Engineering Education Excellence at King Abdul Aziz University: ABET Accreditation and Beyond

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Abstract

The College of Engineering at King Abdul Aziz University (KAAU) crossed a historic milestone in 2003 when it acquired the substantial equivalency status for its 12 degree-programs after undergoing evaluation by the ABET. This marked a strong beginning of a life-long process of continuously improving engineering education at KAAU. The entire process of preparing a large faculty to face up to the challenges of arriving at the target, spanning over a period of three years, provided unique experiences of mobilizing human and physical resources akin to a large-scale project management. Out of this experience came several strategic initiatives that will position KAAU to be a leader in engineering education in the Middle East. The two most important initiatives are: (1) the offering of a new mandatory course, Introduction to Engineering Design, and (2) the creation of the Engineering Consulting and Professional Development Office (ECPDO). The goal of the new course is to introduce students to the Engineering Method which can be accomplished by focusing on 1) Self Regulation, 2) Communication, 3) Working Cooperatively and Collaboratively, 4) Problem Solving, 5) Modeling, and 6) Quality. These objectives are achieved by the use of Active Learning in class where student teams, continuous improvement of the learning process and constructivist learning exercises are routinely used. The ECPDO's mission is to build the most effective partnership between the industry and KAAU. This partnership will help the development of cutting edge research and innovation that benefits society as a whole and fosters regional and national industrial and economic development. ECPDO will help to develop innovative programs that provide students with hands-on, real world experience in industry, and provides industry with excellent opportunities to advance research, leverage the university's state-of-the-art technology and recruit the engineering talent of the future. A number of important issues relating to the accreditation process and its impact on engineering education at KAAU will be reviewed in this paper.

Introduction

One way of ensuring and demonstrating the high quality of engineering education is through evaluation carried out by accreditation bodies like ABET[1]. The College of Engineering at King Abdul Aziz University (KAAU) is a pioneering institution in the western region of the Kingdom of Saudi Arabia. The College took a strategic decision when it resolved to seek ABET accreditation for all of its 12 engineering degree programs for which it formed a College Steering Committee[2] (CSC) in March 2000.

In line with the vision of the University and the commitment of its top management, the Dean and Vice-Dean of the College attended the 2000 ABET's annual meeting in the U.S. and made a formal request for the evaluation of all the engineering programs of the college. It is worth mentioning here that for countries outside the U.S., where ABET is requested to assist in the evaluation of the engineering degree programs, 'Substantial Equivalency' is used as the outcome instead of accreditation. 'Substantial equivalency' status being accorded to a foreign engineering education program implies that the graduates possess the competencies needed to begin professional practice at the entry level. Also, it judges that the degree is comparable in program content and educational experience. It is granted if current conditions are judged to be meeting or exceeding the minimum requirements set by ABET. For an institution seeking accreditation for the first time, there is an enormous amount of pre-visit preparations to be done before the on-campus visit by a team of ABET's Program Evaluators (PEV's). The on-campus visit took place in April, 2002, culminating in the successful granting of Substantial Equivalency status for the following B.Sc. degree programs:

i - Aeronautical Engineering
ii - Biomedical Engineering
iii - Chemical Engineering
iv - Civil Engineering
v - Computer and Control Engineering
vi - Electric Power & Machine Engineering
vii - Electronics & Communications Engineering
viii - Industrial Engineering
ix - Mining Engineering
x - Nuclear Engineering
xi - Production Engineering & Mechanical Systems Design
xii - Thermal Engineering & Desalination Technology

The criteria used to evaluate the above programs were the 'conventional criteria' whereas Engineering Criteria 2000 (EC-2000) is being currently employed in the U.S.

Efforts and Experiences

College of Engineering at KAAU is a fairly large college with over 3000 students, 330 staff members, and 155 faculty members. There are nine departments offering graduate- and postgraduate-level education. Each department has well equipped laboratories, library facilities and well developed computer laboratories and other necessary infrastructure. Some of the facilities at the university level and in the college of science are also utilized. To motivate and activate all the students and staff members and to prepare the necessary documentation according to ABET prescribed format was a challenge of mammoth proportions.

Financial and physical resources were of little importance compared to the intellectual inputs and other efforts rendered by staff members. These efforts and experiences are briefly recounted here under the following sub-sections:

- Pre-visit preparation,
- On-campus visit, and
- Post-visit activities.

Pre-visit preparation

Pre-visit preparations involved training of the faculty members from each department through a number of workshops conducted by foreign and local experts. Preparations involved elaborate documentation of all aspects of the academic activities at the college as well as program level. A number of committees at various levels worked tirelessly in order to complete the tasks assigned to them under the guidance of the CSC. The following documents had to be prepared for each program to be evaluated by the ABET evaluators' team:

- Self-study questionnaire for reviewing engineering programs concerning College/University level data and information (Volume I),
- Self-study questionnaire for reviewing engineering programs concerning department level data and information (Volume II),
- Course Files for each course being taught in the department. At least two course files for two recent semesters are required for evaluation. Each course file should contain the following information:
  1. Course description and course instructor,
  2. Detailed syllabus on weekly basis,
  3. Textbook and reference book (s),
  4. Assignments; home work, quizzes, exams, projects, computer applications, design contents, laboratory work, and
  5. Three examples of students' work for each of the above assignments,
- Senior projects design reports showing the accomplishment of capstone design content,
- Safety manuals for laboratories, and
- Student advising system and student co-curricular and extra-curricular activities substantiated by various student clubs and societies.

Along with the documentation process a "Preliminary Program Assessment Questionnaire" was sent to the ABET International Activity Committee (INTAC), which is responsible for foreign program evaluation. In response to our questionnaire, a two-member consultancy team was selected by ABET to visit KAAU to evaluate its readiness for a formal visit. The visit of the consultancy team took place in February, 2001. The team checked all the documents, visited various laboratories, interviewed a number of faculty members and students and called on a number of the university authorities. The team's visit proved to be beneficial because they pointed out some of the areas where further improvement was needed. The consultancy team submitted their report to the INTAC with their recommendations that a visit by the ABET evaluation team could be scheduled, at KAAU's request, within 6 months to a year's time. The work on self-study documents and other areas continued with more vigor and zeal in which virtually all the faculty members were involved in way one or another.

On-campus visit

On-campus visit is the most auspicious event of the accreditation process. Its main purpose is to conduct detailed examination of the materials compiled by the institution in self-study questionnaires (Volume I and II) as well as to make qualitative assessment of the other important factors that were not included in the self-study questionnaires. After three years of intensive preparations, a team of 14 evaluators including the team chairman and vice-chairman did a thorough inspection for three days. The University administration facilitated the work of the evaluators in every respect besides extending hospitality. It is worth mentioning that the evaluation team members were very senior in their respective organizations and undertook the evaluation work on an honorary basis as service to the profession. Among the evaluators' team, 2 members were Ex-Rectors of universities and 4 members were Deans of Engineering in various American universities. The schedule of activities during the on-campus visit was really hectic and professional-like for all the parties. Following is a list of the activities the evaluators undertook for each degree program:

- Evaluating class work and student material documented in course files.
- Visiting facilities like laboratories, offices and classrooms in the departments.
- Holding meetings and conducting interviews with students, staff and administrators.
- Visiting other supporting departments in the University to inspect their relevant laboratories and course files.
- While the program evaluators engaged themselves in their respective program evaluation, the chairman and the vice-chairman of the team paid visits to other facilities as documented in self-study questionnaire Volume I.
- As a last part of the activities of the evaluation team, the final drafts of the Exit Interview Statements outlining the possible accreditation actions, were finalized. The copies of final versions of the Exit Statements were e-mailed/faxed to the head office of ABET in the U.S.
- In a joint meeting of evaluators' team with the Vice-Rector of the university, Dean and Vice-Deans of the college of engineering, Chairmen of the departments and members of the Steering Committee of the college, the Exit Interview Statements were presented by the evaluator of each program. It was a solemn occasion exhibiting the climax of the visit when each evaluator read out the statements indicating their comments.

Post-visit Activities

Post-visit Activities constitute the implementation stage for the recommendations of the evaluators. The Chairman of the evaluation team acts as a liaison officer between the INTAC office and the Dean of the college. A 30-day period is provided to set right any concerns, weaknesses or deficiencies in the program. The remedial actions taken or proposed by the Dean of the college are considered and, if found satisfactory, the draft Exit Interview Statement is amended and then sent to the INTAC authorities. The decision about the final substantial equivalency statement is communicated to the university authorities after the final approval of the ABET Board, which was officially communicated to KAAU in September, 2003.

Impacts and Advantages

In the previous section, a synoptic view of coordinated efforts spanning over 3 years was presented. However, a detailed account of efforts and anxieties of all the stake-holders in this process will be out of context of this paper. Countless hours of hard work, as part of the deliberations of various committees working at different levels, was of paramount importance for the successful completion of the project. Each department tried to excel in projecting their program to the satisfaction of the ABET evaluators. Performance of various teams exceeded expectations and whole faculty felt elated with the outcome of the evaluation. It is certain that the process will have many positive impacts on the quality of education for the college of engineering. A number of tangible advantages from acquiring the substantial equivalency status are outlined below:

- The new curricula for all the 12 programs of the College have recently been revamped in the light of the ABET recommendations. In the new curricula, the total number of credit hours has been reduced from 165 to 155, thereby reducing time spent for the B.Sc. degree in engineering. In financial terms, this change alone will have enormous advantages on individual as well as national level. The new curricula have been implemented from the Fall semester of the academic year 2003/2004.

- Under the directive of the President of the University, an Industrial Advisory Committee has been established in the academic year 2002/2001 to strengthen and formalize the College-industry relationship on regular basis. Members of this Committee are leading industrialists from public and private organizations and are senior members of the College. The Committee has appreciated the acquisition of substantial equivalency status for the engineering degrees of the College as a great confidence boosting measure for employment of engineering graduates. The Committee has held regular meetings for seeking new ways and means of enhanced co-operation for improving the quality of education and research for the mutual benefit, thereby providing opportunities to the faculty members to enhance their professional experience. Following objectives are envisaged for the committee

    - Consolidate the relationship between the Faculty of Engineering and the Public and Private Sector organizations.
    - Provide for the Public and Private Sectors an opportunity to recommend changes and contribute to the development of Faculty's educational programs to suit market manpower needs and professional requirements.
    - Synchronize development in academic programs and the number of engineering graduates according to specialization and market needs.
    - Assess and fulfilling the needs of the Private Sector for training seminars for their employees, through short courses and seminars.
    - Increase cooperation with the Private Sector in all engineering disciplines for purposes of promoting scientific research within the Faculty, addressing and solving real-life problems of the local industry and community.
    - Increase cooperation with the Private Sector organizations for all engineering disciplines for participation in summer training programs for the

students as well as to providing an opportunity for the Faculty members to professionalize their experience.

- Accreditation process has positively encouraged innovation both in curriculum development and in teaching methods. One example of it was the adoption of two compulsory courses (IE201 and IE202) for all engineering students in the new curricula. This course involves interactive learning for instilling among the students notions like life-long learning, working in teams, quality consciousness, simple modeling and simulation tools, engineering problem-solving skills and time management, which are considered necessary for meeting the 21st century challenges of engineering profession. While this effort was covered in previous publication it will briefed in Appendix A for completeness.

- Engineering Consulting and Professional Development Office (ECPDO) was established in September, 2003, to fulfill one of the recommendations of ABET Evaluators' Team, as well as to fulfill the requirements of strategic planning of the College. ECPDO will help build effective partnership between the industry and the Engineering College to the mutual benefits of all the concerned parties in years to come. Appendix B gives an overview of the office goals and activities.

- Faculty members and students have felt a sense of achievement and satisfaction on the award of the substantial equivalency status for all the engineering programs. This is an assurance of quality of education being offered in the college of engineering. It is certain to have the following advantages for our students:
  1. Increase the job potential in the local and international markets.
  2. Graduates desirous of higher education can easily seek admission in other international institutions.
  3. A continuous overall improvement process for the educational programs has been set in motion which will assure keeping abreast with international standards.

Lastly, it is to be realized that on the path of quality and excellence in education we have made a modest beginning. We are living in a world where globalization and fast growth rate of knowledge are order of the day. Internet and information technology are affecting profound changes in our professional practices. We have to cover a long way in strengthening the graduate and postgraduate programs of the College. Capstone design projects where concerns have been noted by the evaluators need to be improved in line with the international trends.

Conclusions

The successful culmination of efforts for acquiring of substantial equivalency status for all our engineering degree programs has provided us the realization that excellence can be attained only through concerted and continuous hard work by collective efforts. Experience gained through this process will help direct our vision for even greater heights, thereby making it our life-long mission to continuously improve the standards of engineering education and introduce cadres of engineers who will be leading the development of our nation and serving the society through their professional work.

Appendix A

There is an obvious overlap in industry between engineering and science which directly affects engineering schools curricula. Engineering education is highly theoretical and emphasizes math and science. This emphasis is based primarily on the assumption that engineers are likely to learn the more applied portion of their field on the job while they are unlikely to learn math and science on the job. Students are expected to learn but never taught how to learn. They are expected to solve problems but never taught how to solve problems. All of this creates a gap between what engineering students learn at school and what practicing engineers really do on the job.

The School of Engineering at KAAU has recognized this gap between engineering education and the engineering profession and has taken ambitious steps to close it. One important step is the offering of a new course, Introduction to Engineering Design, for the first time during the Summer Term of 2003. Below, we will review the course material and discuss its underlying philosophy.

Course Goal - Engineering Method

The goal of the new course is to introduce students to the EM which can be defined as[3]:

"The use of heuristics to cause the best change in a poorly understood situation with the available resources."

Course Objectives

The course goal is further defined with the below-mentioned objectives. These objectives represent areas of interest that are needed for the student to become proficient at the EM.

1. Self Regulation

One of the course objectives is to produce self-regulated learners who share the following characteristics:

- They plan, set goals, organize, and self-evaluate at various points of the learning process.
- They use self-oriented feedback.
- They proactively seek out and profit from the learning process.

In IE201, students' affective behavior is assessed to check if they are demonstrating self regulation.

2. Communication

Communication is a total of all the things said – and not said. It is the perception, not the intention, that counts. Therefore, communication skills can not be overemphasized. A brilliant idea could never see the light if it is poorly presented. On the other hand, a not-so-brilliant idea could be a huge success if it is conveyed the right way at the right time. A successful engineer is not only technically competent but also able to transfer his ideas to people around him.

In IE201, students are exposed to the following concepts which they use in making presentations to small groups and to the entire class:

- Communications roadblocks,
- Listening skills and techniques,
- Communication tools, and
- Presentation of technical work

3. Working Cooperatively and Collaboratively

Most of the problems facing society today consist of divisible, optimizing, conjunctive tasks that will be solved only by teams of people, working together. Engineers work in teams to solve problems. When problems are ill-defined, teams help clarify the problems and generate potential solutions. When problems are clearly defined, they are generally too involved for a single engineer to solve. Teams of engineers, not single ones, are the building blocks for successful technical groups.

In IE201, students learn and practice, in semester-long teams, the following concepts:

- Stages of team development,
- Team dynamics jigsaw exercise which is an active learning exercise,
- Team building issues,
- Team composition and roles,
- Types of team decisions,
- Guideline for productive meetings, and
- Team norms.

Problem Solving

The underlying approach to develop the solution to any engineering problem is practically the same regardless of the solution nature. IE201 teaches students the following techniques:

1. Problem definition,
2. Solution generation,
3. Decision analysis,
4. Implementation, and
5. Solution evaluation.

Students, in teams, apply these techniques in mini projects as well as in a semester-long project to solve engineering problems which are not major-specific.

Modeling

There is hardly any solution to any engineering problem that does not include modeling. Modeling can be conceptual, mathematical, physical, or visual. Mathematical modeling receives particular emphasis, and sketching is routinely practiced as it is important for representing visual models.

The course teaches students the following techniques:

1. Heuristics and spreadsheets,
2. Results presentation,
3. Stochastic modeling,
4. Information organization,
5. Introduction to optimization,
6. System dynamics,
7. Solution strategies and trade-offs, and
8. Expert systems.

The course development committee thought that Modeling can be offered as a stand-alone course, Modeling IE202, and decided to offer it for the first time in the Spring Term of 2004.

Quality

Quality is a term that has a wide range of meanings. It pervades all aspects of today's engineering work environment. In IE201, students are exposed to the following concepts:

- Customer needs,
- Quality culture,
- Improving quality,
- Flowcharts, and
- Process check.

Quality is an essential part of all student activities. It affects the type of homework they submit; it defines the grade they receive in the class. Students strive hard to meet, or exceed, the customer (instructor) set of requirements that is determined before class through the use of checklists. Students are given the chance to assess other students work products to learn how to appreciate and reward quality. They practice continuous improvement first hand by giving feedback on the learning process at the end of each class. They demand and expect instructors to follow up on their feedback to see if they "walk the talk".

Management of the Course

Following are management issues that need to be presented to give a clear and complete picture of the course.

Active Learning

In a study done by the National Training Laboratories it was found that the learner's retention rate is highly affected by the learning environment. To lecture is at the top of the learning pyramid and to teach is at the bottom. In conventional class, the instructor who prepared and delivered the lectures is the one who benefits the most. Through active learning we move the students closer to the bottom of the pyramid where the retention rate is higher. Active learning encourages information restructuring when students integrate the new information with what they already have to form a new body of knowledge. It encourages the students to be mentally, emotionally, and physically engaged in the learning process.

One of the active learning techniques is the constructivist learning exercise where student teams are assigned a problem but are not given any suggestions on how the problem might be solved. The teams work until they are unable to proceed. At that time either some guidance is given by the instructor or teams share their views on how to proceed. The teams then continue working on the problem and the cycle is repeated.

The Three-Session Course

The course topics are delivered in three different learning environments and, therefore, there are three different sessions in the course.

1. The Concepts Session

The important concepts are *first* introduced, examined, and tested in the Concepts Session; these are large classes. A mixture of short lectures, group work, quizzes, and videos is employed to deliver and assess the material. Generally, it is assumed that the students have read the material related to the topic *prior* to the class meeting; therefore, class time is used to assess what has been learned, clarify the reading, and, in small groups, test the ideas that have been presented in class. Thus, group work is required during class and individual work is required outside of the class. The Engineering Journal is also used in the Concepts Session to initiate the reflection process which includes both Self Regulation and Information Restructuring. This journal is designed to be used for recording, or documenting, *and continuously improving* the student's learning process through student reflection upon the assigned textbook reading.

2. The Laboratory Session

All of the work in the Laboratory Session is team based. In Laboratory, the teams are assigned a broad problem context and are then expected to work a number of smaller problems that are consistent with the specified context. The general problem provides a series of opportunities for the teams to practice and master the specific concepts introduced in the Concepts Session. The Laboratory Session is somewhat less structured than the Concepts Session. There are two general problems assigned; one that culminates in the development of a process, and one that culminates in the development of an artifact. As in the Modeling Session, the actual final work product is not as important as the process the teams used to develop the work product. The students will be continually encouraged to reflect on and document their decision process.

3. The Modeling Session – to be offered as part of IE202

The Modeling Session is the smallest class and is delivered in computer classrooms in which the ratio of students to computers is 2 to 1. The students are expected to work in small teams to build models and present intermediate work products to the class. A constructivist approach is used in which students are given a new problem and asked to start developing models that could be useful in solving the problem. The Modeling Session concentrates on encouraging the students to think about how they created their models, and why they created them; the final work product is not as important as the process the students used to develop the work product or model.

Assessment

Work products are assessed, not graded, using the following terms: meets expectations (M), exceeds expectations (E), or needs improvement (NI). This division into three distinct categories is used to assess: 1) submitted work products, 2) session activities, and 3) session participation. The student is assigned the task of doing the work, self assessing the work, and correcting any work that needs improvement. The Grader/Faculty are assigned the task of assessing the work to determine if it meets expectations on the first submittal (or on subsequent re-submittal, if required). The Faculty are responsible for establishing the expectations and determining when a work product exceeds expectations. Based on the above assessment process, it is very important for the faculty to *clearly and completely* define their expectations of any work product *prior* to its offering via a checklist. This eliminates expectations *creep* which de-motivates students considerably.

Appendix B

The Engineering Consulting and Professional Development Office (ECPDO) was established in September 2003 to fulfill the recommendations of ABET reviewers and the requirements of the strategic planning of the Faculty of Engineering. ECPDO mission is to build the most effective partnership between the industry and the King Abdulaziz University Faculty of Engineering. ECPDO will help to develop innovative programs that provide students with hands-on, real world experience in industry, and provides industry with excellent opportunities to advance research, leverage the university's state-of-the-art technology and recruit the engineering talent of the future. ECPDO primary objectives are summarized herein.

For juniors and staff:

1. Prepare the engineering students to become young professionals.
2. Prepare engineers sensitive to the environment and the society needs.
3. Focus on engineering ethics using available economical resources and applying available regulations.
4. Expose the students to real-life situations and orient their mentality towards the needs of the industrial society.
5. Initiate applied research programs suitable for the undergraduate level to ignite the creativity and competition between the students.

For seniors and staff:

6. Emphasize the need of applied research programs to solve industrial problems.
7. Focus on community services and solving community problems on the local and national levels.
8. Establish consulting services for private and government sectors where faculty members and graduate and undergraduate students work together as a professional team.
9. Construct a bank of ideas.

10. Establish a reward system for participants.

ECPDO has initiated and supervised the development of the following projects, which lead to one another:

- Launching a techno entrepreneurship program
- Creating a mentoring program
- Linking the techno entrepreneurship program to the capstone design projects
- Establishing a student factory

ECPDO has developed an entrepreneurship program to make a paradigm shift in the mentality of some of our graduates to become job providers instead of being job seekers. The first training program was offered in the summer semester of 2004. The program provides the students with the necessary tools to start Small to Medium Enterprises (SMEs). Knowing that SMEs represent almost 60% of the economical force in some countries, the Faculty of Engineering took the lead and believed that the program should start as soon as possible for the benefit of the society and economy. For example, SMEs have been a primary factor in the astonishing industrial development in India. In our region, some countries (e.g., Bahrain) have implemented similar successful Entrepreneurship programs. In the techno entrepreneurship program and through an active-learning environment, the students learn and practice the following primary subjects:

- Who is an entrepreneur?
- Entrepreneur competencies
- Identification and selection of business opportunities
- Planning a small scale enterprise
- Introduction to marketing analysis
- Introduction to financial analysis
- Introduction to economical analysis
- Business plan

In the program, the students use their accumulated engineering knowledge to adopt new and existing technologies. The students are encouraged to start new techno-businesses to achieve the following goals:

- Serve the society and improve people life style
- Contribute to the economical growth of the Kingdom
- Reduce and replace imports
- Develop experts in different technological sectors
- Create job opportunities for themselves and others
- Take advantage of their accumulated knowledge in their engineering programs

As a complementary program part of the techno-entrepreneurship program, the Faculty of Engineering has created a simultaneous mentoring program. Successful businessmen are invited to the classroom to share the journey of their success with the students. Also, entrepreneurship experts and bankers were invited and lectured our students. The students were highly excited and encouraged seeing life examples of successful new comers in the market and high caliper businessmen. We have also scheduled regular meetings between selected industry investors and our promising senior students. The students prepare pre-feasibility studies of their ideas and chair them with the businessmen who in return give them an advice, edit and modify the business plan until it becomes ready to implement. Some of these meetings are held monthly and others are held quarterly. Some businessmen even offered partnership to some of our students.

The next element of our chain process is the capstone design project. ECPDO will encourage some outstanding senior students to use their gained engineering knowledge and apply it to modify existing technological ideas or invent new ones. Knowing the concepts of techno-entrepreneurship will help them direct their innovative ideas in a business way of thinking. The students will also be able to perform the preliminary financial analysis of their proposed product and predict its feasibility.

The other element of our chain of thought is the student factory, which is still in the proposal phase. The student factory will consist of research units for the student, faculty and industry technological projects. Each unit represents a research activity of a certain engineering discipline. There will be also a smooth link between different incubators in the case of joint projects. The primary objectives of the student factory are to transfer and incubate different technologies and develop partnership with the industry.

The Faculty of Engineering and ECPDO are encouraged with the preliminary results of the techno-entrepreneurship and mentoring programs. ECPDO is currently preparing the proposal of the student factory to be submitted to the university administration. Implementing the above projects has helped establishing the link between the Faculty of Engineering and the society and the industry and improved the quality of the students.

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BIOGRAPHIES

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