Int. J. Engng Ed. Vol. 16, No. 2, pp. 104–108, 2000
Printed in Great Britain.

0949-149X/91 $3.00+0.00

Quality Assurance of Engineering Education in Canada: its suitability for graduates working in global markets*

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The quality of engineering education in Canada is maintained within a very narrow band of uniformity by virtue of an accreditation process. Since all provinces and territories of Canada require that all individuals practicing engineering must be registered professional engineers, all established engineering programs offered in Canada are accredited to meet the educational requirements for registration. Furthermore, new programs are developed with the objective of securing accreditation at an appropriate time. The Canadian Engineering Accreditation Board (CEAB), acting on behalf of all professional engineering associations, through their parent, the Canadian Council of Professional Engineers (CCPE), conducts accreditation on the invitation of deans of engineering and applied science faculties. This paper describes the objectives and the process of accreditation. In particular it describes the process of dealing with emerging engineering disciplines and the assessment challenges presented by new technologies such as distance education. In order to calibrate educational standards of Canada in an international market, the paper also outlines the international activities of the CEAB.

INTRODUCTION

THE ENGINEERING profession in Canada is highly regulated through 12 provincial and territorial associations of professional engineers. Each association is charged with the responsibility to regulate the practice of engineering in the interest of and for the safety and protection of the public through specific acts of legislature. Engineering is, therefore, a self-regulated profession in Canada.

In order to practice engineering in any province or territory of Canada, each individual must be a registered professional engineer in that province or territory. To be eligible to register as a professional engineer an individual is required to possess acceptable engineering education as well as a required duration of experience as an engineer in training under the mentorship of a registered professional engineer in Canada. At present, the required duration of experience for professional registration is changing, and as a consequence, most associations have either increased the duration from two to four years or are contemplating doing so.

In order to ensure that the competency of professional engineers keeps pace with the rapidly expanding engineering know-how, many professional associations are now requiring their membership to annually report individual continuing education activities. In most jurisdictions, reporting of continuing educational activities are currently voluntary, however, consideration is being given by various associations to set minimum standards and expect continuing competence from their membership.

Acceptable engineering qualifications is a key requirement for the eventual professional registration. In order to minimize the assessment effort required by various professional associations of the educational qualifications of each applicant, in particular of the graduates from Canadian engineering schools, all 12 provincial and territorial associations have empowered the Canadian Council of Professional Engineers (CCPE) to undertake this task on their behalf.

The CCPE is the national federation of the 12 provincial and territorial professional engineering associations of Canada. The Canadian Engineering Accreditation Board (CEAB) is one of the standing committees of the CCPE. It was established as the Canadian Accreditation Board (CAB) in 1965 and renamed as the CEAB at a later date, to accredit Canadian undergraduate engineering programs. The accreditation activities of this Board are described in greater detail later in this paper.

For assisting the graduates of unaccredited engineering programs arriving in Canada and those who have acquired engineering qualifications by self-study, another standing committee of

* Accepted 30 October 1999.

the CCPE – namely The Canadian Engineering Qualifications Board (CEQB) sets the syllabus of various disciplinary programs. These syllabi set the curriculum requirements on the basis of which the provincial and territorial associations evaluate each applicant's educational qualifications and prescribe written examinations in deficient subjects. The CEQB syllabus also provides a well-defined framework for prospective applicants for professional registration.

The third and equally important committee – The International Affairs Committee (IAC) was established by the CCPE in 1997. Its role is to promote international recognition of the Canadian educational and licensing standards, recognize equivalent foreign standards and promote mobility of engineers internationally. This constitutes an important set of activities in an environment of rapidly growing free trade and globalization.

In summary, through its three standing committees – CEAB, CEQB and IAC, CCPE assists its member provincial and territorial associations in carefully regulating acceptable engineering qualifications for licensed practice in Canada and in other countries with which it has successfully negotiated mutual recognition agreements.

ENGINEERING EDUCATION IN CANADA

At present there are 34 engineering schools/colleges/faculties in Canada. Each of these educational institutions through their deans interacts with the Canadian Engineering Accreditation Board (CEAB) and aspires to offer fully accredited engineering programs by the CEAB. Currently there are 216 accredited engineering programs in Canada. It is useful to note that specific undergraduate engineering programs and not the departments or faculties or schools offering engineering programs are accredited.

By virtue of a rigorous accreditation process the CEAB has regulated the Canadian engineering educational standards in a rather narrow band. This is not to say that innovation in education is stifled. On the contrary by setting only the minimum curriculum requirements engineering schools have been encouraged to develop special attributes for their programs.

Accreditation process

The CEAB is composed of thirteen professional engineers drawn from the private, public and academic sectors. These members are volunteers and represent different parts of Canada as well as a wide range of engineering disciplines. The CEAB is responsible for the accreditation of Canadian engineering programs for the purpose of professional registration. It is also responsible for ascertaining the equivalency of the accreditation system in other countries and for monitoring the activities of those bodies with which mutual recognition agreements have been signed.

The accreditation criteria used by the CEAB are developed by it with input from the National Council of Deans of Engineering and Applied Sciences (NCDEAS) and other stakeholders in Canada and approved by the CCPE [1]. The engineering profession expects of its members competence in engineering as well as an understanding of the effect of engineering on society. Thus, accredited engineering programs must contain not only adequate mathematics, science and engineering but also a component of complementary studies comprising technical communications and an understanding of the environment, cultural, economic and social impacts of engineering on society and of the concept of sustainable development.

The accreditation process starts with an invitation by a dean to the CEAB. After receiving such an invitation, the CEAB sets up a visiting team with one of its board members as the team chair, a vice-chair, a program visitor for each program to be accredited and one or two general visitors appointed by the host provincial or territorial association. All members of the team must be professional engineers and experts in their discipline. In preparation for a site visit by the CEAB team, a detailed questionnaire is completed by the host institution and sent to the visiting team prior to the visit. The questionnaire contains quantitative information about the institution, its program resources, teaching faculty and their curriculum vita, curriculum content, etc. Detailed guidelines for the preparation of the questionnaire are provided by the CEAB to the host institution. The criteria for accreditation are annually published by the CEAB in its annual report as well as posted on the web: http://www.ccpe.ca.

All accredited programs are required to include the word 'engineering' in the title; the title must be descriptive of the curriculum content. Dual program names, such as Civil and Environmental Engineering are required to satisfy the content requirements of both disciplines.

For quantitative assessment of the curriculum an Accreditation Unit (AU) is defined as one hour of lecture (50 minutes of contact time). Each hour of laboratory and tutorial is assessed at 0.5 AU. The CEAB requires that each accredited program contain the following minimum content:

- Foundation of Mathematics: 195 AU
- Foundation in Basic Sciences: 225 AU
- Complementary Studies 225: AU
- Breadth of preparation in Engineering Science [ES]: 225 AU
- Application of Engineering Design [ED]: 225 AU
- Combination of ES and ED: 900 AU
- Total curriculum: 1800 AU

Experience shows that most Canadian engineering programs contain about 2000 AU. The CEAB has purposely chosen 1800AU as the minimum content to promote innovation in program design.

An important part of the accreditation process is a site visit to ascertain the quality of students, academic staff, support staff, educational infrastructure and facilities and program delivery.

For an accurate quantitative and qualitative assessment the visiting team typically spends two and a half days at the site. The team usually invests the first half day browsing through material such as textbooks, reference materials, examinations and test papers, examples of students' work – answer books, assignments, etc. In the remaining two days, while the program visitors spend time with respective program coordinators, interviewing all instructors, meeting with students and visiting laboratories and workshops, the team chair, vice-chair and general visitors spend their time interviewing administrators such as the president, vice-presidents and other service providers such as chairs of mathematics and science departments and members of the executive bodies of engineering student organizations. Also, this group divides among its members its responsibilities of assessing library, computing facilities, workshop facilities, determining the suitability of conditions of appointment and professional development of faculty members. Specific attention is paid to admission and progression policies for students used by the school. Sample student transcripts are assessed. All of the above activities are organized by the team chair in partnership with the host dean.

The visit concludes by the visiting team making an oral report of their findings of strengths and weaknesses in various programs. The report is made to an assembly of dean, associate deans and all program coordinators.

Subsequent to the visit, the first draft of the team report comprising reports from all program and general visitors is prepared by the team chair and directed to the host dean through the CEAB. This allows the host dean an opportunity to suggest corrections for errors in the factual information contained in the report. Upon receiving such feedback the team chair prepares his/her final report and submits it to the CEAB, a copy of which is also delivered to the host dean. For final accreditation decision, this report serves as the basis and the host dean is invited to provide any clarification the CEAB may seek prior to arriving at its decision.

The accreditation decisions take one of the following forms:

- Programs fully accredited for six years (6V);
- Programs accredited for shorter terms due to noted deficiencies. Some of these are required to submit a report demonstrating that the noted deficiencies have been corrected (e.g. 3R) and others are required to be revisited (e.g. 3V);
- A program may be placed on termination notice (1T) due to its failure in meeting the accreditation criteria.

It is safe to say that no Canadian engineering school wishes to offer an unaccreditable program and hence, the standards of all engineering programs in Canada meet or exceed the minimum standard.

New programs

It is fully recognized that the entire engineering profession and certainly various engineering programs are continuously evolving. It is an organic process. To respond appropriately, engineering schools are encouraged to report any major changes contemplated in already accredited programs. However, since the accreditation is based on the program curriculum as well as its effective delivery, accreditation of a new program for the first time must wait for a visit until such time when the students of the new program have reached their final year of study. The uncertainty about the accreditation status from the start to the graduation of the first batch of students constitutes a risk in the eyes of students enrolled in the program as well as for the academic administrators. The CEAB has partially addressed this uncertainty by assisting the institutions starting new engineering programs by allowing an informal assessment of the program by an experienced individual preferably a former CEAB member. To further improve this situation the CEAB is considering adoption of a new procedure, which may lead to a provisional acceptance of the curriculum of a new program when it is launched.

Whereas the normal accreditation is conducted free of charge to the host institution, the cost of an informal assessment must be borne by the host institution. Which party will bear the cost of provisional acceptance will be decided when such a procedure is put in place.

The CEAB enjoys a constructive and active relationship with the NCDEAS. The two bodies, the providers and regulators, formally get together frequently. Their discussions include emerging disciplines as well as the forthcoming changes in the CEAB criteria. For example, when engineering schools were contemplating adding new programs in software engineering, the CEAB and CEQB were busy defining curriculum content, which would lead to accreditable programs. Each body conducted workshops and expressed their views in public forums.

Software engineering

The accreditation process in Canada is very accommodative of new and emerging engineering disciplines. However, as an emerging engineering discipline, the name 'Software Engineering' has created a rare conflict between the universities and the engineering profession in Canada. In Canada, the right to practice engineering and safeguard public interest is zealously guarded by the professional engineering associations in their respective provinces and territories and, on their behalf, by the Canadian Council of

Professional Engineers. Consequently, these associations have legally protected the use of words 'engineer' and 'engineering' by registering these as trademarks.

On the other hand, computer scientists have been using the term 'software engineering' for some time and, most recently, in order to fill the market demand for software professionals, have embarked upon creating a 'software engineering specialization' in B.Sc. Programs in Computer Science.

One example of such conflict is in the Province of Newfoundland. In 1996, the Department of Computer Science at Memorial University of Newfoundland secured the university's approval to offer a software specialization in their B.Sc. Computer Science program. The Association of Professional Engineers and Geoscientists of Newfoundland (APEGN) objected [2] to their use of the term 'software engineering'. The basis of APEGN's objection was that the graduates of this program may present themselves as engineers whereas the specialization has neither engineering content nor is its curriculum controlled by the Faculty of Engineering and Applied Science at Memorial. The University's view is that APEGN and on its behalf CCPE is intruding on the academic freedom of the University because Computer Science has been using 'software engineering' to designate a special body of knowledge and, therefore, it has the right to use these words to label a specialization. The university's position is fully supported by the Association of Universities and Colleges of Canada (AUCC) comprising the presidents of all universities and colleges in Canada. The disagreement remains unresolved and, therefore, has resulted in a court case.

Currently, engineering schools at McMaster University, University of Ottawa and the University of Western Ontario are offering Software Engineering degree programs which are due to be accredited by the CEAB in June 2001. The first batch of engineers from these programs will graduate in 2001. It is expected that other engineering schools in Canada would shortly join the above three in offering accredited engineering programs in software engineering.

Forthcoming challenges

In addition to a new body of knowledge leading to establishing new engineering programs, the accreditation process faces additional challenges of new content delivery methods such as distance education, and shifts in emphasis from teaching to learning and from input to output assessment. The question is: 'What is important – the prescribed content and its teaching or the outcome of a program in terms of the competence gained?' Let us comment briefly on each of these aspects. (These comments represent authors' individual views and do not constitute the stated position of the CCPE or CEAB.)

Without doubt a significant proportion of engineering curriculum can be effectively delivered in electronic media and distantly. Much of the delivery can be interactive. Distance education by internationally recognized experts can be significantly superior than that offered by less experienced instructors. And, if outcome assessment is properly used, such departures in content delivery from the conventional, person-to-person classroom teaching to distant learning are inconsequential. Delivery of the entire engineering program by distance education is, however, problematic. Many engineering courses must use experimental validations. Engineering graduates must learn to design and conduct experiments. In their formative years engineering students should receive mentorship of practicing professionals. The CEAB expects that professors teaching courses which contain a significant part of engineering design must be registered professional engineers in Canada. This requirement strengthens the quality assurance mandate of the CEAB.

With regard to the accreditation of engineering programs based entirely on outcome assessment such as that being introduced by the Accreditation Board for Engineering and Technology (ABET) (EAC 2000) in the USA [3], the CEAB is taking a cautious approach. There are very many components of outcome assessment already entrenched in its processes and more are likely to influence future changes in criteria.

CEAB'S INTERNATIONAL ROLE

The CCPE has entered into several international agreements to enhance the mobility of engineers internationally [4]. CEAB is charged with the responsibility to ascertain equivalency and acceptability of foreign countries to assist CCPE in negotiating and maintaining bilateral recognition agreements. The assessments take the form of granting substantial equivalency to programs.

In 1980 the CEAB and CCPE signed a mutual recognition agreement with Engineering Accreditation Commission (EAC) and ABET in the USA. This agreement was updated and ratified in 1997.

In 1989, an agreement promoting recognition of equivalency was signed by Canada, Australia, Ireland, New Zealand, the United Kingdom and USA. Hong Kong was added to this list in 1996. Subject to satisfactory verification of the Engineering Council of South Africa, it too may join the above list of signatories. The above agreement is now revised (1997) and is called 'The Washington Accord'.

In addition to participating in various international agreements the CEAB has lent a helping hand to various countries in setting their own accreditation systems. Through a project funded

by Canadian International Development Agency (CIDA), during 1994–97, representatives of the CEAB worked with their counterparts in the Latin American countries of Mexico, Costa Rica, Columbia, Peru and Chile to develop a framework of engineering programs applicable in Latin America. In another project funded by CIDA the Canadian Society of Civil Engineers is working with the Jamaica Institute of Engineers to establish an accreditation and licensing system for engineering in the Caribbean.

Participation with many countries internationally through a process of evaluation of engineering standards or setting new standards helps Canada in keeping its activities internationally calibrated.

CONCLUSIONS

The Canadian Council of Professional Engineers on behalf of its member organization and through its standing committees – CEAB, CEQB and IAC – has admirably provided the needed quality assurance of engineering education in Canada. On account of this Canadian engineering graduates are received well internationally and are noted to be making valued contributions. The IAC is continuously helping other countries in adopting accreditation processes and licensing arrangements similar to Canada. The CCPE has entered into several international agreements to enhance the mobility of engineers internationally.

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