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In Search of Excellence in Engineering Education: from 1998-2001

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At recent UICEE conferences, participants have voiced their concerns about the lack of interest in engineering education. Many challenging solutions have been then suggested to the problems caused mainly by the recent global economic changes. The author seeks here to contribute to the family of educators with some ideas that have emerged from the experiences gained in the last two decades. It seems that the key to achieving positive change can be found in the effective collaboration between university, industry and the government.

INTRODUCTION

In a recent report prepared by a UNESCO Committee, the four pillars of education were presented in great detail; namely:

- Learning to know.
- Learning to be.
- Learning to do.
- Learning to share.

The significance of effective partnerships between all those involved in the education process is clearly recognised in the Report [1]. Since the issue of this Report in 1966, we have been experimenting on different educational approaches to enhance the quality of our work as instructors.

In the following sections, an account of the work carried out at Bogazici University in Istanbul, Turkey, which has been published in prior proceedings of conferences organised by the UNESCO International Centre for Engineering Education (UICEE), is presented and was triggered after a preliminary work on the reconciliation of education with research activities. The nine different topics covered by the author are:

- Hands-on experience.
- Oral presentations.
- Project based learning.
- Life-long learning.
- Holistic curriculum.
- Teacher training.
- Role models.
- Cyclic learning.
- Case based reasoning.

It is hoped that others will join in this continuing search for excellence in engineering education.

EARLY SEARCH WORK

The conflict faced by a peer working in the author's Department, while struggling to do research work and education activities at the same time, ended with his tragic death. He was so discontented with the low-level subjects he was teaching and the low performance in his research work that he decided to suicide. His research work on microelectronics was way above the level of the requirements of the Department curriculum. This situation triggered the author to look for a solution to a problem that many of educators face today.

A wonderful opportunity for research on this area came whilst preparing a paper on the occasion of an academic meeting in honour of Bogazici University's first Dean of Engineering. His findings during his nine years of office described in several of his papers suggested, amongst many other ideas, that:

- Engineering methods that apply the traditional disciplinary boundaries (ie mechanical, electrical, chemical and civil) are no longer adequate to solve the industrial expectations of today.
- The policy of having a broad-base curriculum scheme remained in conflict with the need to

provide engineering students with the specialised techniques they would require in their professional life.

- The education system should develop the ability of self learning in the *common fields of activities* needed in applying scientific tools to problems that require the use of natural resources for the convenience of humankind.
- Engineers are required to have the ability to communicate with others, and are expected to find economical, practical, durable, innovative, aesthetic, safe and clean solutions to human needs.
- Radical changes are necessary in order to be able to assign projects that can provide the proper environment for the students to develop the abilities to solve real problems.
- Students enrolled in special programmes should be encouraged to make use of computer centres, laboratories and libraries, and evaluated by a special committee headed by a tutor.
- The education system should:

  - Improve the ability to question and to seek answers.
  - Sharpen the vision of the details.
  - Refine the mind for greater sophistication at interpreting data and encourage independent thinking.

Encouraged by these advanced ideas, the author *conceptually mapped* the research done by an environmental engineer educator to the requirements of the curriculum. The results of this analysis revealed the possibilities of developing an educational programme in line with the needs of researchers [2]. A similar idea was put into action the following year by the National Science Foundation in the USA by providing funds to institutions willing to venture in reconciling research and education activities. At this point, the author started to participate in UICEE meetings with the aim of finding more concrete solutions to engineering education problems. The results of this search can be found in the next section.

RECENT RESEARCH WORK

The urgent need to change the content and method of the current engineering education system was the reason for the author to start attending UICEE conferences in September 1998. At that time, Bogazici University launched a new plan envisaging changes in the curriculum to meet the demands of the industry, now facing strong competition as a consequence of recent technological changes. The accreditation board required that the programmes should be changed in order to meet the 25% design target. A *hands-on programme* implemented in a new course tried to resemble as much as possible the actual working conditions in industry. The available teaching facilities, such as library, laboratory, computer and workshop, were used to the best possible advantage so as to meet the new goals proposed by the administration [3].

High schools are geared to teach only problems in mathematics, chemistry, physics and biology without attempting to introduce basic technological applications. Generally, students have only very vague knowledge of what a bridge or a dam is and the way the engineer approaches the process of design.

A recent study based on interviews with top executives of 29 local companies suggests that, in order to the enhance leadership and communication skills, students should be requested to prepare both written and *oral presentations* on the work they prepare during the course. With this aim, the author developed a course wherein each student was requested for unique equipment to:

- Describe the basic components.
- The manufacturing process.
- The time schedule for production.
- The analysis of deformation.
- The cost calculation.
- Layout of the manufacturing plant.
- The breakeven calculation.
- The impact on the environment.

Written reports were graded before the oral presentations, as seen in Figure 1, and short examinations assured that concepts were properly covered [4].

The experience gained at these first stages made the *project-based learning* approach to engineering

Figure 1: Freshmen engineering students evaluating presentations.

education to be the main strategy for change in this area at Bogazici University. Although this approach has advantages over the classical teaching-focused education, it also has its own drawbacks; since students are expected to work extra hours outside the classrooms doing research in the libraries and consulting different documents that the instructors may provide, the possibilities for unfair practice exists. There is unfortunately the temptation on the side of the student to indulge in unethical practices, hoping that the instructors will not be aware of the situation.

However, creating an atmosphere that enhances the enthusiasm of the students to work for the intrinsic motivation of being successful can prevent misconduct. Other tactics include:

- Praising outstanding performance and warning in case of failure should enhance group dynamics.
- Genuine interest in changes in attitude should help in the disclosure of intimate issues.
- Implementing a generous bonus system should motivate doing extra work.
- Immediate advice should overcome the feeling of panic and thus help in creating an appropriate atmosphere [5].

The importance of *life-long learning* was portrayed in the personal history of an active member of the University's Skin and Scuba Diving Club in 1984, when he began his undergraduate studies in 1984 in the Electrical Engineering Department. He completed the Turkish Navy Frogman Course with an outstanding degree and was assigned as Diving Instructor. In 1989, he received his BS degree in Electrical Engineering, implementing a project on a dive computer and received the University President Award due to his success on both academic and extracurricular activities. After completing the MS degree in biomedical engineering, he started his doctoral studies on the *Evaluation of altitude decompression procedures and development of new decompression strategies*, which he completed in 1999. A research grant from the European Council for Higher Education allowed for the animal experiment phase of his thesis to be carried out in SINTEF UNIMED, Section for Extreme Work Environment, Trondheim, Norway. There were 212 dives accomplished without any case of decompression sickness during 1994 and 1997 [6].

Experience now shows that in order to enhance the quality of education reached so far, we need the support of our peers. The work started here by the author should continue throughout the whole curriculum, including other courses. All parties involved should critically reflect on the individual projects as the new *platform* for learning. Every student should be well aware that, whatever the subject of the project he/she is dealing with, he/she is part of a bigger *holistic world*, as has been briefly described in Figure 2. Only when learners and tutors (both acting as co-learning partners) have a full grasp of the trans-disciplinary relations involved in a holistic approach to education, including natural and social sciences as well, will education become a self-rewarding venture [7].

The appeal by the UICEE to launch a professional development programme for *teacher training* encouraged the author to urge young staff to follow closely suggestions made in designing class-work, course, curriculum and counselling programmes. Eager to introduce the programme for the young staff, the author has recently delegated the coverage of the computer graphics section of the course to the research assistants with full responsibility for teaching including the grading. The response has been very positive and the assistants are feeling highly motivated to work as they provide the author with evidence for their performance.

The experience gained thus far shows that the training of young staff is enhanced with hands-on practice; it is necessary to give encouragement to take full responsibility by showing interest in the performance and not in the method adopted. Nevertheless, it is clear that the rules of the *game* should be strictly followed in order to secure a fair deal in the evaluation process and not to allow students to provide excuses for personal reasons and prevent the weekly programme from being disrupted [8].

Educating engineering students requires more than the transfer of the knowledge and skills needed by the profession. Engineering is indeed *a way of life* that must be experienced through *role model* examples. Many educators in the field of engineering have contributed in enhancing the quality of the profession.

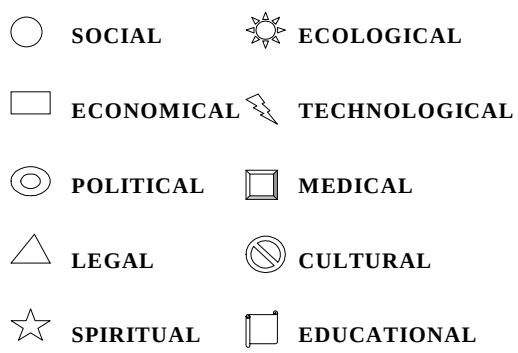

Figure 2: Proposal for a holistic approach in a life-long education programme.

One distinguished educator, the late Prof. Curi, throughout all his life, kept a persistent zeal and enthusiasm in the accomplishment of his vision for a better world. His vision involved a world where peace and solidarity would be high in the agenda of all human societies. As the head of the Environmental Science Institute at Bogazici University in Turkey, he became especially interested in developing public awareness *on the impact of human activities on the environment.* The work on environmental ethics he encouraged (covered extensively in another paper) was his posthumous and most valuable contribution [9].

The classical method of education requires that instructors present their subject in carefully planned lectures following the course outline. Mid-term exams are given to students during the semester and a final examination completes the academic calendar. The instructor should ensure that the student has a substantial knowledge of the prerequisites of the course and that the knowledge given will be enough to understand the subjects covered in the courses to come.

There have been attempts by the author to enhance the quality of education by introducing technology, such as computers and multimedia. However, as reported in an earlier publication, the results are below expectations. A *cyclic learning* approach, where topics are repeated in deepening levels of complexity as shown in Figure 3, has proven to be more effective [10].

Case based reasoning is a new design tool that was developed from Artificial Intelligence. This method can help experts and users to make better inferences from previous experience. Using this new technique, it is envisaged that the decision-making skills of students will be enhanced. Sharing past experiences in a systematic way may eventually lead to general conclusions on best practices. A more holistic approach and process orientation to education is suggested as a means to increase the value added by the expert intervention. Personal experience has shown that this new tool can be used in project management and results can be transferred to the education of young engineers [11].

FUTURE RESEARCH WORK

During the second half of the last century, we have witnessed impressive political, economic and social change in the world. As a consequence of these changing conditions, there is a greater need to improve the educational methods and contents currently being implemented. Paradoxically, as these changes continue to occur, the resources allocated to education are not enough to satisfy the needs in the training of the younger generations. It is suggested here that

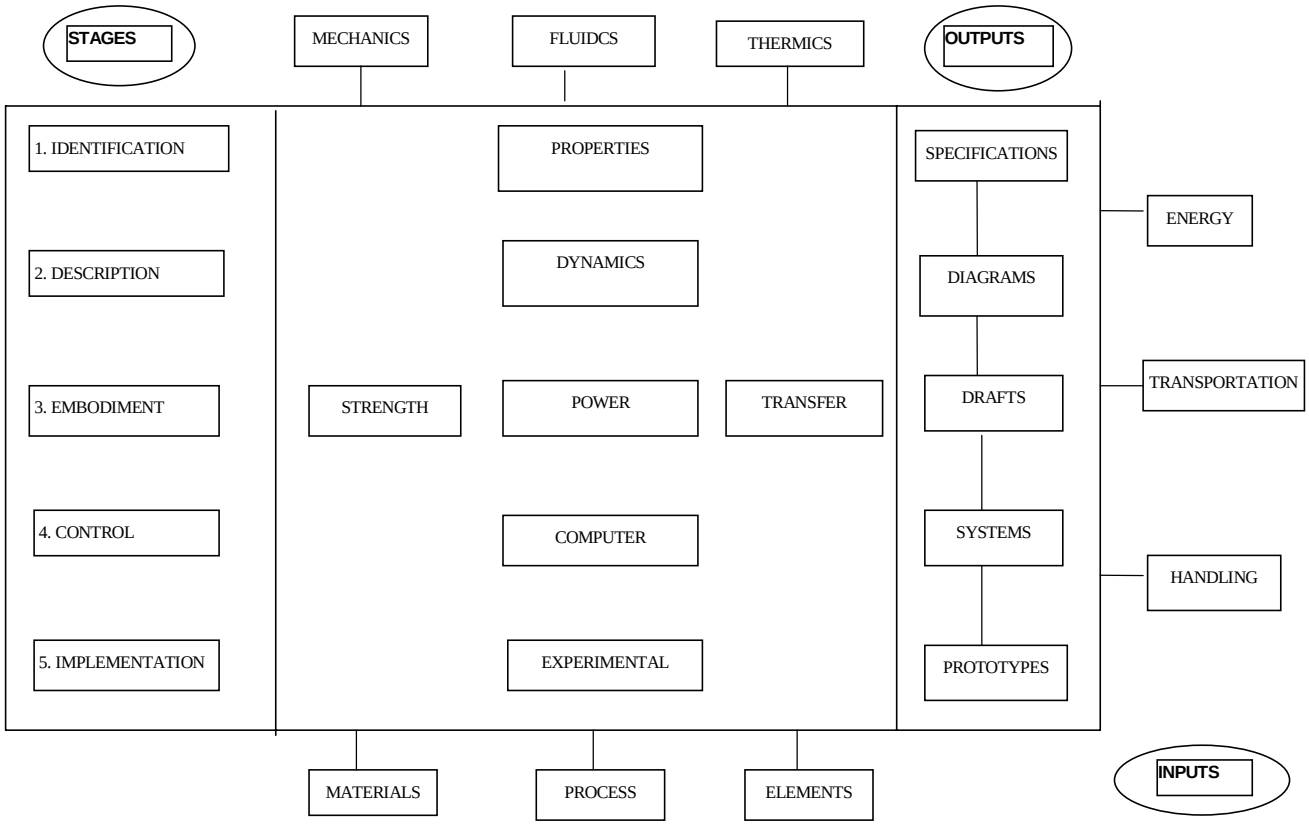

Figure 3: Mechanical engineering undergraduate integrated curriculum proposal.

stakeholders in the global economic development should provide more help in order to cope with the present conditions.

Practices at three Scandinavian universities show how changes are being successfully managed in close cooperation with the society at large. These universities are namely:

- Norwegian University of Science and Technology (NTNU), Trondheim, Norway.
- Chalmers University of Technology (CUT), Göteborg, Sweden.
- Technical University of Denmark (DTU), Copenhagen, Denmark.

In summary, it can be stated that the role of the leader in the university, industry and government cooperation is different in each country. While industry is the leader in Norway, the university plays a greater role in Sweden. In the case of Denmark, the government is more active in promoting relations between stakeholders.

These cases highlight the challenges that educational institutions are currently facing as a consequence of changing political, economic and social conditions on this world. Considering the current conditions, in order to make a quantum leap change, it is suggested here to extend this model of cooperation to other parts of the planet.

Changes in the physical conditions in the world we live in require that the leaders bring forward new ideas and action plans. The cases of three Scandinavian universities show the appropriate methods to manage change in the organisations. Closer cooperation between the sectors involved in economic development (university, industry and education) contributes to the well-being of the planet and its inhabitants. These measures will ensure that life will be also possible in the coming future [12].

CONCLUSION

The author recalls the story of a traveller who was amazed with the beauties he saw in the construction site of a new building he was visiting for the first time. He asked an artisan what he was doing. The artisan answered reluctantly that he was putting bricks one on top of the other. The traveller moved on and asked a second artisan the same question. This time the artisan answered by explaining that he was building the wall of the government's new headquarters. Satisfied with the second answer, the traveller repeated exactly the same question to a seemingly more experienced artisan. The third artisan answered enthusiastically: *I am working on the wall of a building that will in the future be the pride of our citizens.*

This work concludes with a quotation from the UNESCO report *Learning: the Treasure Within*, prepared by a commission headed by Jacques Delors and published in 1996. This has been the author's inspiration, and states:

> *There is, therefore, every reason to place renewed emphasis on the moral and cultural dimensions of education, enabling each person to grasp the individuality of other people and to understand the world's erratic progression towards a certain unity; but this process must begin with self-understanding through an inner voyage whose milestones are knowledge, meditation and the practice of self-criticism* [1].

We have been in search for excellence in engineering education for the last two decades. It is hoped that others will join in future search work with the aim of enhancing the quality of the work currently underway.

ACKNOWLEDGMENT

The author wishes to express gratitude to the UICEE Director, Prof. Zenon J. Pudlowski, for the support given since 1998. The experiences gained at the various UICEE conferences since have helped the author to change the educational approach he has been implementing. It is hoped that the light of the Centre will continue to inspire young educators.

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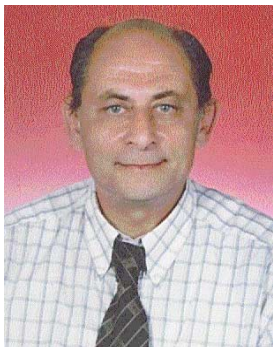
BIOGRAPHY



Erol Inelmen graduated from the American Robert College in Istanbul, Turkey, in 1963 as a Mechanical Engineer. After spending ten years in industry as a project engineer, he joined Bogazici University in 1982. Later, in 1992, he received his PhD in engineering management from the Marmara University in Istanbul, Turkey.

He is now assistant professor and is involved in subjects related to project management, computer-aided design/learning and engineering education. He has been attending UICEE meetings regularly since 1998.