

Engineering Education in Australia*

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The purpose of this paper is to provide a brief overview of the processes by which a major Review of Engineering Education was initiated and undertaken in Australia, a summary of the recommendations that emerged, and some comments on the implementation process and associated developments. The selection of material to be covered has necessarily been somewhat arbitrary, and readers interested in gaining a more balanced appreciation of the nature and extent of the Review should obtain a copy of the Report from the Institution of Engineers, Australia [IEAust]. The author was, at that time, the Chief Executive of the IEAust. However, the opinions and perspectives appearing in this paper are his own, and are not to be construed as representing the current position of the IEAust.

INTRODUCTION

IN 1994, the Institution of Engineers, Australia, as the professional and accrediting body, the Australian Council of Engineering Deans and the Academy of Technological Sciences and Engineering decided that a fundamental review of engineering education in Australia needed to be undertaken as a matter of urgency. The reasons included:

- significant changes in the general objectives for higher education;
- the emergence of new engineering disciplines and new technologies;
- the rapid increase in student numbers and decrease in the unit of resource;
- the increasing number and degree of specialization of engineering programs;
- increasing emphasis on need for interpersonal skills, leadership and teamwork;
- difficulties in recruiting staff with appropriate qualifications and experience;
- difficulties in retaining high quality staff and maintaining their currency;
- difficulties in giving staff and students access to modern equipment;
- the low level of industry support for engineering education;
- the need for graduates to be prepared for work in a global environment;
- the need for Australian services and products to be internationally competitive;
- the need for all courses to reflect the principles of sustainable development;
- significant changes in the objectives for secondary school education;
- changing community perceptions of the benefits of engineering education;
- significant changes in the capacities of tertiary students at the point of entry;

- increasing demand for continuing professional development;
- increasing community demand for articulation and credit transfer opportunities;
- significant changes in the interaction between engineering research and practice.

The primary aim was to examine, report upon, and make recommendations relating to the evolving structure of engineering education in Australia, mainly at professional level. However, the need to build engineering teams which meet the diversity of industry and community needs effectively and create career development opportunities for their members was recognized, and experiential learning and continuing professional development were central to that process.

The Review was undertaken as a collaborative venture by the sponsoring organizations. The Department of Education, Employment and Training provided a substantial grant to assist in the process. Importantly, however, the Department chose to remain at arms length from the process, so that the Review could be carried out as an independent effort by, and on behalf of, the key stakeholders. Detailed terms of reference were developed, and expressed in the form of six key tasks to be coordinated by a Steering Committee. The critical factors considered included:

- trends in student knowledge and skills at the point of entry;
- articulation and recognition of prior learning and life experience;
- the capacity of programs to recognize and respond to emerging demands;
- cross-sectoral issues relating to the quality, efficiency and flexibility of programs;
- the partnership between universities and industry;
- the accrediting role of the national professional association;
- capacity to deal with new and emerging disciplines and practice areas;

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- the international competitiveness of Australian engineering graduates;
- the role of general and/or specialized undergraduate education;
- the role of practical experience, design projects and management studies;
- the role of interdisciplinary and/or complementary studies;
- the role of postgraduate education and training;
- the need for uniformity and/or diversity in engineering programs;
- recruiting and maintaining the knowledge and skills of well-qualified staff;
- the impact of staffing factors on university responsiveness;
- the overall structure of the engineering education system.

FUTURES CONFERENCE

Following some preliminary testing of the terms of reference, the Review began with a major Futures Conference in July 1995, and concluded with the publication of the final Report in December 1996. The Futures Conference involved representatives from an extensive selection of industry, community, professional and academic organizations. They were asked to explore how engineering practice might develop over the next fifteen years, and the challenges that would face engineering education as a result. All accepted that major changes were under way, driven by:

- globalization of industry, commerce and the professions;
- increased community expectations for consultation and involvement;
- deregulation and a progressive withdrawal by government from service delivery;
- a more competitive business environment, favoring small and medium enterprises;
- new management systems, built on communication technologies and information systems.

These factors had combined to change the role of engineers, affecting their self-awareness and sense of identity, and reducing their perceived capacity to project their ideas effectively in the wider community. However, participants were quite optimistic about the future. There was a widespread, if not universal, view that many of the problems that appeared almost insuperable at present would have been solved, and, that in identifying and implementing solutions, Australian engineers would have developed skills and capacities that would find a ready world market.

The consensus was that existing modest growth, largely driven by selective immigration, would continue and that, in consequence, the population of Australia would have risen to over twenty million. Engineers would have achieved major advances in the effective and efficient utilization of water and energy, which together allowed that

level of population to be sustained without unacceptable social and environmental impacts. Emerging communications technologies would have enabled a greater degree of decentralization in decision-making, within a framework of national objectives. Sustainability would have become a real national goal, and a much larger proportion of the national energy supply would come from renewable resources. Engineers would be at the heart of new industries built upon engineering expertise in areas such as:

- waste management
- materials technology
- environmental management
- infrastructure replacement
- agriculture and horticulture
- food processing
- medical technology
- biotechnology
- nanotechnology
- software engineering
- optronics
- sports and recreation.

There would be a continuing need for both generalists and specialists, with most engineers working in multi-discipline teams. With an aging population, and continuing shortfalls in entrants to the profession, there would be increased pressure on engineers to defer retirement, more need for them to engage in lifelong education, and more capacity for them to place their accumulated skills and knowledge at the disposal of society once they did retire.

There would be an increased emphasis on communication, teamwork, management, and the capacity to acquire and apply information from many sources. However, deep understanding of fundamental engineering principles was essential. Participants were unanimous in the view that engineers must never accept without question the predictions of computer-based models, and must be able to mobilize basic knowledge, practical skills and professional judgment to identify, investigate, research, develop and implement solutions.

There was considerable discussion regarding the nature of the educational experience that might best prepare engineers for practice in this new environment. The majority view was that most engineers should experience a broadly based undergraduate course, and later develop their specialist skills by postgraduate study. That study, however, was considered more likely to be industry-based than discipline-based. The existing trend towards double degrees was expected to continue, although participants felt that more effective ways could be found to give engineering graduates a broad education.

An alternative view, which received some support, was that study in depth in a specialized area represented the best preparation for work in multidiscipline teams. Proponents of that view pointed out that technologically literate graduates

in the arts, humanities, law and business were just as necessary to such teams as broadly educated engineers.

There was a consensus that industry experience should be integrated with, or a prerequisite for engineering degree programs, although there was very little discussion of the precise skills that should be developed in this way. Participants felt that industry should tell universities what capacities they really wanted to see developed in graduates, and be prepared to share the cost of the industrial training needed to achieve that outcome. There was consensus that the cumulative education of an engineer, leading to initial recognition as an independent practitioner, would become longer than four years, with trade-offs between the resources allocated to undergraduate education and those allocated to the processes of lifelong learning being inevitable.

The emphasis in an undergraduate program should move away from the present focus on examinations, in one form or another. Many students saw skills and knowledge as hurdles to be surmounted rather than tools for future practice. Assessment one semester at a time was called into question, with several participants calling for examinations to be repeatable, allowing room for students to improve. A balanced undergraduate course should cover:

- learning skills;
- information management;
- problem definition and problem solving;
- effective communication, listening and questioning skills;
- the fundamental characteristics of physical and biological systems;
- systems engineering, model building and simulation;
- life-cycle design of products, projects and programs;
- social, economic, and environmental costs and benefits;
- process design, quality management and maintenance;
- management of people, materials and resources;
- ethical and professional issues;
- industry experience.

THE REVIEW PROCESS

The Steering Committee, with a small secretariat, set out to solicit, analyze, consolidate and reflect upon a wide range of input from the profession, industry, the engineering schools and the general public. Six task forces were established, to take responsibility for undertaking research, consulting with interested parties, and preparing recommendations in the following areas:

- the interface with students;
- the interface with industry;
- the interface with the profession;

- the interface with the community;
- design and delivery of educational programs;
- institutional policies and systems.

The methods adopted by the task forces naturally reflected the significant differences in the issues themselves and the associated stakeholder constituencies. In general, however, the review achieved a far higher level of consultation and ownership than any of the government-initiated discipline and professional reviews conducted over recent years. That very spread of ownership and responsibility limited the capacity of the process to generate dramatic recommendations for change but, at the same time, greatly increased the likelihood that a substantial portion of the developments that were recommended would in fact be achieved.

A less welcome outcome of the democratic process was the considerable shortening of the effective time horizon. The Futures Conference largely succeeded in maintaining a fifteen-year perspective. However, task force deliberations concentrated much more on the near future. Most participants were deeply involved in and committed to some element of the education process, and found it difficult to extend their vision beyond the natural life cycles of that element. In spite of, or perhaps because of, that limitation, the exercise offered an effective mechanism for identifying and transmitting current best practice. During the review, some changes that were ultimately to be recommended actually began to be introduced in many of the engineering schools involved.

RECOMMENDATIONS

The final report observed that Australian engineering schools enjoy a high reputation for producing adaptable, competent graduates, well equipped to meet the early challenges of their professional life. However, their subsequent career pathways can no longer be predicted with the degree of certainty that might once have been possible. The report commented that the advent of rapid and effective worldwide communication systems and an unprecedented expansion of mass education, had made people increasingly aware of the social, economic and environmental forces that shape their destiny, and led to community demands for greater control over those forces, and set out a number of broad directions for development:

- engineers must have a broader education and be drawn from a wider range of backgrounds;
- student intakes must be sufficient for Australian industry to be internationally competitive;
- engineering courses must be outcome-oriented, and equip graduates for lifelong learning;
- professional accreditation systems must encourage innovation in course content and delivery;

- the priorities for engineering research, and its relationship with teaching, must be reviewed;
- many engineering schools must consider networking and resource sharing to remain viable;
- internationally competitive advanced engineering centers must be developed;
- engineering schools must be prepared to form alliances and facilitate student mobility;
- an independent national center for engineering policy should be established;
- school and community liaison must be enhanced so that more students choose engineering;
- four-year full-time courses must remain the benchmark, but diversity must be encouraged;
- staff profiles must balance teaching, research, professional practice and community skills;
- engineering schools must be prepared to collaborate to produce innovative courseware;
- students and staff must be given more opportunities to get relevant industry experience;
- the sponsoring bodies must take immediate action to implement these recommendations.

Detailed recommendations were developed to support each of these broad directions, and any selection of highlights must inevitably reflect the biases and special interests of the person making the selection. The following comments must be read in that context.

Student intakes

The social and industrial environment has changed significantly in recent years, and the rate of change is accelerating. In a highly competitive world market, the future economic and social development of Australia will depend critically upon the availability of increasing numbers of graduates with the attitudes, skills and knowledge needed to enable them to provide professional engineering services, or bring a deep technical understanding to their work in other professional roles. Australia already relies on immigration to make good a substantial deficit in the domestic supply of engineering graduates. To make no effort to address this situation would be to place the economic future of the country at the mercy of international migrant flows.

Entry criteria

Professional engineers need many competencies, and are often required to lead, or at least take a central role in, a multidiscipline team. The entry criteria for engineering programs should be reviewed and amended as appropriate to provide greater opportunities for people with diverse educational and social backgrounds to select engineering as a career and to enter the necessary education and training. In particular, care should be taken to ensure that studies in mathematics and physics at secondary school are not seen as the only way in which applicants can demonstrate a capacity to acquire and weigh evidence, create predictive models of reality, and reach informed

judgments. Universities must be prepared to provide bridging programs as and where necessary.

Undergraduate programs

Programs must equip graduates with a good technical and professional background, and the attitudes and capacities required to communicate effectively, understand the social and economic framework in which they practice, and engage in lifelong learning. Students should not have to enroll in double degree programs in order to get the breadth of education necessary for recognition as a professional engineer. The increasing dependence placed upon computer software packages emphasizes the need for all engineers to gain a thorough understanding of fundamental principles applicable to their discipline and to develop sound technical judgment, in order to:

- identify the basic parameters and constraints applicable to any situation;
- specify the fundamental assumptions to be applied in the course of design and analysis;
- assess the relative merits of proposed solutions, whether computer-based or not;
- recognize when results emerging from the design process are less than satisfactory.

The report concluded that the four-year degree program, more broadly based than existing programs, should continue to be the standard route to professional recognition for school leavers. However, the emergence of new learning structures and delivery systems should be encouraged.

In particular, while most courses required an enhanced practice content, there was general acceptance that provision should continue to be made for more technically focused engineering science programs, targeted mainly at students aiming for postgraduate research work. Graduates from such programs would be able to qualify for full recognition as professional engineers after completing continuing professional development activities focused on practice issues.

Learning pathways

There must be an increased range of educational programs which meet the specific needs of individuals and organizations for lifelong education, including those associated with professional mobility. Resource allocation and accreditation criteria should encourage an integrated system for recognizing prior learning, including that gained through on-the-job training and experience.

Teaching and learning models

Engineering schools must become more outward-looking, drawing strength and purpose from interactions with practice and society. There should be a major increase in the proportion of engineering courses based on the cooperative model. Significant benefits should flow from closer relationships between industry and universities, implicit in such a development. The ownership

of educational processes should shift from staff to student, and teacher to learner. The best available educational methods and technologies should be adopted. Accreditation procedures and criteria should place continuing pressure on schools to respond to these challenges.

Partnerships

Universities will have no monopoly on the provision of professional engineering education, and students will be free to choose from regional, national or international providers delivering services through a wide range of mechanisms. The preferred model should be for partnerships to emerge between industry, universities and government; partnerships that allow each partner to contribute to and gain appropriate benefits from particular aspects of engineering education. Funding systems and taxation policies should encourage collaborative activities, and government should work closely with industry and the profession to support the development and operation of a coherent and comprehensive system of advanced engineering centers and networks to address identified industry needs and mobilize long-term industry influence and involvement.

Learning networks

No single university can, or should attempt to, offer a complete range of advanced studies or carry out effective and credible research, in every specialized field of engineering. Rather than seeking to achieve economies of scale or assemble a critical mass of researchers by consolidating the present system into a smaller number of larger schools, a networked, differentiated system should be developed. Networks should be built around the strengths and identities of individual engineering schools. Government, industry and the profession must encourage and facilitate the establishment and operation of national and international learning and research networks, taking advantage of the best available communications technologies.

Staff recruitment, development and reward

Staff profiles must balance strength in teaching and learning, research, professional practice and community service. Selection or promotion criteria must reward excellence and advancement in all these areas, not simply those which have become traditional or which lend themselves to objective measurement of outputs. Universities and the profession should promote and facilitate secondments, joint appointments, and easy mobility between universities and industry.

IMPLEMENTATION

Some recommendations whose general directions emerged during the process are already being implemented progressively by universities in Australia. Much, however, remains to be

done, and only a concerted effort by all stakeholders will realize the full benefits from the review. Recent developments in the higher education field have served to emphasize that the Australian Government wishes to reduce its financial commitment to, and control over, the higher education sector. Partnerships with industry, as recommended in the review, represent one potent weapon that could be brought to bear on the otherwise intractable problem of meeting the increasing costs of high quality education.

The three bodies which initiated the review decided that, while they might from time to time have different perspectives on the priorities that should accorded to various aspects of the recommendations, they should continue to work together to ensure that the recommendations are implemented as soon as practicable. The exercise did require more positive collaboration between the IEAust and the ACED than had sometimes been evident in the past, and closer relationships developed during the review have been maintained through the implementation process.

While the Australian Government generally welcomed the directions being followed, no special government funding was available to support the implementation phase of the exercise. In the end that was probably a blessing in disguise, since those involved in implementation were able to feel a genuine sense of ownership, and were not distracted by the constant effort to secure funds through the tortuous processes usually associated with public funding sources.

THE ENGINEERING TEAM

A further study, covering the education and training of engineering officers and engineering technologists has since been initiated and completed. This was seen as an essential complement to the Review of Engineering Education which, apart from articulation issues, was otherwise essentially concerned with the higher education sector. Clearly the contribution of the vocational education and training sector to the development of a well-balanced engineering workforce must be given equal weight. While the key factors that affect this sector are somewhat different from those operating in the higher education sector, the need expressed by industry for well-educated engineering officers and technologists is as urgent as that for professional engineers. An essential finding was that the competencies of engineering officers and, to a lesser extent, technologists are not, in general, subsets of those required by professional engineers.

The study resulted in a coherent and integrated plan of action for the education and training of members of the engineering team over the next generation, so that engineering education in Australia can remain in touch with industry demands and community needs, and produce

high caliber graduates and diplomates at all levels to maintain Australia at the forefront of engineering design and practice. The vocational education and training sector in Australia is administered by States and Territories, and different approaches tend to be adopted within each jurisdiction. A central purpose of the study was to identify any efficiencies which might flow from a national perspective on the education and training of engineering officers and technologists.

Implementation of the outcomes of the review of education for engineering officers and technologists is still in progress. However, there have already been interesting developments. For example, competency-based assessment techniques have been introduced by IEAust. These offer a formal and objective system for measuring the outcomes of experiential learning, and for designing professional development programs based on such learning. This reflects the need felt in many industries to meet skills and knowledge shortages through development and upgrading of their existing workforce.

ACCREDITATION OF ACADEMIC PROGRAMS

IEAust accredits the programs delivered by Australian universities which are designed for professional engineers (4-year degree) and engineering technologists (3-year degree), recognizes equivalent programs delivered in overseas jurisdictions, and recognizes programs delivered by the Australian vocational education and training sector (and by some universities) designed for engineering officers (2-year diploma). Graduates from such programs are exempted from further assessment of their competencies until they seek recognition as an independent practitioner.

Accreditation of degree programs thus represents one of the primary quality assurance mechanisms available to IEAust. Procedures and criteria must be such as to develop and maintain the capacity of programs to provide graduates with the specified competencies. IEAust presently accredits 200+ professional engineering programs in 36 universities. The number of accredited programs is growing, reflecting new areas of specialization within the profession, in fields such as Software Engineering, Environmental Engineering, and Biomedical Engineering. Double or combined degrees, usually five or six years in duration, have become common, and tend to attract students with stronger academic records. Examples include Engineering with Arts, Languages, Business, Commerce, Economics, Law and Science.

The IEAust accreditation system has been concerned basically with inputs and processes. However, the changes that have occurred, and are continuing to occur, in tertiary education in Australia, and the new technologies becoming

available, which have opened the way to a range of alternative delivery methods, have generated a need for the accreditation system to change in order to address the emerging challenges.

With the advent of national competency standards for professional engineers, developed and owned by the IEAust, and concern with the development of a quality culture in the workforce, more emphasis has been placed on ensuring that graduates from engineering programs have the competencies required to enter professional practice.

After extensive debate, IEAust decided, in line with the above recommendations, to move from an input-focused to an outcome-focused accreditation system. Other factors contributing to the decision included increasing costs, and the decreasing availability of volunteer resources for traditional accreditation activities. The latter factor has been driven by competitive pressures in the private sector, and the demise of the large public sector agencies which once employed large numbers of professional engineers.

Basic requirements – graduates

The procedures and criteria should be such as to ensure that the educational experience provided in an accredited program equips graduates to demonstrate at least the following range of basic attributes:

- ability to apply knowledge of basic science and engineering fundamentals;
- ability to communicate effectively with engineers and the community;
- in-depth technical competence in at least one engineering discipline;
- ability to undertake problem identification, formulation and solution;
- ability to utilize a system approach to design and operational performance;
- ability to work effectively as an individual practitioner;
- ability to work effectively in multidisciplinary and multicultural teams;
- capacity to be a leader or manager as well as an effective team member;
- understanding of social, cultural, business and environmental responsibilities;
- understanding of and ability to apply sustainable development principles;
- understanding of and a commitment to professional and ethical conduct; and
- preparedness to undertake lifelong learning.

The new IEAust accreditation system takes advantage of the quality assurance systems and procedures now required to be implemented by Australian universities to secure the underlying quality of the educational inputs. These systems and procedures amount to internal accreditation processes, and overlap to some extent with the professional accreditation processes traditionally undertaken by IEAust. There is expected to be significant scope for improving efficiency through

minimizing duplication between the internal and external accreditation processes.

The IEAust will continue to visit university engineering schools at intervals not exceeding five years to ensure that the educational experience produces graduates with the attributes listed above. The visits will, however, become audits, designed to confirm that quality systems claimed to be in place are working effectively, and to evaluate, and provide universities with authoritative feedback on, the outcomes achieved from the educational process. There will be more emphasis on verification of the standards by closer scrutiny of the outcome measures.

Basic requirements – engineering schools

Verification methods will include independent reviews of examination papers, marking schemes and scripts, evaluation of project reports, and interviews with students and graduates. There will be correspondingly less emphasis on process elements such as ensuring that the prescribed number of texts are held in the library. However, to ensure that the basic prerequisites for a rewarding educational experience are firmly in place, the engineering school must be able to demonstrate that:

- the teaching and learning environment;
- the nature and content of the academic course;
- the level and extent of exposure to professional engineering practice are maintained at a satisfactory standard;
- the school has a structured responsibility for engineering education within the university;
- a strategic statement on engineering education endorsed by the university;
- effective advisory mechanisms involving industry participation; and
- staffing and resources sufficient to meet the stated objectives.

Basic requirements – education program

Consistent with the general outcome-oriented focus, no attempt is made rigidly to prescribe program content. However, there is an underlying presumption that the overall program will be at least equivalent in scope and rigor to a four-year full-time degree course, entered on completion of secondary school. Programs might typically have the following components:

- Mathematics, science, engineering principles, skills and tools: $\approx 40\%$
- Engineering design and projects: $\approx 20\%$
- An engineering discipline specialization: $\approx 20\%$
- Integrated exposure to professional engineering practice: $\approx 10\%$
- More of any of the above elements, or other elective studies: $\approx 10\%$.

Basic requirements – integration with environment

The university must use external benchmarking to ensure that the educational material and

standards reflect best practice. Exposure to professional engineering practice must be integrated throughout the academic program so that students can develop an engineering approach and ethos, and gain an appreciation of engineering professional ethics, and must include:

- use of staff with industry experience;
- practical experience in an engineering environment outside the university;
- lectures and seminars, including case studies, on professional ethics and conduct;
- use of guest lecturers;
- use of industry visits and inspections;
- an industry-based final year project;
- regular use of a logbook in which experiences are recorded.

DISTANCE EDUCATION

Accreditation of distance education programs in engineering raises difficult issues, and it is only within the last few years that IEAust has been prepared to consider such a step. The advent of national competency standards for professional engineers has, however, created an objective reference point against which the outcomes of both face-to-face and distance education programs can be compared. The overall strengths and weaknesses of distance education programs are now reasonably well understood, and, in determining an approach to accreditation, it was considered sufficient to focus on specific competencies defined in the national competency standards where distance education programs might arguably offer less scope for development and demonstration than the otherwise equivalent face-to-face programs.

Professional competency standards, as developed in Australia, require that competencies be demonstrated and assessed in parallel and in context. Furthermore, the review of engineering education laid particular stress on the need to foster teamwork and communication. A reasonable conclusion would be that collaborative and effectively supervised work over an extended period should be an integral part of any undergraduate course, whether delivered by distance education or otherwise. The approach taken to date has reflected that conclusion.

Accreditation for distance education programs is available only where entry is restricted to mature students already working in an engineering environment and where, at least during the final year, the programs make extensive provision for residential schools.

Careful consideration must be given to implementing rigorous quality assurance systems to ensure that the claimed equivalence of internal and external programs is matched by the actual learning experiences of the individual students. For example, distance education students may be

required to complete log books, in much the same way as graduates, recording the engineering activities in which they have been engaged, and to have the accuracy of the log books verified by a professional engineer approved as a professional supervisor by the university.

Residential schools in the final year are expected to place special emphasis on developing key competencies in planning, collaboration and communication, and ensuring that opportunities are provided for effective and broadly based interaction to take place between staff and students, particularly when major projects are being initiated and evaluated.

In face-to-face programs, interaction between students takes place in formal and informal environments and is widely regarded as an essential element in developing the key competencies identified above. Such interaction appears to be most effective in the later years of a course, and provision must be made in distance education programs for student-to-student communication beyond that possible in the often high pressure environment of residential schools. Well-designed and readily accessible Internet facilities can be a useful tool in fostering such communication.

CONCLUSIONS

Fundamental changes in the nature of professional practice have affected most practitioners and the changes can be expected to continue, and even accelerate, over the coming decade. While recognizing that many engineering schools have already begun to respond to the challenges, the Report concluded that a culture change is now required in professional engineering education.

The nature of some elements of engineering practice is such that the half-life of technical knowledge is now, in many cases, shorter than the duration of the programs that prepare students for practice. Some estimates in jurisdictions that have introduced audited continuing professional development suggest that, for each full-time year of pre-entry education, competent engineers will undertake the equivalent of another full-time year of continuing professional development.

This has placed more emphasis on defining student performance in terms of their command of fundamental principles, and their ability to deploy those principles effectively and creatively. Graduates must also understand the nature of the social and economic environment in which they work, recognize and respect their personal strengths and limitations, apply high communication skills, build, and participate in, multi-level and multi-discipline teams and, above all, maintain their professional skills by lifelong, self-motivated study.

The review process had considerable intrinsic value in facilitating broad, informed debate on the future roles of professional engineers, engineering technologists and engineering officers and the nature of the education required by such practitioners. However, the real benefits have flowed from the positive, and often innovative, responses to its findings by engineering schools across Australia. These schools have recognized and addressed the challenges and opportunities of coming decades, and their graduates are better equipped to take their places in an increasingly complex and demanding workforce. More attention must now be directed to the programs and services required to enable practitioners to maintain their competence at the high levels expected by clients and the wider community.

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