Symposium on Engineering Education 2009
May 16-18, 2009,

A CASE STUDY ON ABET ACCREDITATION REQUIREMENTS AND PREPARATION

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Accreditation of academic programs is an essential step for ensuring high quality education. Accreditation helps students and their parents to choose quality college programs; enables employers to recruit graduates they know are well-prepared; helps registration, licensure, and certification boards to screen applicants, and gives colleges and universities a structured mechanism to assess, evaluate; and improve the quality of their programs.

Among several accreditation boards of the academic programs, Accreditation Board for Engineering and Technology (ABET) is responsible for the specialized accreditation of educational programs in applied science, computing, engineering, and technology. ABET accreditation assures that a college or a university program meets the quality standards established by the profession for which it prepares its students.

In this paper, a case study on how to prepare for ABET accreditation is presented. A process on how to set the program vision, mission, educational objectives and outcomes is presented. Additionally, various assessment methods for program educational objectives and outcomes are presented and analyzed using real data. Finally, improvement actions taken to improve weaknesses are explained.

Keywords: Accreditation, Assessment, ABET, Educational Objectives, Program Outcomes.

1. Introduction

Accreditation is one mean of ensuring that minimal educational standards have been met. Accreditation is a voluntary, non-governmental process of peer review and requires an educational program to meet defined standards. Accreditation standards for engineering have been adopted by the Engineering Accreditation Commission (EAC) of the Accreditation Board for Engineering and Technology (ABET), a federation of 28 participating societies that represent the engineering and engineering-oriented disciplines, and virtually all engineering subjects in the USA. The evaluation begins with an institution and its degree programs. Each program in every institution prepares a self-study report (SSR) that is examined closely by the ABET as part of the accreditation process. The ABET currently accredits over 1,500 engineering programs, 700 engineering technology programs and 50 programs in engineering related areas, such as occupational safety, industrial hygiene and surveying. Thus, with the input and guidance of industry and academia, the ABET sought to develop an accreditation system that would provide the means for engineering programs to successfully prepare graduates for engineering practice in the 21st Century.

1.1. *Benefits*

Several benefits can be gained from ABET accreditation, for example:

- Schools make sure of their programs quality.
- Schools know their strength, weakness and set improvement actions.
- Students can choose the best programs.
- Parents can assure the quality of their kids.
- Employers can recruit the best graduates.
- Government and parents make sure that fund is spent well.
- Admission in worldwide programs.

The ultimate goal is to facilitate the acquisition of the knowledge, skills and strategies needed to professionally train future engineers. Current trends are such that engineers of the 21st Century are now expected not only to be efficient in their technical fields, but also have leadership qualities, good knowledge of contemporary issues, ability to think critically, sensitivity to ethical responsibility, skills to communicate effectively, and the ability to engage in life-long learning and cultural literacy.

2. Accreditation Process

Accreditation is a continuous process that involves several preparation and action steps including:

- Preparing a self-study report (SSR).
- Conducting several institution-wise seminars about accreditation to promote student and faculty awareness. Promoting an ABET culture and encouraging faculty members to attend local and international workshops on ABET accreditation.
- Establishing departmental accreditation committees.
- Setting programs vision, mission, educational objectives and program outcomes.
- Establishing an industry advisory board.
- Identify constituents consisting of primary ones such as students, faculty, alumni, employers, training supervisors and industrial advisory board, and some non-primary members such as parents and university administrators.

3. Self-Study Report (SSR)

It is the responsibility of the program seeking accreditation to demonstrate clearly that the program meets the following criteria which demonstrates clearly that the program meets a specific bench mark (target) representing that the program educational objectives and outcomes are achieved.

- Criterion 1: Students.
- Criterion 2: Program Educational objectives.
- Criterion 3: Program Outcomes.
- Criterion 4: Continuous Assessment/Improvement.
- Criterion 5: Curriculum.
- Criterion 6: Faculty.
- Criterion 7: Facilities.
- Criterion 8: Support.
- Criterion 9: Program Criteria.

3.1. *Students*

The program must evaluate student performance, advice students regarding curricular and career matters, and monitor student's progress to foster their success in achieving program outcomes, thereby enabling them as graduates to attain program objectives. The program must have and enforce policies for the acceptance of transfer students and for the validation of courses taken for credit elsewhere. The program must also have and enforce procedures to assure that all students meet all program requirements.

3.2. *Program Educational Objectives*

Each program for which an institution seeks accreditation or re-accreditation must have in place:

(a) Published educational objectives that are consistent with the mission of the institution.

(b) A process that periodically documents and demonstrates that the objectives are based on the needs of the program's various constituencies.

(c) An assessment and evaluation process that periodically documents and demonstrates the degree to which these objectives are attained.

3.3. *Program Outcomes*

Engineering programs must demonstrate that their students attain the following outcomes:

(a) An ability to apply knowledge of mathematics, science, and engineering.

(b) An ability to design and conduct experiments, as well as to analyze and interpret data.

(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

(d) An ability to function on multidisciplinary teams.

(e) An ability to identify, formulate, and 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, economic, environmental, and societal context.

(i) A recognition of the need for, and an ability to engage in life-long learning.

(j) A knowledge of contemporary issues.

(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Program outcomes should be similar to ABET outcomes (a) through (k) plus any additional outcomes that may be articulated by the program. Program outcomes must foster attainment of program educational objectives. There must be an assessment and evaluation process that periodically documents and demonstrates the degree to which the program outcomes are attained.

3.4. *Continuous Assessment and Improvement*

Each program must show evidence of actions to improve the program. These actions should be based on available information, such as results from Criteria 2 and 3 processes.

3.5. *Curriculum*

The curriculum requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The faculty must ensure that the program curriculum devotes adequate attention and time to each component, consistent with the outcomes and objectives of the program and institution. The professional component must include:

(a) One year of a combination of college level mathematics and basic sciences (some with experimental experience) appropriate to the discipline.

(b) One and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study. The engineering sciences have their roots in mathematics and basic sciences but carry knowledge further toward creative application. These studies provide a bridge between mathematics and basic sciences on the one hand and engineering practice on the other. Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs.

(c) A general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives. Students must be prepared for engineering practice through a curriculum culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.

3.6. *Faculty*

The faculty must be of sufficient number and must have the competencies to cover all of the curricular areas of the program. There must be sufficient faculty to accommodate adequate levels of student-faculty interaction, student advising and counseling, university service activities, professional development, and interactions with industrial and professional practitioners, as well as employers of students. The program faculty must have appropriate qualifications and must have and demonstrate sufficient authority to ensure the proper guidance of the program and to develop and implement processes for the evaluation, assessment, and continuing improvement of the program, its educational objectives and outcomes. The overall competence of the faculty may be judged by such factors as education, diversity of backgrounds, engineering experience, teaching effectiveness and experience, ability to communicate, enthusiasm for

developing more effective programs, level of scholarship, participation in professional societies, and licensure as Professional Engineers.

3.7. *Facilities*

Classrooms, laboratories, and associated equipment must be adequate to safely accomplish the program objectives and provide an atmosphere conducive to learning. Appropriate facilities must be available to foster faculty-student interaction and to create a climate that encourages professional development and professional activities. Programs must provide opportunities for students to learn the use of modern engineering tools. Computing and information infrastructures must be in place to support the scholarly activities of the students and faculty and the educational objectives of the program and institution.

3.8. *Support*

Institutional support, financial resources, and constructive leadership must be adequate to assure the quality and continuity of the program. Resources must be sufficient to attract, retain, and provide for the continued professional development of a well-qualified faculty. Resources also must be sufficient to acquire, maintain, and operate facilities and equipment appropriate for the program. In addition, support personnel and institutional services must be adequate to meet program needs.

3.9. *Program Criteria*

Each program must satisfy applicable Program Criteria (if any). Program Criteria provide the specificity needed for interpretation of the baccalaureate level criteria as applicable to a given discipline. Requirements stipulated in the Program Criteria are limited to the areas of curricular topics and faculty qualifications. If a program, by virtue of its title, becomes subject to two or more sets of Program Criteria, then that program must satisfy each set of Program Criteria; however, overlapping requirements need to be satisfied only once.

4. Case Study

In the following sections, the experience of the Department of Petroleum and Natural Gas Engineering in King Saud University, Riyadh, Saudi Arabia is demonstrated using real examples.

4.1. *KSU-PGED Vision*

To be internationally recognized as a premier academic Department of Petroleum and Natural Gas Engineering.

4.2. *KSU-PGED Mission*

- Providing high quality educational programs, training and research activities.
- Graduating students with required skills to compete at international level.
- Attracting and developing high caliper faculty members.

4.3. *KSU-PGED Educational Objectives*

PGED constituencies were involved in developing the Petroleum and Natural Gas Engineering Department objectives including: industry advisory board, faculty members, alumni, and students. Initially, several short statements describing the accomplishments of PGED graduates (three to five years after graduation) were selected by the department council (consistent with ABET) and documented in a survey form. The final statements, shown below, revealed that most of the initial proposed statements are highly accepted by the surveyed constituencies and integrated together to form the KSU-PGED educational objectives.

- Graduates will perform as highly skilled engineers in the local and international petroleum and natural gas industry.
- Graduates will continue to learn, improve and evolve in their jobs.
- Graduates may pursue higher education to participate in academia and involve in research.

5. KSU-PGED Program Assessment

The KSU-PGED Program assessment plan is set to primarily confirm that the PGED program graduates are achieving the desired program outcomes. The results are used to improve the program success and the student learning based on real evidence.

The Department Advisory Committee and the Department council periodically review the program assessment and make any necessary modifications.

5.1. *Program Educational Objectives Assessment*

Program educational objectives, mentioned above, are prepared in conjunction with the stake holders to

serve the country needs. The following sets of indirect and direct assessment mechanisms are used respectively:

- Survey employers' opinion about the PGED graduates' performance on their jobs.
- Collecting information about PGED graduates' current positions and their advancement in postgraduate studies.

5.2. *Program Outcomes Assessment*

The Program Educational Outcomes is assessed directly and indirectly as follows:

5.2.1. *Direct Assessment Methods*

5.2.1.1. *Student Final Grades Assessment*

For those outcomes that are closely matched to specific course content, student exams and assignment grades provide an excellent measure of satisfaction of program outcomes, provided that each course exam is prepared carefully to address all listed course objectives. Analyzing the student final grades in each course can explore the overall degree of achievement of program outcomes to reveal any actions needed for program improvement or adjustment as shown in Table 1.

5.2.1.2. *Course Educational Outcomes Achievement*

This technique is used to measure the course educational outcomes achievement to target ratio (a bench mark) based on all measurable tools including home works, quizzes, term papers, design projects, midterm exams, and final exam. Score of all students in every specific measuring tool is used as an indictor for the specific course educational outcomes achievement.

Tables 2 and 3 show the analysis of results using this method for one of the PGED core courses offered in 1st semester (2008-2009).

5.2.2. *Indirect Assessment Methods*

5.2.2.1 *Student Course Evaluations Survey*

Each course taught by the department undergoes a student evaluation at the end of each semester, through the Student Course Evaluation Form. This form has a two major parts; the first part measures the degree of achievement of the program outcomes that are related to that course. The second part measures the degree of student satisfaction of the course in terms of contents, related text books, and laboratory facilities if applicable.

Results of these surveys will reveal how students perceive the quality of the courses, and look for problematic patterns in certain courses. Individual faculty members use the evaluations to monitor student perception of their courses, and to propose improvements and adjustments as appropriate.

5.2.2.2 *Faculty Survey*

For each course at the end of each semester, the faculty member submits the Faculty Survey Form that corresponds to his teaching course in order to express his satisfaction about the senior year student abilities on achieving the program outcomes that are related to his course. Results of such survey will be useful for both the Department Chairman as well as the faculty member to take any necessary actions to improve the graduates' quality in accordance to the program outcomes.

5.2.2.3 *Graduating Senior Exit Survey*

The graduating senior exit survey is conducted for each group of students that will be graduated and exiting the program. It mainly measures the level of satisfaction of the senior exit students about the program outcomes as a whole (independent of specific course or instructor) and it provides a mature perspective on the effectiveness of the program on achieving its objectives. It also reflects the positive and negative aspects of the students toward the program. Analyzing the results of the survey will encourage for appropriate actions to be taken for further improvements of the program.

5.2.2.4 *Alumni Survey*

The Alumni survey is conducted biannually one year after graduates have completed their degree. Most of the questions are asked to measure the degree of program outcomes achievement that is also linked to ABET criteria. These data provide useful information and are particularly helpful in measuring those outcomes that are less directly to specific courses. The results of such survey play a role in both assessing the program outcomes and monitoring program quality and effectiveness.

5.2.2.5 *Employer Survey*

The effectiveness of the program outcomes can be assessed and measured through the employer survey, since the employer is one of the main constituencies of the program. Such survey is conducted at least

once a year after employment and be submitted by the employer to express his satisfaction towards the graduates quality, knowledge, effective communication, continuing learning and working professionally in multi-disciplinary teams. The employer feedback will have appreciable overviews that help in assessing and improving the program.

6. Concluding Remarks

In conclusion, for better quality outcomes, two major actions have been taken as follows:

- A preparatory year program for newly admitted engineering students has been established. In this program, the students are focused on English language, communication skills, computer usage, and basic science courses.
- The total program credit hours for the petroleum and natural gas engineering department were reduced to accommodate the preparatory year in the five year program.
- This reduction gave us the opportunity to revise, combine, and update the curriculum core courses taking into consideration the opinion of the oil industry with reference to well known international petroleum schools.

Acknowledgments

The authors would like to thank King Saud University represented by the Dean of College of Engineering Professor Abdul-Aziz Al-Hamid and Vice-Dean for higher studies and quality Professor Abdullah Al-Mohaideb for unlimited support, encouragement and permission to publish this paper.

Bibliography

[1] Criteria for Accrediting Engineering Programs 2008-2009, Engineering Accreditation Commission, ABET Inc., USA.

[2] Self Study Report, Department of Petroleum and Natural Gas Engineering, College of Engineering, King Saud University, Riyadh, Saudi Arabia, 2009.

[3] Waleed Abulfaraj, Adnan H. Zahed, Mohammad Kabesh & Solaiman Ali:" The international trends and reforms in engineering education at King Abdulaziz University", World Transactions on Engineering and Technology Education, Vol. 5, No. 1, pp. 143-148, 2006.

Table 1. Results of Courses Final Grades

2nd Semester 2006-2007											
Courses	A+	A	B+	B	C+	C	D+	D	F	% ≥ Grade C	Comments
PGE 251	21	29	11	7	18	4	0	7	4	89	✓
PGE 361	14	10	14	29	10	5	0	10	10	81	✓
PGE 462	33	0	0	0	33	0	0	33	0	67	✓
PGE 475	10	10	0	20	0	20	20	10	10	60	✓
PGE 481	0	10	0	20	10	40	20	0	0	80	✓
PGE 483	13	13	0	13	0	25	13	13	13	63	✓
PGE 485	44	33	0	0	0	11	11	0	0	89	✓
PGE 487	25	0	0	25	0	25	0	0	25	75	✓
Grand Average										75.5	Target Achieved

Department Target (Bench Mark) = 60% ≥ Grade C

Table 2. PGE 491 Educational Outcomes Mapping

PGE 491: Petroleum and Natural Gas Economics and Legislations

Topic addresses Course learning outcome:
(0) Not at all (1) slightly (2) moderately (3) considerably

Topics Related to Course Learning Outcomes	**ABET and Program Outcomes**										
	1	2	3	4	5	6	7	8	9	10	11
History and legislations of oil in Saudi Arabia, Oil pricing methods, Economical resources, Swing producer.	1							3			
Inflation, cartel and market clearing price, Historical data for oil prices development.	0							3			
OPEC, OAPEC, International Energy Agency and Basic engineering economy terms.	3							3			
Simple and Complex interests, Nominal and Effective and combined interest rates, Deterioration and sinking fund factor.	3							2			
Screening yardsticks for economical projects: Formulas for continuous and lump sum flow of fund, Net present value, Rate of return, Accounting rate of return, Growth rate of return, Discounted and undiscounted Payout time, Profit-to-Investment ratio, Benefit-Cost ratio, Present value ratio, Incremental analysis.	3							3			
Real economical examples based on oil field production data.	3							3			
Average weight	39%							61%			

Course Learning Outcome:

1. Apply the knowledge of mathematics, geology, physics, chemistry as well as other engineering sciences. (Corresponds to ABET Outcome "a").
2. Conduct experiments safely and accurately and to be able to correctly analyze the results. (Corresponds to ABET Outcome "b").
3. Design an engineering process or system to meet desired needs. (Corresponds to ABET Outcomes "c").
4. Work in a team environment. (Corresponds to ABET Outcome "d").
5. Identify, formulate and solve engineering problems. (Corresponds to ABET Outcome "e").
6. Understand professional and ethical responsibilities. (Corresponds to ABET Outcome "f").
7. Communicate successfully and effectively. (Corresponds to ABET Outcome "g").
8. Understand the impact of engineering solutions in a global, economic, environmental and societal contest. (Corresponds to ABET Outcome "h").
9. Recognize of the need for, and an ability to engage in life-long learning. (Corresponds to ABET Outcome "i").
10. Knowledge of contemporary issues. (Corresponds to ABET Outcome "j").

Understand the use of modern techniques, skills and modern engineering tools necessary for petroleum and natural gas engineering practice. (Corresponds to ABET Outcome "k").

Table 3. Example for Actual Course Educational Outcomes Achievement

King Saud University - College of Engineering
Petroleum and Natural Gas Engineering Department
Assessment of Course Educational Outcomes

Course No. and Code: PGE 491
Course title: Economics and Legislations of Petroleum and Natural Gas
No. of Credit hours: 2
Semester and Year: First 1429-1430 (2008-2009)
Instructor name: Professor Musaed N. J. Al-Awad
No. of students: 20
Section no.: 18278

Grades Distribution	
Test Method	**Marks**
Home Works	10
Quizzes	5
Term Paper	N/A
Project	N/A
Mid Term Exam 1	15
Mid Term Exam 2	20
Final Exam	50
Total	**100**

Weight	**Course Educational outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
Home works	4							6			
Quizzes	2							3			
Term paper	--							--			
Project	--							--			
Midterm exam 1	6							9			
Midterm exam 2	8							13			
Final Exam	20							30			
Assigned weight	**39**							**61**			

Students Score for Outcome "a"										
Student ID #	HWs (4)	Quizzes (2)	TP (--)	Project (--)	MTE 1 (6)	MTE 2 (8)	FE (20)	Total (40)	Score	
									100	5.0
421004xxx	4	2	--	--	6	8	18	37	92	4.6
422003xxx	2	1	--	--	3	5	15	27	67	3.3
423102xxx	4	2	--	--	6	8	20	40	99	5.0
423102xxx	3	1	--	--	4	6	15	29	74	3.7
423104xxx	3	2	--	--	5	7	18	35	88	4.4
423106xxx	2	1	--	--	3	4	14	24	61	3.1
424104xxx	3	2	--	--	5	7	18	35	88	4.4
424105xxx	4	2	--	--	5	7	15	33	82	4.1
424117xxx	3	1	--	--	4	5	15	28	70	3.5
425101xxx	4	2	--	--	6	8	20	39	98	4.9
425102xxx	3	2	--	--	5	6	17	33	83	4.1
425103xxx	3	2	--	--	5	7	17	34	86	4.3
425103xxx	3	2	--	--	5	7	18	35	87	4.4
425104xxx	3	2	--	--	5	7	17	34	86	4.3
425106xxx	4	2	--	--	6	8	19	39	98	4.9

426101xxx	4	2	--	--	6	8	19	38	95	4.7
426102xxx	3	2	--	--	5	7	18	34	86	4.3
426103xxx	3	2	--	--	5	7	16	33	82	4.1
426112xxx	3	2	--	--	5	6	19	35	88	4.4
426112xxx	4	2	--	--	6	8	19	39	97	4.8
Department target score: ≥70% (≥3.5 out of 5)								**Average**	85	4.3
Comments	Satisfactory (✓) Unsatisfactory ( )									

Students Score for Outcome "h"										
Student ID #	HWs (6)	Quizzes (3)	TP (--)	Project (--)	MTE 1 (9)	MTE 2 (13)	FE (30)	Total (61)	Score	
									100	5.0
421004xxx	6	3	--	--	8	12	26	55	90	4.5
422003xxx	3	2	--	--	5	8	21	39	64	3.2
423102xxx	6	3	--	--	9	13	28	58	96	4.8
423102xxx	4	2	--	--	6	9	20	42	69	3.5
423104xxx	5	3	--	--	8	11	25	52	85	4.2
423106xxx	3	2	--	--	5	7	20	36	59	3.0
424104xxx	5	3	--	--	8	11	26	53	86	4.3
424105xxx	5	3	--	--	8	11	22	49	81	4.0
424117xxx	4	2	--	--	6	8	29	49	80	4.0
425101xxx	6	3	--	--	9	12	29	59	96	4.8
425102xxx	5	2	--	--	7	10	21	46	75	3.8
425103xxx	5	3	--	--	8	11	25	52	85	4.2
425103xxx	5	3	--	--	8	11	25	51	84	4.2
425104xxx	5	3	--	--	8	11	25	52	85	4.2
425106xxx	6	3	--	--	9	13	27	58	95	4.8
426101xxx	6	3	--	--	8	12	26	55	90	4.5
426102xxx	5	2	--	--	7	11	25	50	83	4.1
426103xxx	5	3	--	--	8	11	22	48	79	3.9
426112xxx	5	2	--	--	7	10	28	53	87	4.3
426112xxx	6	3	--	--	9	13	28	58	96	4.8
Department target score = ≥70% (≥3.5 out of 5)								**Average**	83	4.2
Comments	Satisfactory (✓) Unsatisfactory ( )									