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Engineering Tomorrow's Engineers

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In this article, the author discusses education and research activities with special emphasis given to initiatives for improving and monitoring the educational system at the Middle East Technical University in Ankara, Turkey. The experiences gained through activities related to curriculum design, accreditation, globalisation, collaboration with other institutions at the local and international levels is also reported. The impact of such activities on both the local and international communities are also presented and discussed in this article.

INTRODUCTION

The most important mission of a technical university is the advancement of science and technology for the benefit of humanity. In accomplishing this mission, a university uses two fundamental instruments, namely: *education* and *research*. The quality of the contributions to society depends upon how efficiently these two instruments are utilised and on the involvement of every university member in the university's affairs.

For those having a special interest in playing a role in administrative matters, the manner of involvement is somewhat different. They must not only undertake research and provide education, but they should also try to pull their colleagues into the game. They should motivate others and ensure that educational and research activities complement, as well as cross-fertilise each other. They should harmonise their efforts with their counterparts in other educational and R&D institutions that belong to the private and state sectors.

Some important targets for those who design the research and the education processes are as follows:

- Providing a sound background on the basics of engineering;
- Establishing a structure that emphasises the roles of motivation and creativity in education;
- Allowing for the easy implementation of inter-disciplinary work;
- Establishing a basis for life-long learning;
- Setting the basis for future R&D studies in newly emerging disciplines;
- Providing the structure necessary to adapt to growing globalisation trends in engineering education;
- Allowing a dynamic structure for each engineering programme to follow and integrate new developments in its engineering discipline [1][2].

Establishing a basis for life-long learning should be given high priority and may only be achieved through an education system that produces graduating students who have *learned how to learn*.

SCHOLARLY ACTIVITIES IN ENGINEERING EDUCATION AND RELATED ACHIEVEMENTS

The goals for realising a sound education system may be reached through the realisation of the right curricula for engineering programmes and through cooperation, and integration with educational and R&D institutions at the national and international levels.

Some examples of the scholarly activities of the author of this article and his experiences are reported here. The impacts of the accompanying achievements are discussed in the next section.

As most of the experiences reported on are concerned with the activities carried out while the author was the Dean of the Faculty of Engineering (FE) of the Middle East Technical University (METU) in Ankara, Turkey, first, some background information about the METU and the FE is provided.

The METU was founded in the mid-1950s in

recognition of the need for highly qualified university graduates in the scientific, technical and professional fields in order to advance the development of Turkey and other countries in the Middle East region.

Instruction at the METU began in 1956. Today, the METU's modern campus, which is equipped with the most advanced scientific and technical facilities, provides educational and social services to over 20,000 students. Over 40% of the METU's students go on to postgraduate studies. Each year, around 800 to 1,200 students with various academic degrees from nearly 50 different countries come to the METU. Undergraduate and graduate students from a number of countries attend the METU as *special students* or *exchange students* for a semester or a year. The METU has currently active student exchange programmes with several universities in various countries.

The METU has 41 undergraduate programmes within five faculties. There are also five graduate schools with 93 Masters and 51 doctorate programmes, as well as a *School of Foreign Languages*, which includes the English Preparatory Department. Six undergraduate programmes (including one international programme) are offered in connection with the METU's Northern Cyprus campus.

The language of instruction at the METU is English. This not only allows for the accommodation of a fairly large number of foreign students, thereby providing a very unique international atmosphere to the METU, but also gives students direct access to the most recent literature in their fields.

The METU is one of Turkey's most competitive universities. Each year, among those students who take the National University Entrance Examination, over one third of the 1,000 applicants with the highest scores choose to study at the METU. Due to the high level of demand, most of the METU's departments accept only the top 1% of the approximately 1.5 million applicants who take the National University Entrance Examination. The campus area is 4,500 hectares and the forest area is 3,043 hectares.

The Faculty of Engineering, which is the largest of the five faculties at the Middle East Technical University, has 14 engineering departments that offer 13 undergraduate programmes, as well as numerous graduate programmes at both the Master's and PhD levels. Based on minimum scores in the nationwide student selection and placement examination, the rank figure of newly enrolled students in the FE, considering all its undergraduate programmes, has been in the order of 0.25. This figure is below 0.1% for departments, such as Electrical and Electronics, Computer and Industrial Engineering.

Activities Related to Curriculum and Course Development

The curricula of the engineering departments were initially designed to be very similar to the curricula of the leading universities in the USA. Later curricula revisions shifted the main focus to solving specific problems. Such modifications introduced not only an undesired level of diversity between engineering programmes, but also resulted in serious deviations from the basic educational philosophy of the FE. This undesired level of diversity was a threat mainly for the realisation of interdisciplinary programmes and R&D activities. The integration of new additional courses to programmes, without monitoring their overall effect thoroughly, resulted in excessive loads on students.

The Dean's Office (the author serving as the Dean at the time), in order to bring about permanent solutions to the undesired status of engineering curricula, initiated extensive assessment studies related to the existing programmes. With the beginning of the 1992-1993 academic year, two newly established committees, the *Education Committee* and the *Strategic Planning Committee*, both providing counselling service to the Dean's Office, as well as to the Academic Board of the Faculty, carried out extensive assessment studies on existing curricula of individual undergraduate programmes in the FE. A draft proposal was formulated for a new *FE core curriculum* in order to meet the goals emphasised in the first section of this article.

The engineering departments contributed to this process through their representatives on the respective committees and then, during discussions with the Academic Board of the FE, through their chairpersons, where they are ex-officio members. In working out the details of the curriculum, the Education Committee studied the current curricula of the engineering schools of many prominent universities in the USA and made use of the criteria of the Accreditation Board for Engineering and Technology (ABET) in the USA. The structure of the *FE core curriculum* was finalised in June 1993. Detailed information related to the development of the 1993 core curriculum is provided in refs [1] and [2].

In the 1993-1994 academic year, all the departments of the FE, in coordination with the Dean's Office, conducted extensive studies to adapt their programmes to the new core curriculum. All the departments, the Education Committee and the Dean's Office worked out an additional set of guidelines that had to be followed during departmental curriculum studies. Eventually, the new programmes were

accepted by the Faculty Academic Board and approved by the University Senate, and became effective by the beginning of the 1994-1995 academic year. Together with the new programmes, a number of complementary programmes, referred to as the minor's programmes, were also launched. Those programmes had goals like enhancing interdisciplinary work and creating informatics awareness [3][4].

The new core curriculum demanded the presence of suitable capstone design courses in all engineering programmes. The existence of suitable design courses was one of the ABET's requirements as well. Some engineering departments already had such suitable courses. However, other departments had so-called *project* courses that could hardly be regarded as real design courses.

In June 1996, the Dean's Office, in order to ensure that each programme was equipped with a suitable design course, organised a workshop. The main goals of this workshop was as follows:

- Help the engineering departments to assess the current status of the design courses;
- Establish intersections between departments in the areas of design philosophy and practice;
- Create a platform for the discussion of the design element in the engineering curricula.

Following the workshop, several engineering departments, having deficiencies in their design courses, improved them in a systematic way. The new design course sequence of the Department of Electrical and Electronics (EE) Engineering is a fine example. The author of this article, after his term as the Dean was over, together with some colleagues from the Department of Electrical and Electronics Engineering, contributed actively to the development of a two-semester design course [5]. The course objectives were to provide students with major design experience through the completion of a project and exposure to key principles and tools of engineering design.

Through information obtained via feedback from the course instructors and students, it has been found out that both *the one-term design course* developed after the new core curriculum and the existing *project course* fell short of achieving their goals, ie it was not possible to motivate students, nor provide them with sufficient design experience. The non-uniformity regarding the assignment, supervision, assessment, and the very uneven distribution of the projects among the faculty, were observed as the major drawbacks in achieving the design goals. Furthermore, the existing structure did not contribute to students' ability to work in teams. Thus, it was necessary to restructure the senior design courses to meet contemporary requirements. After studies lasting more than a year, the new two-semester design course sequence was developed. The development of this course sequence, according to the feedback obtained from the graduates of the Department, as well as many employers in industry, is now judged to be a highly successful initiative.

Activities Related to the External Evaluation of Programmes

There is no formal engineering accreditation process in the higher education system in Turkey that is similar to those practiced in countries like the USA or UK. However, since the curricula of the engineering departments were initially designed – and still are – very similar to the curricula of leading universities of the USA with similar educational philosophies, the Dean's Office requested a formal external evaluation from the ABET. The purpose of this activity was to:

- Acquire an external opinion about the quality of programmes and thus to assist in curriculum reform activities;
- Create an awareness about recent trends in engineering education;
- Obtain further international recognition;
- Gain the experience necessary to establish a national accreditation system;
- Keep up to date with current trends in the globalisation of engineering education.

The formal application for obtaining external evaluation was made to ABET in 1994. As a pilot activity, the chemical engineering and mining engineering undergraduate programmes went through the evaluation process. Because of this evaluation, the first to take place at a Turkish university, both programmes were judged to be *substantially equivalent* to comparable accredited programmes in the USA by the ABET, the only kind of positive accreditation statement provided by the ABET for programmes outside the USA. ABET evaluations were later requested for other departments as well. Currently, all the 13 departments of the Faculty of Engineering offering undergraduate education are judged by the ABET to be *substantially equivalent* to comparable accredited programmes in the USA.

This activity has proven to be very valuable in complementing the core curriculum studies. The result of the evaluation has shown that the core curriculum initiative has been successful so far as the philosophy and targets of the undergraduate education are concerned.

Assessment and Enhancement of Educational and Research Activities

In the 1994-1995 academic year, the Dean's Office undertook studies for assessing and enhancing the standards of education. These studies involved the preparation of necessary databases and the development and use of performance indicators and time allocation mechanisms for the planning of future activities. It is essential for qualified academic staff to make the best use of their working hours in order to provide a high standard of education to a select student body.

However, the student admission figures are determined by an external authority; ie the Board of Higher Education. Therefore, it was highly important for the Dean's Office to make optimum planning regarding the teaching loads of the academic staff. Furthermore, the Dean's Office sought to place special emphasis on education and R&D activities in certain priority areas. Hence, careful monitoring of the times allocated for various activities was necessary in order to employ enough work forces in these priority areas. Each faculty member was required to fill in *activity time allocation* forms on a monthly basis. Working hours devoted to activities such as teaching, R&D, counselling, etc, were reported by the faculty. The primary motive for this activity was to engage better *resource planning* through an evaluation of the data obtained from these forms, together with the available workforce. Details of this activity are reported in ref. [3].

Activities Related to Cooperation and Integration with Education and R&D at the National and International Levels

The Faculty of Engineering at the METU recognises the challenges and opportunities that have arisen from the recent trend in the globalisation of engineering and technology education, and it has attempted to determine solutions by increasing the level of involvement in global engineering activities. To this end, during the term of the author in which he served as the Dean of the FE, emphasis was given to:

a. Involvement in international accreditation activities;
b. Establishment of courses that are of an international nature;
c. Establishment of worldwide student exchange agreements;
d. Participation in international R&D programmes, such as COST and EUREKA;
e. Involvement with international education institutions and networks.

The activities related to (a) and (b) are considered complementary activities to curriculum and course development, and were discussed in the previous sections.

An example of the emphasis given to the establishment of worldwide student exchange agreements is the Monash University-METU collaboration. Following the initiative taken by the Director of the UNESCO International Centre for Engineering Education (UICEE), Prof. Zenon J. Pudlowski, and with the cooperation of the Dean's Office of the METU-FE, a student exchange programme was established between METU and Monash University, Melbourne, Australia. In the years to follow, several students from both sides participated in the programme.

Cooperation between the International Research Centre for Telecommunications, Transmission and Radar (IRCTR), Delft University of Technology (TU-DELFT) and the Department of Electrical and Electronics Engineering (EEE) in the Faculty of Engineering (FE), Middle East Technical University (METU) was initiated by the Director of the IRCTR.

Following the correspondence related to the terms of the cooperation and the visits of the Dean of the METU-FE to the IRCTR, and the Director of the IRCTR to the METU, a Memorandum of Understanding (MoU), was signed by the presidents of the two institutions in the fall of 1996. The MoU foresaw several different modes of cooperation, such as project related interactions, exchange of scientists, etc. Considering the volume and the quality of the output related to the *Transportable Atmospheric Radar Antenna* project, and the benefits obtained from short and long-term scientific visits, it can be concluded that the IRCTR-METU-FE cooperation has been a very fruitful and successful one.

Participation of faculty members in international R&D projects has always ranked among the priorities of the Dean's Office. The experience gained through such collaboration has a very positive effect on the quality of education. The author, as the national coordinator of European Cooperation in the Field of Scientific and Technical Research (COST), promoted COST actions throughout the universities by being instrumental in setting up a national coordination and funding system, as well as encouraging participation in COST actions. Between 1992 and 1997, more METU-FE teams took part in over 20 COST actions. A number of PhD and MSc students had the chance to participate actively in projects of an international character.

Participation in international education institutions was also one of the top priorities of the Dean's Office. Special importance was given to collaboration with the UICEE and to participation in its activities. Further information about this collaboration is provided in the next section.

UICEE/METU-FE Collaboration

In March 1995, representatives of the Faculty of Engineering of the Middle East Technical University (METU-FE), Ankara, Turkey, and the UNESCO International Centre for Engineering Education (UICEE), which is based in the Faculty of Engineering, Monash University, Melbourne, Australia, signed a Memorandum of Understanding (MoU) on collaboration in the area of engineering education.

The presidents of both institutions subsequently signed another MoU that extended the scope of the collaborative activities. The METU-FE thus became actively involved in the UICEE's coordinated activities for an international engineering education network, participating in joint meetings, electronic networking and the preparation of a common database for engineering education. The achievements of the first year of collaboration were presented at the *2nd Asia-Pacific Higher Education Network* (APHEN) *Regional Conference*, held in Sydney, Australia, in November 1996 [5].

In order to collaborate efficiently, the collaborating partners had to learn more about themselves by identifying their strengths and weaknesses. Hence, the first step of this collaboration was to undertake a survey on engineering education, developed by the UICEE, in all the 13 departments of the Faculty of Engineering at the METU in 1995. Questionnaires were distributed to 350 Faculty members, and 187 responses were received (53% response rate).

The survey, developed for the investigation of engineering education resources and achievements in engineering faculties at the UICEE's partner institutions worldwide, was based upon two survey questionnaires developed by the UICEE and administered earlier at Monash University. The scope of the survey questionnaire was to elicit qualitative and quantitative information on a range of engineering education activities and resources.

Another important aspect of the survey was to indicate the attitudes of academics regarding the sharing of resources with developing countries, as well as the need of the respondents for self-development through a range of engineering education interest groups and professional resources available.

The survey responses identified a number of strengths and weaknesses in the METU-FE in terms of education and training activities [6]. A number of different issues were also questioned. The answers obtained were stored in a database and a quantitative and qualitative evaluation was carried out by the METU-FE.

Involvement in Conferences and Meetings

Engineering conferences, especially those of an international character, have always been regarded as one of the essential instruments for globalisation. One important activity, the *IEEE 1994 MELECON Conference* organised at Antalya, Turkey, managed to bring together many researchers from many different countries.

Fruitful discussions took place at the *Engineering Education and Accreditation* panel, which was chaired by the author during the *7th National Congress on Electrical - Electronics and Computer Engineering* at the METU, Ankara, in September 1997. Participants had the chance to exchange their experiences and their views on topics such as the future of accreditation processes in Turkey.

Similar panels were organised and talks as a panellist were given at institutions like the Military Academy and the Union University Teaching staff at the METU.

The International Virtual Design Studio Experience

In 1996, initiatives developed by the Dean's offices of the UNION College, the USA and the METU-FE resulted in a collaborative design course entitled the *International Virtual Design Studio*. This course was one of the first experiences in design studios on an international scale using the World Wide Web (WWW). On the METU's side, the course was developed by the mutual efforts of the colleague responsible for the design course at the Department of Mechanical Engineering and the Vice-Dean for Educational Affairs [7].

IMPACT ON LOCAL AND INTERNATIONAL COMMUNITIES

Detailed information concerning the results of the activities carried out by the author of this article and his colleagues related to the issues on curriculum development, accreditation, globalisation, assessment and enhancement of teaching effectiveness, creation of informatics awareness in engineering education have been reported in several articles listed in the

references. These publications can provide some useful results for both the local and the international educational communities.

The impact of activities related to curriculum development, accompanied by external ABET evaluations of the engineering faculties in the country, are fairly observable. The purpose of these activities and the associated process have been discussed above. As emphasised, this activity was the first to take place at a university in Turkey. Many engineering departments belonging to several prominent universities followed the METU-FE's example and requested the ABET's *substantial equivalency* evaluations.

This process has resulted in creating awareness and experience about accreditation issues in engineering education in Turkey. The critical workforce needed for establishing a national accreditation system can be created. Eleven years after the METU-FE's first ABET evaluation initiative, the formation of a national accreditation system has been almost realised. Only some juridical matters, which still need some clarification, remain. Already, several engineering programmes at various universities have gone through the accreditation process of the national body. Integration with the newly developing European Union (EU) accreditation system has already taken place.

SUMMARY AND CONCLUSIONS

Considering the extremely rapid developments in science, especially in technology, there is an increasing need for further cooperation in engineering education on a worldwide basis.

There is a need for the enhancement of collaboration in research and development in engineering education, the promotion of further international collaboration through regional conferences and meetings, and for the expansion of the coverage of collaborative networks in engineering education. The realisation of a distributed database that satisfies the needs of a collaborative network's participants has emerged as one of the priority areas in engineering education.

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BIOGRAPHY

Professor M. Tuncay Birand received his PhD degree from the Electrical and Electronics Engineering Department (FE) of the Middle East Technical University (METU), Ankara. He has served as the Dean of the Faculty of Engineering of the METU.

Prof. Birand was the IEEE Region 8 Educational Activities Committee

Coordinator for the 2001 term. He also served as the national coordinator and representative for the Senior Officials Committee of European Cooperation in the Field of Scientific and Technical Research (COST), as well as a member of the National Scientific and Technical Research Council.

Prof. Birand was a visiting scholar at Queen Mary College, London, England, UK, and at the University of Illinois at Champaign-Urbana. He also worked as a consultant at ERA Technology Ltd in England. Prof. Birand worked as the head of the Antennas sector at the International Research Center in Telecommunications, Transmission and Radar at the Technical University of Delft in the Netherlands.

He received the 1983 Science Promotion Award of the Scientific and Technical Research Council, Turkey. In 1997, he was awarded the Silver Badge of Honour by the UNESCO International Centre for Engineering Education (UICEE) and the Meritorious Achievement Award in Accreditation Activities by the Educational Activities Board of the Institute of Electrical and Electronics Engineers (IEEE). He is a senior member of the IEEE, and a member of the IEEE Antennas and Propagation (AP) and the UICEE.

Prof. Birand contributed to the organisation of many international and national meetings, including the *IEEE MELECON 1994 Conference*, which he chaired.

Proceedings of the 4th Asia-Pacific Forum on Engineering and Technology Education

edited by Zenon J. Pudlowski

Bangkok, Thailand, provided the exciting venue for *4th Asia-Pacific Forum on Engineering and Technology Education*, held between 26 and 30 July 2005. Bangkok itself is a vibrant and varied city that acts a hub, connecting Asia with the rest of the world.

This Volume of Proceedings comprises of 45 papers presented at the Forum, representing contributions coming from 16 countries, including three opening addresses and nine keynote addresses. The Asia-Pacific region is an area that represents great diversity, both culturally and in educational matters, which in turn reflects, to some degree, the national identity and the effects of globalisation on education, and on engineering and technology education in particular. This parallels the diversity of submissions to the Forum, printed in the Proceedings, that all relate to engineering and technology education.

As with previous meetings run by the UNESCO International Centre for Engineering Education (UICEE), the Forum is divided into a number of distinct sessions, each headed by a lead paper that is considered to be most representative of the area under discussion. Topics covered include the following:

- Opening addresses
- Keynote addresses
- Case studies
- Innovation and alternatives in engineering and technology education
- Important issues and challenges in engineering and technology education
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- Quality issues and improvements in engineering and technology education
- Recent developments in engineering and technology education
- Social and philosophical aspects of technology and its impact on modern societies
- Specific engineering and technology education programmes

It should be noted that independent international peer referees have reviewed all of the papers included in this Volume. This should ensure their high quality and reference value for years ahead.

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