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Engineering Education in Canada

G. W. HEINKE
Faculty of Applied Science and Engineering, University of Toronto, 35 St. George St., Toronto, Ontario, Canada M5S 1A4

This paper summarizes three recent reports on engineering education in Canada by three national committees, with special emphasis on supply and demand for engineers, and on women's issues for the profession. A list of issues/recommendations is prepared. The author then provides his personal views on the priorities that must be set in order to accomplish the major objectives in a financial climate, which is difficult and getting worse.

INTRODUCTION

BEFORE discussing the topic of this paper, it is necessary to briefly cover two directly related areas: the engineering profession in Canada and the Canadian education system.

The engineering profession in Canada [1]

Canada is a federal state consisting of a national federal government in Ottawa, ten provinces and two territories, each with their own provincial or territorial government.

The regulating of professional practice in Canada is a matter of provincial or territorial jurisdiction. While there are some differences in the status and regulations pertaining to the professions in the ten provinces and two territories, there is a common basis and philosophy underlying all of them.

The practice of engineering in Canada requires registration except where an individual performs his duty under the direct supervision of a registered engineer who takes responsibility for the work. There are two entry paths into the profession:

- graduation from an accredited engineering program and the completion of a specified amount of time in practice, under supervision;
- passing a set of examinations in combination with practical experience over an extended period of time.

The engineering profession in Canada is self-regulating, as are the other regulated professions. Provincial and territorial statutes, and regulations made under the statutes, establish the framework under which the professions must operate, in a manner which will protect the public interest, and ensure the competence of the practitioners. The day-to-day government of the profession and of the practitioners is assigned to associations of professional engineers established under the legislation and made up of registered engineers. The underlying logic of self-government is, of course, the assumption that professionals are best judged by their peers, and that only the professional body has the expert knowledge to determine what constitutes competence in its field of practice.

The title Professional Engineer is protected by law and may be assumed only by members of an association of professional engineers within the province. Temporary licences may be granted to qualified applicants from other jurisdictions. The overriding mandate and purpose of the professional bodies is the protection of the public. For the purpose of carrying this out, the associations are charged with pursuing related objectives which will enhance the competence of their members, and advance the standards of knowledge within the profession.

A national organization, the Canadian Council of Professional Engineers (CCPE), made up of representatives of the provincial and territorial associations, provides co-ordination among its affiliated bodies, conducts appropriate studies and investigations, and administers accreditation of university programs through an affiliated body, the Canadian Engineering Accreditation Board (CEAB). Engineering societies or learned societies, organized by and for the various disciplines within the profession, are concerned primarily with providing forums for the dissemination of knowledge and education to its members. These societies are national, continental, or international in scope. The Engineering Institute of Canada (EIC), an umbrella organization made up of constituent societies serving the different engineering disciplines, is the oldest Canadian learned engineering society. Membership of the societies is voluntary. The Association of Consulting Engineers of Canada (ACEC), and its provincial member associations, are organized to represent the business interest of engineers in private practice.

There are now some 150 000 registered engineers in Canada (Fig. 1). The majority of engineers are employed in industry and government. Close to 3000 consulting engineering firms offer services to the public. The distribution of professional engineers by discipline is shown in Fig. 2. While civil engineers still lead, electrical/electronic/computer engineers are now almost

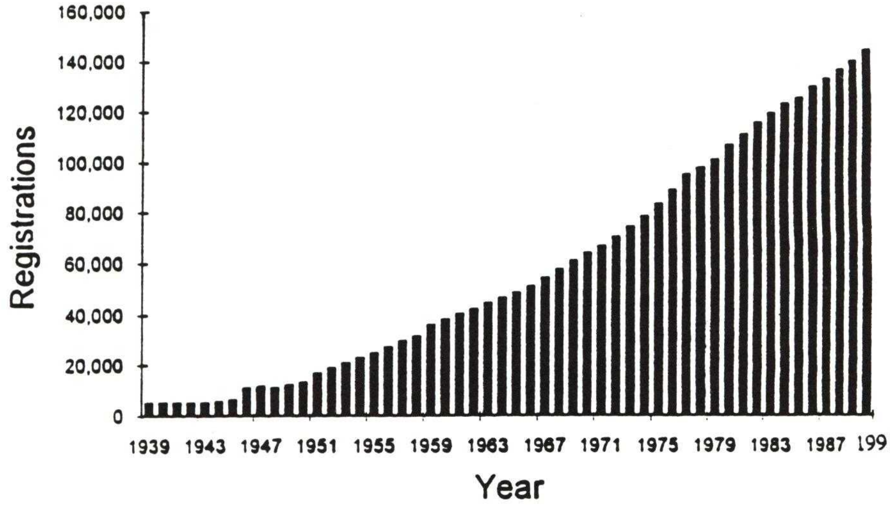

Fig. 1. Registration of professional engineers (P.Eng.) in Canada.

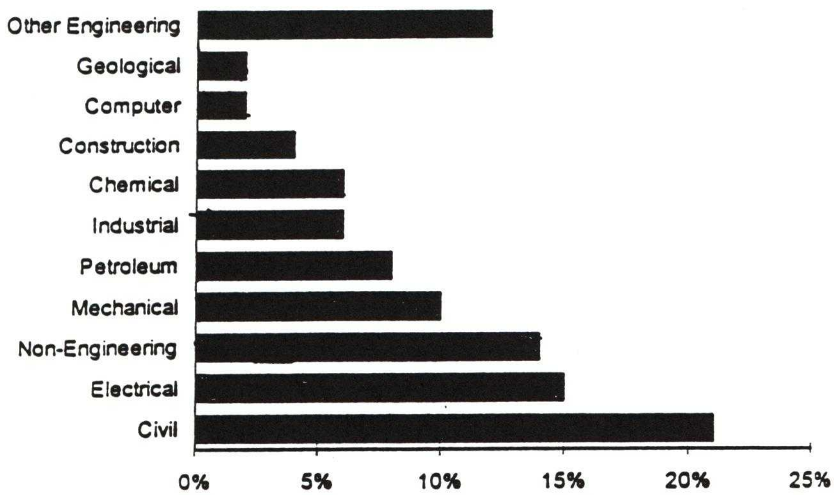

Fig. 2. Professional Engineers in Canada by discipline of work.

universally the largest number of new graduates. At present the engineering profession remains male dominated. The number of women registered as professional engineers (Fig. 3) continues to be small, but the rapid increase in female enrolment in engineering schools in the last ten years will soon change this distribution. Enrolments in Canadian engineering schools are now about 15% from

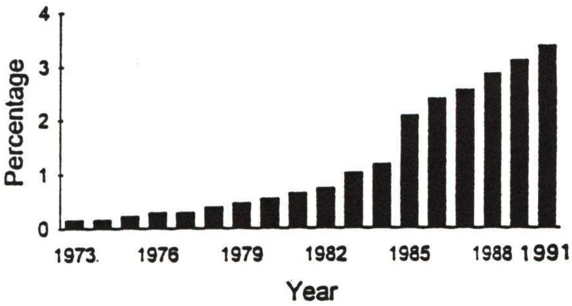

Fig. 3. Percentage of women registered as professional engineers in Canada.

women, up to as much as 35%. A recent study [2] has set goals of between 25 to 35% of women students in first year engineering by 1995! This goal may be ambitious in its timetable, but the recent sharp increases of women engineering students appear to be very promising.

A recent study [3] entitled 'The Future of Engineering Education in Canada' was written jointly by CCPE and NCDEAS (National Committee of Deans of Engineering and Applied Science). It identifies six major forces which shape the practice of engineering and thus the future of engineering education:

- Knowledge explosion
- Environmental concerns
- Infrastructure renewal
- Impact of technology
- Competition
- Globalization

In another report [4] the Canadian Engineering Human Resources Board (CEHRB) attempted to predict the demand for engineers in Canada for the period 1991–2000. It found that the current worldwide economic recession has resulted in growing rates of unemployment for engineers—both beginners and experienced—but that the longer term future offers ground for optimism. It predicts the need to expand Canada's engineering resources by about 20% (or 26 000 new engineering jobs) by the year 2000. Considerable scepticism has been expressed by a number of groups about the validity of the forecast models used, and the predicted results are considered to be too optimistic.

The Canadian education system

Each of the ten provinces and two territories has exclusive constitutional authority over education. There is no national policy for education nor is there a federal Ministry of Education. While there is a high degree of similarity between provinces in the organization and content of formal education, in Canada there are twelve separate education systems.

While the role of provinces and territories is predominant in formal education, from kindergarten to postgraduate studies, the Parliament of Canada has substantial and extensive legislative authority over matters relating to the economy. This has led the federal government to take on major responsibilities in the general area of training and retraining the labour force, through legislation, policies, programs and various funding schemes [5]. The federal government supports work-related education principally through transfer payments to the provinces. It also provides substantial funding for research at universities, through grants and contracts to institutions and individual researchers.

The quality of students and their preparatory education when entering engineering at university is perhaps the single most important ingredient to the quality of the engineering graduate. Figure 4 illustrates the Canadian (engineering) education through which students pass.

With the exception of the Province of Quebec since 1970, Canadian students spend 12 to 13 years in the school system before entering university engineering programs which normally require four academic years. The Quebec program is somewhat different and is not discussed further here. Issues of concern with pre-university education for the engineering profession and engineering school include the following [2, 3]:

- lack of sufficient numbers of well trained teachers of science and mathematics, particularly in the lower grades;
- lack of familiarity by teachers with engineering work and careers;
- lack of women role models as teachers of mathematics and science, resulting in low numbers of women students studying these subjects;
- gender-bias;

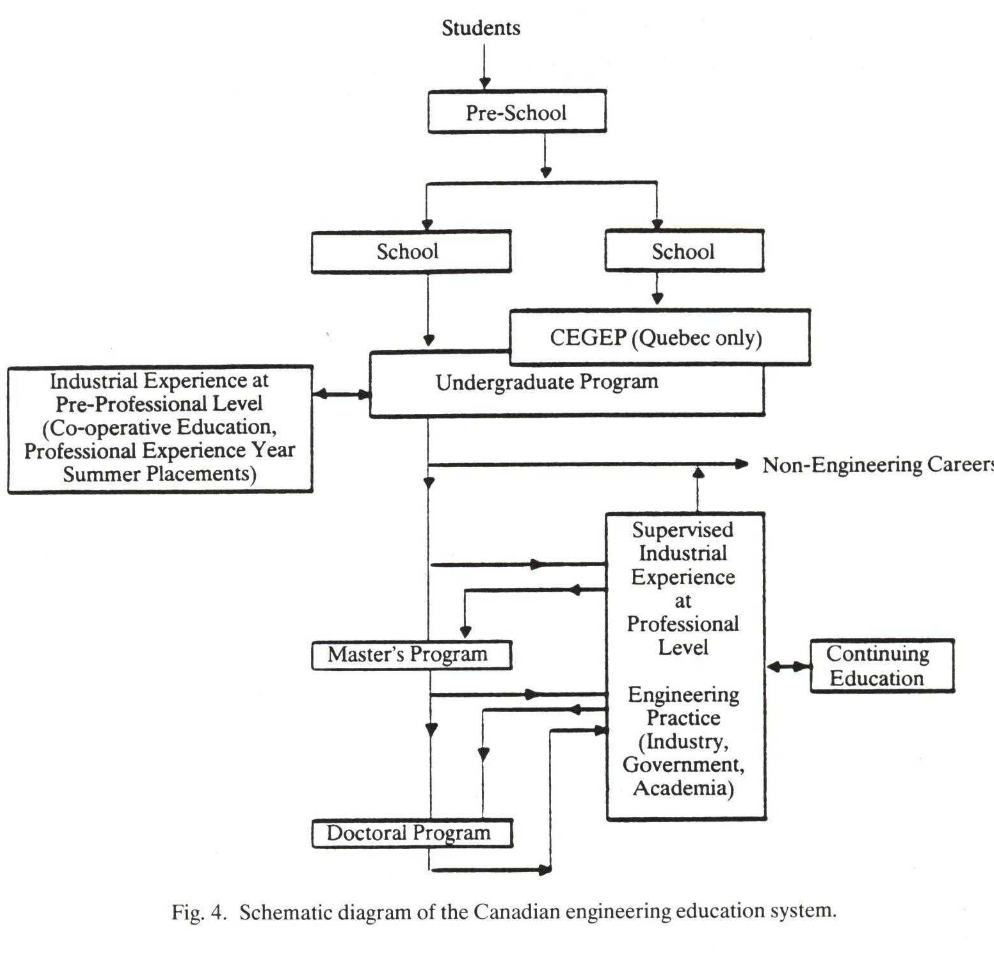

Fig. 4. Schematic diagram of the Canadian engineering education system.

- encouragement of both young women and men towards an engineering career.

The engineering profession and the engineering schools must work with the school boards in order to remedy the above cited problems.

ENGINEERING EDUCATION IN CANADA—AN OVERVIEW

This overview of engineering education in Canada is based largely on the recently published report 'The Future of Engineering Education in Canada' [3].

There are 50 universities and 33 engineering schools in Canada distributed as shown in Fig. 5. All are publicly funded, but each is an independent institution. In addition, there are about an equal number of Colleges of Applied Arts and Technology who train technologists and technicians, generally in two year programs. The earliest of Canada's engineering schools, New Brunswick, McGill and Ecole Polytechnique in Montreal, and Toronto date back to the 1870s. To these were added a number of schools in central and western Canada during the period 1890 to 1920. In 1950 there were 14 engineering schools. A major expansion occurred in the period 1957–63 when 16 new engineering schools were founded. Only three have been added since. Current undergraduate enrolment is about 35 000 students with graduate enrolment of about 5500 Masters' and 3000 Ph.D. students (Fig. 6). A considerable number of the graduate students are part-time. The number of degrees granted annually are about: Bachelors 7200, Master's 1500, Doctorate 400 (Fig. 7). In contrast undergraduate enrolment in 1950 was about 10 000 with very few graduate students enrolled. The number of accredited undergraduate engineering programs (civil, chemical, etc.) are about 200 in 1992, or about six per engineering school. Most have the major programs of electrical, mechanical, civil and chemical, with other programs such as industrial, computer, aerospace, metallurgy, materials, etc., normally only at the larger schools. A few large schools have undergraduate enrolments of 2000 to 3000, graduate enrolments of 500–1000, and up to 200 professors. The large majority of engineering schools are much smaller than this. Table 1 provides statistical indices on engineering schools for 1990. Programs are accredited by the Canadian Engineering Accreditation Board (CEAB), an affiliate of the Canadian Council of Professional Engineers (CCPE), in a manner similar to the American system (ABET).

Undergraduate programs

A typical program consists of four academic years, with the first, and sometimes second year,

Fig. 5. Engineering schools in Canada.

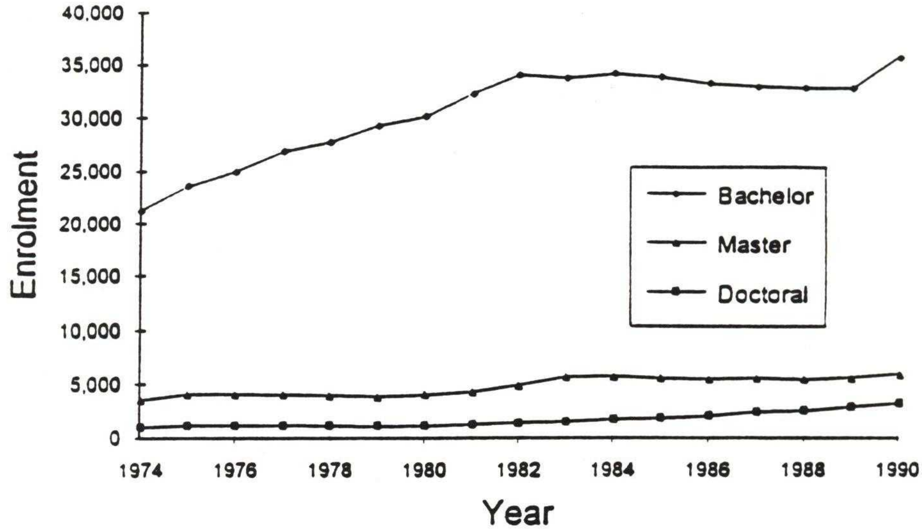

Fig. 6. Enrolment in accredited undergraduate engineering programs and graduate programs in Canada.

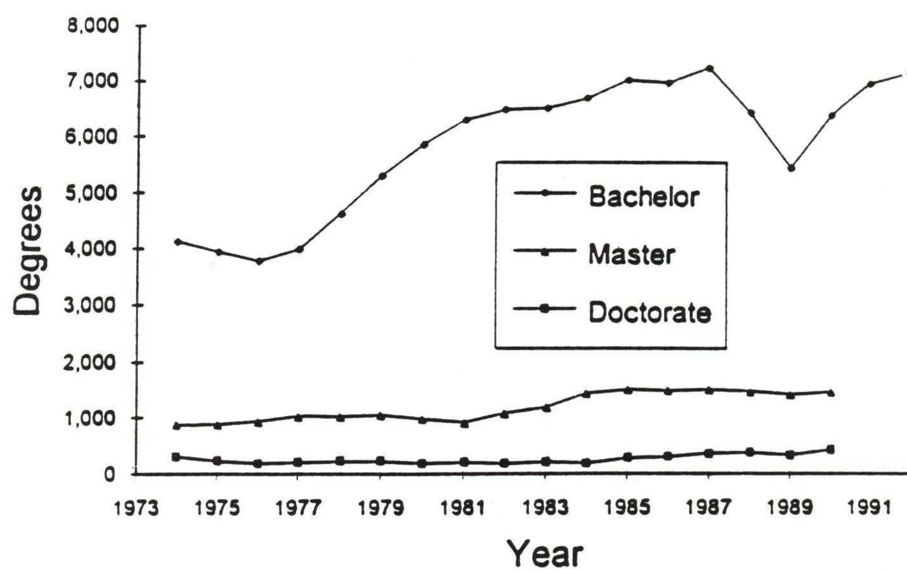

Fig. 7. Degrees awarded by Canadian engineering programs.

Table 1. Statistical indices for thirty Canadian faculties and schools in 1990

Index	Mean	Standard Deviation
Full time equivalent professors (FTEP), #	79	54
Full time equivalent instructors (FTEI), #	91	64
Total operating budget# (TB), $million	9.0	6.7
Full time equivalent undergraduate students (FTES), #	1324	1047
Ratios:		
Student/professor ratio, FTES/FTEP	16.8	6.1
Student/instructor ratio, FTES/FTEI	14.8	5.6
Total budget per student, TB/FTES, $/#	6800	5900
Equipment budget per student (FTES), $/#	400	620
Laboratory space per student (FTES), sq.m./#	7.9	5.0

* Excludes research funds.
Source: [6].

being common to all disciplines. Mathematics and sciences, design, practical skills and complementary studies are covered within the four years, proportions being governed substantially by accreditation requirements. Most programs have two semesters per year, each semester having 13 to 14 weeks of instruction and two weeks of examination. Contact hours tend to be between 25–30 hours each week, usually in 5 or 6 courses per semester. A number of schools have mandatory or optional co-op programs (usually alternating 4 months of work in industry and in school) or internship programs (usually 12–16 months of work in industry, typically the second or third year). The normal length of study for work experience programs is five years.

Graduate programs

Two types of graduate engineering programs are available: Master's and Doctoral programs. Two Master's programs exist: course work and research, and course work (and project) only. The latter is designed primarily for engineers in the workplace, often taken on a part-time basis. More recently, some schools have introduced a combination of engineering and management Master's program. Many Master's programs tend to take longer than US Master's programs, usually between 18 and 24 months.

Doctoral programs are a critical element in the Canadian engineering education and research system. They produce engineers with research skills for industry and they supply future professors of engineering. More recently, much collaborative work between industry and university at the Doctoral and Master's level has brought about better understanding between 'town and gown' to the benefit of both.

Continuing education programs

Because of the inadequate funding of universities, the high levels of student enrolment and the pressure for research results and publications, engineering schools have not been very active in continuing education, with some exceptions. The demand for continuing education has not risen as sharply as elsewhere because of the lack of incentives or mandatory requirements for continuing education of engineers [1, 7]. This situation is likely to change significantly in the near future. It is unclear what roles the engineering schools will play, as opposed to commercial enterprises, the professional associations, and learned societies in a greatly expanded continuing education field.

ISSUES, PROBLEMS AND RECOMMENDATIONS

The issues and problems identified in the CCPE/NCDEAS report [3] are listed in abbreviated form without elaboration.

Pre-university education

Teachers and counsellors

- attitude towards competence in mathematics and science;
- insufficient familiarity with engineering work and careers;
- inadequate counselling regarding engineering;
- negative attitudes of perceived difficulties of engineering conveyed to students, particularly women;
- variable grading practices of the schools.

Students, parents, engineers, and industry

- low awareness by students of engineering and related subjects, e.g. mathematics and sciences;
- parental and student attitudes towards perceived difficulties of mathematics, science and engineering, particularly among women students;
- lack of knowledge of engineering career opportunities among members of some minority groups, including the handicapped;
- low awareness of the activities of engineers and the impact of their work on daily life.

Undergraduate engineering programs

- programs are at full capacity;
- student-to-staff ratios of about 16:1 do not permit individualized instruction;
- teaching equipment and design tools are frequently inadequate;
- broad base of engineering programs is threatened
- course load is high due to the required inclusion of new subject matter;
- many students are unable to complete their studies in the prescribed period;
- engineering design deserves greater emphasis;
- training in leadership and team-work skills is inadequate;
- exposure to engineering practice in international setting is generally lacking.

Graduate engineering programs

- time required for completing Master's programs which include research is excessive;
- range of Master's programs is too limited;
- engineering studies with other disciplines such as Master's programs which combine graduate-level management are lacking;
- admission into Doctoral programs from undergraduate programs is not generally possible;
- time required to complete Doctoral programs is excessive;
- participation of Canadians, and particularly Canadian women, in graduate programs is often insufficient;
- financial support for graduate students is too low.

Engineering faculties and universities

- university reward system;
- lack of initiatives to help young faculty members become proficient teachers;
- young engineering faculty members experiencing great pressures in obtaining research grants and contracts and to produce publications for journals;
- impending shortage of new faculty members with industrial experience;
- low number of women choosing academic careers.

Engineering professoriate

- many engineering professors lack extensive design and current industrial experience;
- faculty members experience difficulty in keeping conversant with industrial practice;
- age distribution of engineering professors in Canada (see Fig. 8) indicates that large numbers of replacements will be needed in the next 10 to 15 years, which will be further increased by voluntary early retirements.

Post-university

Initial experience and professional development

- no national standards for adequate, progressive experience;
- exposure to challenging engineering projects varies widely among young engineers;
- standards for professional engineering development are lacking;
- leadership and management training for young engineers is lacking;
- commitment of senior management to fostering the continuing education is inadequate.

Continuing competence and education

- no formal system to ensure that professional engineers maintain their engineering competence;
- only with difficulty can employers provide the resources for training and support programs;
- funding for programs aimed at ensuring the competence of professional engineers is inadequate;
- no satisfactory Canada-wide delivery system to provide continuing education programs.

The report makes 47 recommendations each of which addresses one or more of the above listed issues and problems. They are grouped in the six areas, which have the primary responsibility for implementing them. A means of monitoring the implementation of recommendations is currently being developed by CCPE and NCDEAS.

SOME PERSONAL VIEWS

Implementation in hard times

I begin with the issue of resources because of its overwhelming importance to the future development of engineering education. Canada's engineering schools are overloaded and underfunded. Governments and industry tell us that the country needs more and more highly educated engineers, as the country's economic well-being depends on it. Some industrial and government programs have been very helpful at the research and graduate levels, but the financial support for the basic infrastructure and undergraduate programs has been getting worse, year by year, for nearly twenty years. To pretend that quality is not suffering is a folly. If this trend is not changed very soon, either by reallocating resources within the universities towards engineering or through external direct funding of engineering schools, perhaps on a selective basis, it will not be possible for Canada's engineering schools to produce engineers in the quantity and quality desired.

In my view, it is prudent to assume that funding for engineering education in Canada for the rest of

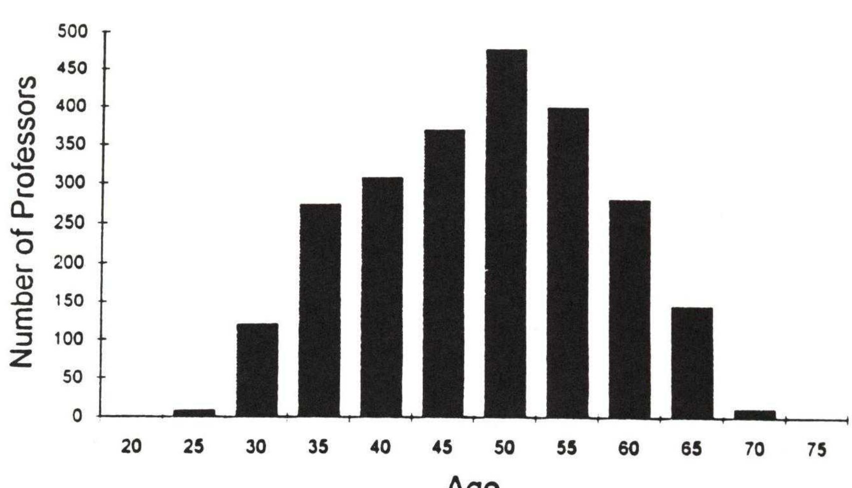

Fig. 8. Age distribution of engineering professors in Canada.

this decade will remain difficult. It is understandable that in public reports, be they country-wide or at an individual university, which have the purpose of pleading for more funds, a more entrepreneurial tone is used, for if we do not argue for our needs, nobody else is likely to do so.

A major failing of the present report [3] is that it contains no estimates of the cost of implementing the recommendations. This must be rectified before implementation of many of the recommendations can be achieved. Whatever resources may become available, they will be inadequate. One must therefore set priorities. Many of the recommendations require additional resources, of people's time and money. Others can be implemented, in whole or in part, with relatively small expenditures.

There are six groups of issues and problems and recommendations. The first (Pre-university) and last (Post-university) I will not comment on. They are very important to the overall engineering education chain, but their implementation rests primarily in the hands of others. Engineering administrators must however play the important role of keeping the pressure on and providing feedback on the success and failure of changes made.

This still leaves 28 recommendations in four groups: undergraduate programs, graduate programs, engineering faculties and universities, and engineering professoriate. Some of the recommendations overlap. Only those that require major new resources are discussed further here:

- expansion of undergraduate programs by 20%;
- lowering of student-to-staff ratio;
- replacement and updating of teaching equipment;
- increased funding for graduate students.

Many other recommendations have significant resource requirements, but, in my judgement, of much lesser amounts than the four above.

Expansion of undergraduate programs by 20%

The need for this large expenditure in capital, for buildings and equipment, and operating funds would need to be demonstrated better than it is at present. Existing unfilled capacities at some of the smaller and medium size schools would have to be established, and filled first, before any building expansion is considered at any schools. There is no need for any new engineering school, even if the full 20% expansion is required. Universities and engineering schools should strongly resist any expansion unless new funds are being provided. Otherwise the quality of the present programs will deteriorate further.

Lowering of student-to-staff ratio

The report recommends that

> student-to-staff ratios in engineering should be lowered from the current 16:1 by at least 10% before the end of the decade to provide better instruction in design and unstructured problem solving; increased teaching assistantships for engineering graduate students could improve the student-to-staff ratios and provide valuable teaching experience as well as financial assistance for graduate engineering students [3].

There is no doubt that this is an important recommendation to improve the quality of the undergraduate program. However, the reality is that over the past ten years, the number of students has gone up, and the number of staff has gone down. Furthermore, there is great pressure on faculties and staff to increase external income through funded research from industry and government. At some successful schools this has resulted in external income exceeding internal income. While this has many beneficial effects, it does have also negative effects: decreased time for the undergraduate program and overloaded staff. Because of continuing base budget cuts, universities have not been able to protect engineering schools, and in many schools, not all retirements can be replaced. Unless the situation is reversed by giving greater priority to engineering by governments and universities, it is not likely that this recommendation can be achieved.

Better funding for graduate students from federal and provincial sources, including recognition for the need of teaching component of some graduate students' development, might provide part of the needed improvement.

Replacement and updating of teaching equipment

The report recommends that

> policies should be adopted and funds provided for the orderly replacing and updating of teaching equipment, design tools and space commensurate with industrial standards. Since the effective lifetime of equipment varies widely, that lifetime should be set in consultation among engineering educators, university administrators, industry representatives and government officials [3]

The reality of the past two decades is that totally insufficient funds have been available to achieve the above objective. In fact many schools do not have a clear plan of their up-to-date equipment needs, because of the many disappointments experienced by a succession of deans and chairs who prepared such plans without positive results. Understandable as this is, it is necessary for all to prepare such plans now, and after the current recession is over, it may be possible with government, university and industry help to make a significant improvement over the next ten years. The provision of funds for research equipment, primarily through the Natural Sciences and Engineering Research Council (NSERC) and some provincial initiatives has kept the current situation from becoming disastrous.

Increased funding for graduate students

The report recommends that

> strong representation should be made to Industry and Granting Agencies to raise financial support for graduate students to approximately 75% of starting industrial salaries. Without such support, the participation by Canadians in graduate engineering studies is unlikely to increase sufficiently to meet demand [3].

Part of the needed funding can be found by implementing the recommendations given earlier to reduce the length of graduate programs. In my view it is doubtful that a 75% level can be achieved. Funding policies should also continue to allow a substantial variation in providing higher stipends for the best students.

Sharing of resources [8]

If the financial plea is to be heard, we must be very credible in the way we use our present resources in engineering. The rapid expansion of the 1960s has brought about too many small and medium size engineering schools in Canada, many of which cannot currently be operated efficiently. Since none is likely to be closed, we must take the initiative ourselves to collaborate with nearby partners and jointly eliminate, trade or combine inefficient small programs. There are recent examples, such as Waterloo and Guelph in chemistry, Carleton and Ottawa in graduate programs, Western and Windsor in environmental engineering. Even large schools must collaborate to have a chance to become internationally competitive; recent examples are joint efforts in engineering at McMaster University, University of Toronto and University of Waterloo, close neighbours, on research and international ventures. Without such self-help initiatives we will not get external help and do not deserve it.

Differentiation

This is clearly expressed in [9] by Professor Charles Vest, President of MIT to the 1992 American Society for Engineering Education (ASEE) convention.

> All of higher education, and especially engineering education, requires a growing diversity of programs and kinds of institutions. I believe that for too long we have all been striving for a single model—the comprehensive, Ph.D.-granting research university. We do not all need to be the same. Similarly, we need a wide variety of experiments . . . we need the flexibility to develop new educational approaches for the 21st century. It will surprise few here that I view the accreditation process by ABET as a hindrance to the educational innovation and experimentation that the nation needs. This process must become sufficiently flexible to promote change and experimentation, or it will be left in the dust.

All we need to do is to substitute CEAB for ABET and it applies exactly to Canada. We are glad that we have an accreditation process, but it must change to allow more flexibility. I am confident that this will happen. I am less certain that the current uniformity in nearly all engineering schools striving to cover undergraduate, graduate and research aspects, including Doctoral studies, will change. The synergy of teaching and research has been a good experience in the education of engineers. Government funding mechanisms and university rewards schemes favour the retention of the present situation. What is more likely to happen is that some schools will independently or jointly narrow the range of their courses.

Professional competence [8]

In my own undergraduate days, I was taught mostly by professors who had gained years of professional engineering experience, although few were active researchers. Today, students would likely say that the reverse is true for them. The science and research revolution of the past thirty years has been a big step forward in putting engineering on a sound scientific basis. But engineering schools must never forget the need for continuing engineering practice by its professoriate and thereby passing that experience on to their students. The rapid wave of large-scale retirements and the financial inability of most schools to hire experienced practitioners and researchers will make this situation even more critical. Government/industry programs such as the NSERC/Industrial Research programs are very positive developments to assist. This program has existed since 1986. It has provided temporary (5–10 years) financing to engineering and science faculties for the hiring of eminent researchers and practitioners, from industry or academia, to strengthen the research capability in key areas. Half of the required funds must come from a sponsoring industry or group of industries, and is matched by NSERC. Close to 100 such professors have been appointed across the country, 12 of them in engineering at Toronto. The practice of appointing experienced engineers as Adjunct Professors is another way to help. But it is critical that the majority of young professsors are given the opportunity to learn the practice of engineering by working in industry and through consulting activities. Universities must have policies that encourage such activities, not just be permissive. This has always been accepted in the medical schools. It is equally important in engineering.

Getting the best students

Canada does not have a climate which encourages young people towards science and engineering. There are many reasons why this is so, and much work at many levels is required to change this situation. At least in the short run engineering schools must be leaders in this task. And we must work together, rather than just concentrate on attracting the best students to our particular engineering school. There are recent hopeful signs of progress [2, 3]. The National Committee of Deans of Engineering and Applied Science (NCDEAS), and provincial groups such as CODE (Committee of Ontario Deans of Engineering) are working together with the professional associations, the school boards and industry on public school and high school liaison programs. There has been an increasing trend of more and better students applying in the last three years.

Quality of programs

Engineering schools themselves must pay more attention to keeping our students satisfied with their education. Key elements include: better curriculum, better teaching, better advising and better follow-up on quality of students with employers. In many of our schools the hurdle of 'getting through' has become a 'rat race'. Too many contact hours, too many courses, too many assignments provide for little time of study and reflection in the undergraduate program. Instead of challenging the intellectual capabilities of our students, we have weighted them down with an unreasonably high workload. Too many students use the required complementary studies designed to broaden their education in other disciplines of the university to lighten their load by choosing easy courses. Given the circumstances, this is not an unreasonable choice for short term relief by the student. But what a waste of a university education! At the University of Toronto we have recently revised the first year curriculum to reduce the required course load from 6 to 5 courses per term, contact hours from the high twenties reduced to the low twenties. It is now also happening in the second to fourth years. Once one accepts that it is not possible to overstuff students with knowledge, curriculum renewal discussions become easier. The emphasis will have to be on learning how to learn, rather than on extensive coverage of the discipline. The need for greater attention to teaching and the need for better advising of students is universally required, and I share the concern and the need for doing better. It will also require better training in industry to make up for the smaller emphasis on disciplinary skills at university.

Lengthening the undergraduate program

Suggestions for a five-year undergraduate program or for a longer teaching term within a four year program are often made. They were implemented by some US schools forty years ago, and generally abandoned years ago. Now the wheel is being reinvented in some quarters.

There are at least two major reasons why I am opposed to either of these suggested solutions. First, the cost to the institution and the student, in today's financial climate, make it very difficult to implement them successfully. Secondly, an undergraduate engineering education, if designed broadly, is an excellent foundation for many careers in today's technological world, not just engineering. The broad career choices that our graduates are making is proof of this. They are not rejecting an engineering career, they are using their basic engineering education as a foundation for other careers. For those who wish to choose a technical professional career, we have a longer program now, called a Master's program. Professional licensing bodies may wish to raise or change their licensing system to reflect the present more complex requirements. There is also a real opportunity for experimentation by individual schools, without abandoning the basic four-year undergraduate degree. Combinations of an engineering Bachelor's degree with commerce, foreign language, social science, etc., degrees can be accomplished by lengthening the combined program to five or six years. On the other hand specially designed Master's programs to achieve similar goals can be created, and have already been initiated in certain schools in Canada, although the demand for these programs has not been large so far.

Women and minorities

We need more women in the engineering profession not just because we need more numbers, but because they can make unique contributions and will increase the quality of professional engineering. I have a strong personal commitment to make rapid progress in this area. Similar things can be said about increased contributions of minorities, such as native Canadians, blacks and the handicapped. The increasing multi-racial population of Canadian urban communities has been very much reflected in the engineering student populations. In fact, the heavy emphasis that Asian people place on education, and particularly on professional education, has resulted in sizeable enrolments of Asian students, probably in excess of the relative numbers in the general population. When such large changes occur, it is not surprising that some tensions and problems arise. They need to be addressed in a positive manner to ensure successful integration at university and in the profession.

Work experience

I believe it to be essential that a student obtains some experience in engineering work prior to graduation as it is a good learning experience. The present situation in Canada is that many schools do not have any formal requirements, some require summer work experience, and some have formal mandatory or optional co-op (usually several periods of four months) or internship (usually a single one year period) programs. By and large the co-op and internship programs have proven very successful. However, the call by some industry people for a universal and mandatory requirement for co-op or internship programs is not sensible either. Differentiation is important. Furthermore, it is very doubtful that Canadian industry could supply the many needed job placements for universal work experience.

A much needed extension of work experience programs to foreign countries has occurred at some schools in recent years: to Japan and other Asian countries and to European countries. Alternate programs for international experience through 'study abroad' programs on a reciprocal basis have also been instituted.

Graduate studies

It takes too long to get a graduate degree in Canada. When graduate studies and research began in Canadian engineering schools in the 1950s and 1960s we appear to have adopted the substantial course requirements of the US education system and the extensive research components of the British system. The result are Master's programs that require as long as two years and Doctoral programs which require four more years after that. Steps have been taken by NCDEAS and NSERC to limit financial support for Master's students to 16 months, with extension where warranted, and to three additional years for Doctoral studies. Direct entry into Doctoral studies without completion of a Master's thesis for promising students is another practical way to shorten the length of the course. In times of economic recession students themselves are, understandably, part of the problem.

Acknowledgements—It was fortunate for the preparation of this paper that three recent major reports [2, 3 and 4] on engineering education issues in Canada were available. Without them the task of writing the paper would have been much more difficult and the content much less representative. I owe a great debt to those who worked on these reports over the past two years. In particular, I would like to acknowledge Dr Axel Meisen, Dean of Engineering at the University of British Columbia, and the Co-Chair of the CCPE-NCDEAS Task Force, whose assistance was extensive and very helpful.

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Dr Gary Heinke is a Professor of Civil Engineering, and is presently the Dean of the Faculty of Applied Science and Engineering at the University of Toronto. Prior to becoming Dean, Dr Heinke served two five-year terms as Chairman of the Department of Civil Engineering, having been on the full-time staff since 1968. He is a member of the Association of Professional Engineers in Ontario and a Fellow of the Canadian Society for Civil Engineering. He has a long-time interest in Continuing Engineering Education and is currently Chairman of the Continuing Education Committee of the Engineering Institute of Canada. His research interests are in environmental engineering with special emphasis on arctic environmental work and on urban infrastructure rehabilitation. Dr Heinke received his B.A.Sc. (Honours) in Civil Engineering in 1956 and his M.A.Sc. in Civil Engineering (Environmental) in 1961 at the University of Toronto; he received his Ph.D. in Chemical Engineering in 1969 at McMaster University. Prior to his joining the University of Toronto, Dr Heinke was in the consulting engineering field in Toronto for ten years, specializing in municipal and environmental engineering. His primary research and consulting activities over the past twenty-five years have been concentrated on environmental improvements of northern Canadian communities. This work has been sponsored by the Governments of the North West Territories, Yukon, Alaska and the National Sciences and Engineering Research Council. Over 40 theses reports have been prepared covering topics such as water supply and distribution, waste disposal, hazardous wastes, fire protection, health and sanitation improvements and planning.