

# Guest Editorial

## Undergraduate Engineering Education Challenged by The Bologna Declaration

### I. CHANGES OVER TIME AND SPACE

**A**FTER his recent China visit, IEEE Education Society Past-President David Kerns quoted Bob Dylan's "The Times They Are a'Changing" as an apt description of the environment surrounding and influencing today's engineering education. Opening-up and restructuring processes are taking place in many parts of the world, most notably in densely populated southern and eastern Asia. A significant redirection of goods and money flow is one consequence of this process.

In a competitive world, this change leads to serious consequences for those who do not quickly and properly adapt themselves to the new situation. To prepare their young citizens for an ever-changing adult life situation, for years governments have considered adjustments of the educational system among their most important actions. Thus, in many countries, a flow of educational reforms at the elementary and secondary school levels has "haunted" teachers and administrators through more than three decades.

Higher education has, through most of this period, been exempted from these sweeping currents of change. A reason for this situation *could be* the traditional role of higher education as a society's supreme guarantor of educational quality. Through the ages, these institutions have received numerous students from the secondary school system. Based on their quality level, as expressed by knowledge reproduction type of exams, universities could set standards, evaluate, and propose adjustments for precollege levels. Such signals from higher education were usually considered normative and accepted.

There is an important reason for such acceptance. As one key element necessary for the creation and development of national states, universities and colleges were often nationally organized and financed. Thus, the structure and ways of higher education could develop differently, depending on the country. By 1999, for instance, Europe could list about 90 apparently different educational programs and degrees. However, as these programs were not considered really unique, eventually a decision was made to harmonize European higher educational systems by form and content. As a consequence, a long-lasting era of an almost unlimited variety of degrees and diplomas will gradually be brought to an end.

### II. THE BOLOGNA DECLARATION—A STRONG FORCE

The cause of this remarkable transition is The Bologna Declaration, signed in Italy in 1999, by European Ministers of Education.

This declaration calls for **easily readable and comparable degrees**, a unified **system of credits**, student/teacher **mobility** opportunities, and a system essentially based on **two main cycles**: undergraduate and graduate. (The bold face type is used in the original document.)

As being mainly administrative measures, the first two objectives can be implemented relatively easily and quickly. Some administrations, spanning from ministry to academy department levels, have already planned and even put to work several practical measures derived from The Bologna Declaration principles. In addition, better student and teacher mobility will be one logical consequence of a unified degree and transfer credit system.

However, to most faculty members, "education" probably means something more than just structure and grading systems. On this *raison d'être* for all educational activities, The Bologna Declaration considers the following "to be of primary relevance" to reach European goals for higher education: "Adoption of a system essentially based on **two main cycles**, undergraduate and graduate. Access to the second cycle shall require successful completion of first cycle studies, lasting a minimum of three years. The degree awarded after the first cycle shall also be relevant to the European labour market as an appropriate level of qualification. The second cycle should lead to the master and/or doctorate degree as in many European countries."

The master and doctorate levels are mentioned collectively without comments. In contrast, the undergraduate-level description contains instructions. As a consequence, it may be assumed that **the new challenges must be met at the undergraduate level**.

### III. LISTENING MINISTRIES

The declaration is echoing what has been foreseen and signaled from engineering education conferences and publications over many years. For instance, Marion Hagler, as President of National Electrical Engineering Department Heads Association, wrote in 1994, "...As more electrical technologies reach maturity and few radically different ones appear, however, the rate of change in the electrical technologies applied by electrical engineers with a bachelor's degree has slowed .... I believe that we try to help students learn three basic things: fundamentals, how to learn, and how to solve problems. ..."

*Fundamentals*, including systems thinking, *how to learn*, and *how to solve problems* could be a short way of describing undergraduate-level content and form. At the same time, this description could also be the short description of daily challenges of

innumerable small and medium-sized companies and their technical staff. The Bologna Declaration quotation indicates clearly that European ministries of education have listened to signals from industry and academia. Therefore, they may expect important changes to take place at, and on the premises of, the undergraduate level.

#### IV. NEAR THE CORE

Two important consequences of this expectation are as follows:

- 1) a shift of the goal from students learning the material to training students to cope with a future ever-changing professional life;
- 2) faculty member development from a knowledge transmitter into a broad-scoped leader and organizer of student learning.

In short, changes are requested in undergraduate-level educational programs' *goals*, *content*, and *form*. Not unexpectedly, there are a few obstacles that are ready to impede a process of making undergraduate engineering education supported by educational research.

#### V. THREE HURDLES

The following are identified as the obvious hurdles to overcome:

- 1) the "well-defined curriculum;"
- 2) "quality" claims;
- 3) the definition of "profession."

Are these concepts really practiced adequately to serve the needs of today's engineering education at the undergraduate level?

##### A. Well-Defined Curriculum

The *well-defined curriculum* has long been accepted as the structured way of organizing some well-chosen learning material, typically delivered by lectures. In this process, *knowledge* is the "system current," and the teacher may represent a "lossy component" through which the knowledge has to pass. Such process, representing a thinking focusing on particular knowledge, is still governing many technical education programs. The question arises: Are the curricula really attractive if the problem is to prepare students for an insecure labor market? And do they possibly create a fertile educational research environment for teachers who consider *learning ability* the "system current?"

##### B. Quality

Descriptions for engineering education quality do exist, even if they are difficult to find explicitly in print. One well-known definition is simply the claim that "we will maintain the same high quality level as always." Other noticeable examples are as follows:

- 1) "grades awarded this year compared with previous years;"
- 2) course content;

- 3) student/teacher rate;
- 4) faculty members' competence level at the time of hiring.

An absence of documented teacher educational research, flexibility, and perseverance is observed. Thus, the message is that scientific work with students and learning processes does not matter. This situation could even mean that the undergraduate level does not matter as well.

##### C. A Profession

Even in universities and colleges, "the profession" generally means the professor's *engineering field*. As a consequence, professors can more easily raise money to attend a professional conference than attend a conference on engineering education. Some have even complained that engaging oneself in educational research could be hazardous to a career. In other words, teaching or learning "facilitation" can hardly be considered valued as a profession in some places. As one result, individuals cannot, in general, become a full professor based on educational research. The research has to be "professional," even for faculty members who are working mainly at the undergraduate level.

Thus, the unanswered question remains: Why should professors engage in something that is neither recognized nor rewarded?

#### VI. PROFESSIONAL AND EDUCATIONAL RESEARCH EQUIVALENCY

As claimed by Charles Darwin, survival will not be granted to the big, the beautiful, or the strong—but to those species that adapt themselves to new conditions. To technical education, handling "new conditions" has, in general, so far been the concern of those who have dedicated themselves to *professional research*. In other words, changes have mostly affected the *course content*, and the work at the educational frontiers has been accomplished by the relatively few. Their work is fully acknowledged, respected, and rewarded. This upper-level situation may be expected to continue, and The Bologna Declaration is silent.

However, even in the future, a vast majority of students may graduate with a bachelor's degree to find work in an increasingly more internationalized market. In this market, these engineers will have an understanding of technical fundamentals and mastery of the use of mature technological products. In fact, they will probably be the only professionals to bring technology as a tool and universal culture into multidisciplinary and multicultural cooperative groups. From a historical perspective, and with so many people directly involved, this situation can be deemed a *new situation*.

Thus, globalization challenges engineering and engineering technology schools in *new ways, where results and quality should not be claimed but assured by educational research*. Examples could include, for instance, *new* delivery methods, *new* learning programs, the effects of *new* learning methods, *new* cooperative partners, and—most of all—an ability to leave former thinking behind.

One may agree that higher technical education concerns learning content and form. If so, professional and educational

research should represent the system yin and yang: both are necessary to form a complete whole.

## VII. MORE THAN EVER, THE RESEARCHING TEACHER IS THE KEY

Globalization in the present form may be a long-lasting historical process that has barely started. Normally, history is shaped by human activities. Thus, change is needed to spur vitality *everywhere* inside those schools for higher technical education wanting to participate in shaping the future. As work with students is the heart and soul of any school at any level, the work of its teachers is instrumental for an institution to fit into a continuously changing environment. In other words teaching, in its widest meaning, must be made a research-based and rewarding profession.

Consequently, no success can be expected from engineering and engineering technology schools that neglect the fundamental bachelor level. The successful ones should understand that even the undergraduate level needs to be supported by high-level research on its own premises—usually called *educational research*.

The overall conclusion follows inevitably: the quality criteria of any engineering education undergraduate program should clearly include the number of teachers who are productive in educational research.

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