinking Creative thinking Positive thinking Modeling Simulation

Table 2. Basic Engineering

Knowledge	Concepts	Elementary Skills	Higher level skills
 Examples of Engineering problems Differences between fields of engineering Engineering practice and profession	Equilibrium Force Energy Momentum Conservation Model Field Cycle Process Reaction resistance Reversible/irreversible Steady/unsteady	Calculation of stress and strain Calculate equilibrium points programming Presentation Power points	Problem solving Team working Critical thinking Creative thinking Positive thinking Component design Subsystem design System design Modeling & simulation Interpreting date

Table 3. Aerospace Engineering

Knowledge	Concepts	Elementary Skills	Higher level skills
Aircraft structure Aerodynamics Propulsion Aircraft performance, control, and stability Aircraft design Helicopter Missiles Satellite	Lift, drag thrust, power load factors degrees of freedom stall, spin stability, control performance linearization Stress, strain Factor of safety Design phases Design process Incompressible/Compressible Viscous/inviscid Laminar/turbulent	Experimental skills Calculation skills Design skills Analytical skills	Problem solving Team working Critical thinking Creative thinking Positive thinking Component design Subsystem design System design Modeling & simulation Interpreting date

BOTTOM-UP RESULTS: IMPLEMENTATION PHASE

Hierarchy of Course objectives, knowledge, skills, and education goals

An essential task is to relate the items of the tables 1-3, course objectives, to the department objectives, to the college objectives and to the university objectives and finally to EC 2000, especially to criterion 3 of EC 2000. Pass and fail decision will be based on the percentage required to achieve (a)-(k). The work needed is to develop methods to correlate the skills, knowledge, and objectives to (a)-(k) criterion 3. The expected methods should produce the following flow of knowledge and skills.

I. Courses level

Each course objectives should correlate skills and knowledge, as outlined in tables 1-3 to the technical requirements of criterion 3 as follows:

Outcome	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Objective 1	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Objective 2	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Objective 3	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Objective 4	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**

II. Department level

Each engineering department should produce the following;

A. Students profiles

Outcome	a	b	c	d	e	f	g	h	i	j	k
Student 1	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Student 2	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Student 3	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Student 4	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
	x%	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Student N	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**

Also, for each student three files are required to produce the students skills and knowledge as outlined in tables 1-3

B. Department profile

Outcome	a	b	c	d	e	f	g	h	i	j	k
Goal 1	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Goal 2	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Goal 3	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Goal 4	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**

III. College of engineering level

College of engineering should produce the following table

Outcome	a	b	c	d	e	f	g	h	i	j	k
Goal 1	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Goal 2	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Goal 3	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**
Goal 4	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**	**x%**

THE MISSING LINKS

Many research tasks are required to link top-down to bottom-up iterative cycle. The missing links will help to draw a global picture of student learning profile and its relation to criterion 3. These links requires:

1. Portfolio for each student to show his knowledge and skills
2. Quantitative methods to assess the technical requirements of criterion 3
3. Qualitative methods to assess the non-technical requirements of criterion 3
4. Emergent theory to show how the holism view is related to reductionism methodology followed in classroom and labs and expressed in form of skills and knowledge.

5. Concept map to show the connections between different engineering knowledge and concepts as shown in tables 1-3.

CONCLUSIONS

A systematic, dynamics, feedback procedure is proposed to produce an education profile for an engineer. This profile will help to assess students' learning of engineering education. An education profile of each student is suggested to augment the A-F grading system. Each student profile consists of four files: a file for mathematics, physics & basic sciences, a file for humanities and two files for engineering. Each file will show the required knowledge, concepts and skills and the percentage the students achieved. Also, the profile should show how course objectives, knowledge and skills are related to Criteria 3 of EC 2000. The procedure is based on relating what students achieved, in terms of knowledge and skills, to the goals of engineering education as expresses through a matrix of performance objectives. Quantitative measures will be designed to assess the engineering knowledge and skills of each student. The success of this proposal will depend on developing methods to relate acquired students skills and knowledge to criterion 3 of EC 2000.

REFERENCES

[1] How Do You Measure Success? ASEE Professional Books, American Society for Engineering Education, 1998.
[2] www.abet.org/criteria.html (last accessed 27 January 2005)
[3] Ronald L. Miller, Reflection on Outcomes ABET Accreditation Process, Proceeding of the 2002 ASEE Annual Conference & Exposition.
[4] Terenzini, Patrick T. et al., Preparing for ABET 2000: assessment at the classroom level, Proceeding of the 1998 ASEE Annual Conference & Exposition.
[5] Hoey, J.J., Trust: Essential to effective assessment, Proceedings- Frontiers in Engineering Conference, v1, 2001, p T1A/13.
[6] Stadler, Alan T., Assessment tools for ABET EC 2000, 1999 National Civil Engineering Education Congress, Oct 16- 20, 1999, Charlotte, NC.
[7] Withington, James P., Short-cycle assessment techniques for ABET EC 2000 compliance, - Frontiers in Engineering Conference, V1, 1999, p.11b1-14-11b1-17.
[8] Fromm, Eli, The changing Engineering Educational Paradigm, Journal of Engineering Education, Vol. 92, No.2, pp 113-121, April 2003.
[9] Splitt ,Frank G., The Challenge to Change: On Realizing the New Paradigm for Engineering Education, Journal of Engineering Education, Vol. 92, No.2, pp 181-187, April 2003.

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