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Quality Assurance of Engineering Education through Accreditation of Programs in Taiwan*

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The number of universities in Taiwan has increased enormously over the last ten years; this has raised concerns over the quality of the engineering programs. In 2003 the Institute of Engineering Education Taiwan (IEET) was established, to ensure quality control of the programs via outcomes-based accreditation. This paper describes key elements of IEET, a provisional signatory to the Washington Accord, and the lessons learned in the application of the scheme. Currently, nearly a quarter of all four-year engineering programs have participated in accreditation. Work in progress includes the fine-tuning of the accreditation process and accreditation of master's degree programs beginning in 2007. The work of IEET should help other economies that are in the process of establishing their own accreditation systems.

Keywords: accreditation; quality assurance; evaluation; Taiwan

INTRODUCTION

WASHINGTON ACCORD is an organization that gives a framework for the mutual recognition of substantial equivalence of accreditation systems for engineering education in nine countries/regions of the world. ABET is a founding member of the Washington Accord and a leader in its operation. In Asia, both Hong Kong and Japan became full signatories in 1995 and 2005, respectively. Malaysia, Korea, and Taiwan are provisional signatories. Singapore is in transition to full signatory status. Asian countries clearly have the ambition and determination to practice substantial equivalent accreditation systems with their counterparts in the western world. This paper introduces an emerging quality control system for engineering education in Taiwan.

Much of the economic success of Taiwan has to do with engineering. To a large extent, the economy depends on the development and progress of the engineering sector, whether in the more traditional fields such as chemical, civil, hydraulic and mechanical engineering, which helped to launch the economic development of the island twenty to thirty years ago, or in electrical/electronic engineering, which have brought Taiwan to the centre stage of the world in recent times. Without the contributions of engineers, the economy would be unable to sustain itself and Taiwan would lose its competitiveness in trade. In addition, many engineers who went abroad and now contribute in their host countries have realized another form of export. Thus, the ability of Taiwan's 160 universities and colleges to produce proficient engineers has become critical, and for some time now these programs have certainly been able to produce a diverse workforce to meet the needs of the industry and society.

However, some of the recent developments have brought in severe competition, which challenges the vitality of the country. On the economic side, as Taiwan suffers a setback when the world's economy endures a downturn, many companies have to either close down or move out of Taiwan in search of cheaper labor and materials. At the same time, when Taiwan joined the World Trade Organization (WTO) several years ago and opened its market to other countries, there was no longer any protection for local businesses. Moreover, several large development projects have recently been completed, and this has affected the growth of some engineering sectors.

In the field of education, since the 1990s the Ministry of Education (MOE) has initiated a number of new policies with the intention of solving the problem of access to higher education. The initiatives included: establishing more colleges and universities to increase the numbers enrolming in higher education establishments, raising some colleges/institutes of technology to university status, allowing programs to expand in student numbers, etc. However, while the access problem seemed to have been alleviated, there is now the challenge of recruiting able faculty members and students to fill the positions. Along with the possibility that more foreign institutions will set up shop here as a result of Taiwan entering WTO,

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the education sector still has much to worry about over the quality and competitiveness of the institutions and their programs.

The concept of accreditation of engineering programs emerged from this environment as a driving force to assure the standard of engineering bachelor's degree level programs in Taiwan. Accreditation of engineering programs has been a common practice in many western countries to assure a threshold level of quality in education. Despite being voluntary, most programs seek accreditation. Whether a program is accredited determines its ability to survive. However, accreditation is a fairly new concept to Taiwan, although there is an existing program evaluation system that has been in place for thirty years. Over the last two years, accreditation of engineering education in Taiwan has not only been established, but it has also flourished. This paper describes the development of the accreditation system in Taiwan in the light of a global trend.

EDUCATIONAL SYSTEM IN TAIWAN

Figure 1 shows the educational paths and the forms of admission in Taiwan. The compulsory education comprises six years of elementary school

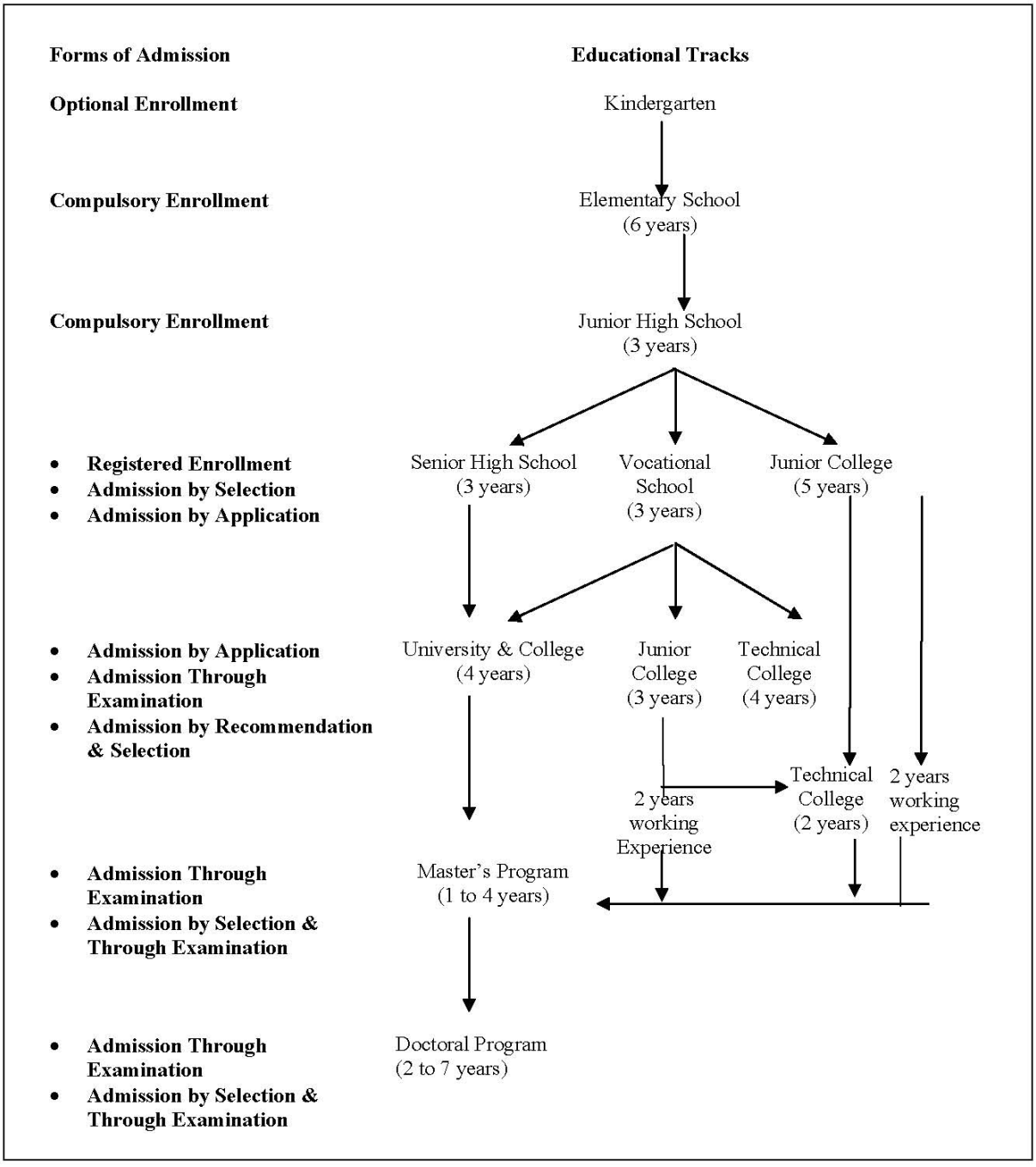

Fig. 1. Educational paths and forms of admission in Taiwan.

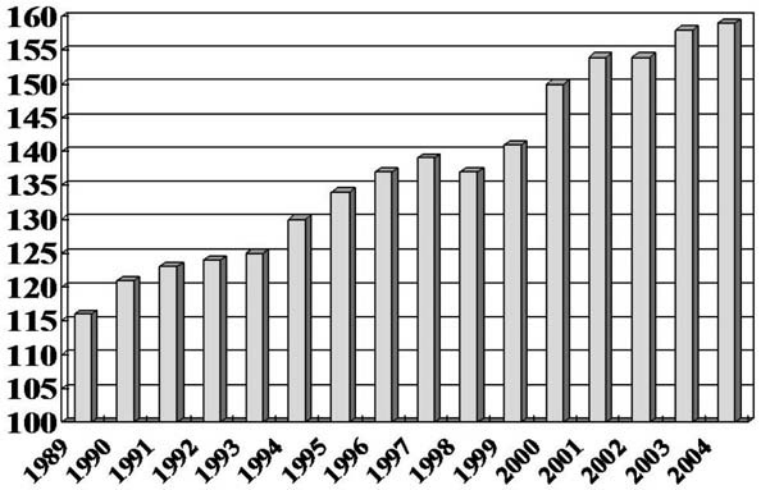

Fig. 2. Growth of higher education institutions in Taiwan, 1991–2004.

and three years of junior higher school. Afterwards, students have to decide whether to enter college-bound senior high school or the vocational system for further education. This is determined partly by standardized entrance examination and partly by choice. College education is typically includes four year of education, and admission is either by application, examination, or recommendation and selection. Master's degree education is normally a two-year course, followed by an average of four to five years for doctoral education. This educational system is fairly robust, but the Ministry of Education (MOE) has begun to initiate a number of measures in recent years to tackle the system's more pressing problems, namely large class sizes and strict entrance requirements for higher education, etc.

The lack of access to higher education has been a serious problem in Taiwan for a very long time, and it has led to many families sending their children to other countries for education: mostly to the USA, Canada and the UK. In order to alleviate the access problem, the Ministry of Education has begun to loosen its tight control over the establishment of new colleges and universities. In particular, the Ministry of Education has continued to grant the upgrade of technical colleges to university level. As a result, opportunities for higher education have suddenly opened. Figure 2 shows that higher education institutions have increased by nearly one third in the space of fifteen years.

There were 159 higher education institutions in Taiwan during the Academic Year 2004–2005. Of the 153 institutions for which data were collected, 97 offered four-year engineering programs. Table 1

Table 1. Number of higher education institutions offering four-year engineering programs (Source: Ministry of Education, 2004)

Types of institution	Public	Private	Total
Comprehensive Universities	19	17	36
Universities of Technology	8	13	21
Institutes of Technology	3	33	36
Other	4	0	4
Total	*34*	*63*	*97*

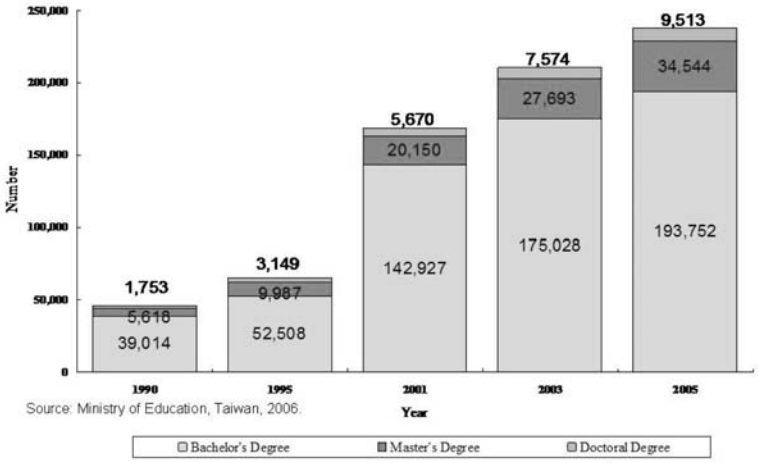

Fig. 3. Student enrollment in engineering programs by degree in higher education, 1990–2005.

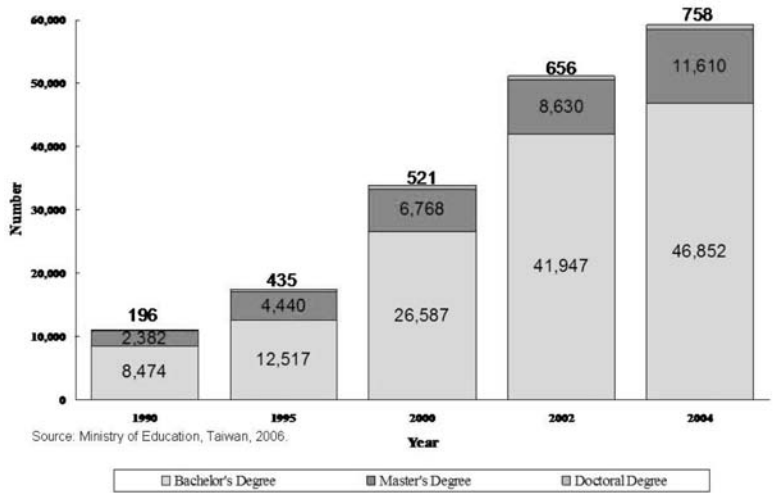

Fig. 4. Number of graduates in engineering programs by degree in higher education, 1990–2005.

shows that approximately two thirds of these 97 institutions are private (65%), and the remaining one third is public (35%).

Table 1 also shows that over two thirds of the institutions are either comprehensive universities (n = 36) or institutes of technology (n = 36), nearly a quarter are universities of technology (n = 21), and the remaining four percent are other types of institutions (n = 4), for instance, military institutions. Of the nearly 100 higher education institutions included in this analysis there are approximately 450 four-year engineering programs, nearly one quarter of these which are in electronic or electrical engineering (28%).

With the expansion of colleges and universities, the college student population has gone up several times. This dramatic increase is also reflected in the field of engineering; this will affect the supply and demand of the engineering labor force. Over the last decade, the numbers of those enrolling on bachelor's degree courses and graduates in engineering programs has increased nearly four times. Similar levels of growth have also occurred at the master's and doctoral degree levels. Figure 3 shows the significant increase from 39 014 in 1990 to 193 752 in 2005 in the enrolment of bachelor's degree engineering programs in universities. Surpassing this level of growth, the number of master's degree level students went up from 5618 to 35 544 during the same period.

Engineering programs show amongst the highest growth of all professional courses. Government researchers predicted that the supply of labor in the science and technology sector will exceed demand by more than 15 000 in the next few years. The growth rate in the supply of engineers is among the highest of all professional sectors. In particular, the growth rate in bio-science engineering is the most extraordinary. This growth is reflected in the business sector, as well as in the supply of instructional staff in higher education institutions. Civil engineering is likely to have a surplus of labor, whereas the supply of manpower in information engineering, engineering design, industrial engineering, materials engineering will fall short.

Along with the expansion of student enrolment in engineering programs in higher education, the number of graduates has grown commensurately. Figure 4 shows that the number of graduates in engineering programs at university level rose from 8474 in 1990 to 46 852, and the master's level of graduates from 2382 to 11 610 from 1990 to 2005.

QUALITY ASSURANCE SYSTEMS IN TAIWAN

Colleges and universities in Taiwan enjoy a substantial amount of financial support from the government and, since 1975, the Ministry of Education (MOE) has imposed program evaluation on Taiwan's colleges and universities to ensure that government money is well spent and results in quality education. The aim is simply to make higher education institutions accountable to the public. Since then, the government has been operating an evaluation system to evaluate all kinds of postsecondary education institutions. In recent years, however, and perhaps due to the practice in developed countries, the Ministry of Education is gradually transferring the running of the evaluation system from the government sector to the non-government sector. That is, evaluation of higher education institutions is now handled by independent, non-government, not-for-profit organizations. And the "government review" is being replaced by a "peer review" mode.

Accreditation has recently been introduced to higher education in Taiwan, and now serves to assure the quality of education in professional fields, such as medical education and engineering education. Accreditation of engineering education was spearheaded in year 2004–2005, administered

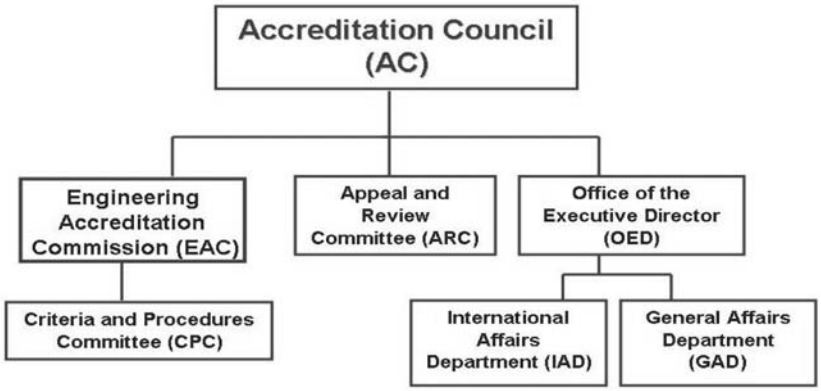

Fig. 5. Structure of IEET Accreditation Council, the body responsible for accreditation.

by a newly established organization, the Institute of Engineering Education Taiwan (IEET).

Institute of Engineering Education Taiwan (IEET)

The Institute of Engineering Education Taiwan (IEET) was founded on June 21, 2003. It is a non-profit-making, non-governmental organization committed to the accreditation of engineering and technology education programs in Taiwan. The mission of IEET includes:

- setting accreditation criteria;
- training qualified evaluators;
- supporting programs in engineering and technology education;
- consulting on issues pertaining to human resources in engineering and technology, and
- other related activities.

The Accreditation Council (AC) of the IEET oversees the entire operation of accreditation matters (Fig. 5), and is composed of 22 senior academic and industry representatives. The major functions of the AC are as follows:

1. promoting supervising accreditation of engineering programs;
2. approving the accreditation criteria and policies;
3. approving the appealing policy, and
4. approving accreditation fee schedule and related financial matters.

AC has three subunits that manage the different aspect of the entire accreditation operation: the Engineering Accreditation Commission (EAC), the Appeal and Review Committee (ARC), and the Office of the Executive Director (OED).

The EAC is responsible for the implementation of accreditation, including organizing related criteria and procedures, selecting and training of program evaluators, managing consistency issues, and delivering accreditation actions. CPC is a subunit of the EAC, with the mission to draft accreditation criteria, policies, and procedures. ARC handles all appeal cases, should a particular program receive a "Not to accredit" action, on the grounds that IEET has an error in the facts and/or an error in procedure. OED, on the other hand, is the headquarters for day-to-day business affairs of the accreditation operation. Under the OED, there are two divisions: the International Affairs Department (IAD), and the General Affairs Department (GPD).

Accreditation Criteria 2004 (AC 2004)

In order to accredit engineering programs, IEET began developing a set of accreditation criteria, policies and procedures immediately after it was founded. The accreditation system, however, did not emerge from a vacuum. At an early stage, IEET sent observers to Washington Accord signatories to join their on-site accreditation of engineering programs and to learn about their accreditation systems and procedures. The first-hand knowledge and experience brought back by the IEET representatives were considered in the implementation of the IEET accreditation system. In addition, IEET invited representatives from the Washington Accord signatories to give lectures at seminars and conferences to help train local participants. These exchanges have been extremely beneficial to the development of IEET's own accreditation system. Table 2 gives a chronological listing of the exchanges between IEET and ABET since 2003.

When considering the cultural differences between Taiwan and many of the signatories to the Washington Accord, two important principles were pivotal in the development of the IEET accreditation system. (1) The system should reflect our own culture and practice; and (2) It must be substantively equivalent to those of the international communities. This was certainly a time- and energy-consuming task. Creating and implementing a set of comprehensive accreditation criteria that are feasible and relevant to all institutions presented a major challenge. Since January 2004, the CPC members have worked intensively on drafting the Accreditation Criteria (AC 2004) for the engineering programs in Taiwan. A total of seven meetings were held by the CPC to draft the AC 2004, supplementary documents, and discip-

Table 2. Exchanges between IEET and ABET since 2003

Time	Activity
Oct. 2003	Held IEET Workshop on Outcomes-based Assessment Method on Engineering Education. Lecturer: Dr. Gloria Rogers, Vice President, Rose-Hulman Institute of Technology.
Nov. 2003	Four members of IEET attended the ABET Program Evaluator Workshop hosted by ASCE in Nashville, Tennessee.
Nov. 2003	Held IEET Seminar on International Engineering Education. Lecturer: Dr. George D. Peterson, Executive Director of ABET.
Dec. 2003	A delegation of 35 attended the *ABET International Faculty Workshop- Continuous Program Improvement* in Singapore.
Apr. 2004	ABET and IEET signed MOU.
July 2004	A team of seven observers attended the ABET EAC accreditation meeting and met with Dr. George Peterson and others for a special meeting.
Apr. 2005	IEET met with Dr. George Peterson in Baltimore, Maryland.
June 2005	Four faculty members participated at ABET's *Faculty Development Workshop for Program Improvement*.
July 2005	Two representatives observed ABET's EAC 2005 Summer Commission Meeting.
Oct. 2005	Six representatives participated ABET's 2005 Annual Meeting.
July 2006	Two representatives observed ABET's EAC 2006 Summer Commission Meeting.
Oct. 2006	IEET sends representatives to participate ABET's 2006 Annual Meeting.
Nov. 2006	Dr. George Peterson of ABET visits Taiwan.
Nov. 2006	IEET representatives observe accreditation visits to ABET schools.

line-based criteria, each meeting involved more than 15 members. The draft for AC 2004 was revised by the EAC three times and finally approved by the top policy-making unit of the AC on April 15, 2004. Approximately, more than 300 man-hours were devoted to drafting the criteria.

The nature of the IEET accreditation criteria is outcomes-based, as opposed to the inputs-based measures that have been familiar to many in Taiwan. Input-based measures are commonly criticized as bean-counting, and unable to assess what students are able to do upon graduation. Outcomes-based criteria, on the other hand, have the potential to investigate and validate whether a program has done what it set out to do in its educational objectives. And, to be substantially equivalent with the international communities, AC 2004 contains many of the elements that are common to those of the Washington Accord signatories, but remain relevant to the educational programs and institutions in Taiwan.

AC 2004 is composed of eight criteria, which are generally equivalent to those adopted by the international organizations:

- *Criterion 1: Educational objectives* This criterion assesses the educational objectives of an engineering or technological program, and the effectiveness of implementing such objectives.
- *Criterion 2: Students* This criterion assesses the quality and capabilities of the students and graduates.
- *Criterion 3: Program outcomes and assessment* This criterion assesses the program's outcomes and procedures for self-evaluation, development and improvement.
- *Criterion 4: Professional components* This criterion assesses the program's curriculum with respect to its components and planning.
- *Criterion 5: Faculty* This criterion assesses the faculty of an engineering or technological program in regards to several key items.
- *Criterion 6: Facilities* This criterion assesses the facilities, classrooms, software and hardware equipment in regards to several key items.
- *Criterion 7: Institutional support and financial resources* This criterion assesses the institutional support and financial resources of the program.
- *Criterion 8: Program criteria* This criterion assesses the program criteria within each discipline.

AC2004 focuses on three core elements: educational objectives, outcomes-based activities, and continuous improvement. Any program under review has to have transparent educational objectives that lay out a general statement about what the graduates will be able to do upon graduation. In the meantime, they need to set up clear outcomes-based core abilities for graduates. Finally, they need to use assessment tools properly to collect data on their students' learning on a regular basis and use the data to improve their teaching methods, a process that is commonly known as "closing the loop." This means that each program should establish a feedback loop for the courses and the environment offered, to collect input periodically from the students, alumni, and/or industry leaders, and then to adjust the structure of their courses, the contents of each course, and other related issues, according to the data that has been collected. The mechanism of continuous improvement will enhance the quality of education of each program in the long run.

Accreditation team

Apart from the accreditation criteria and policies, IEET has invested significant resources in training program evaluators. Unlike many signatories to the Washington Accord, where the training of program evaluators is in the hands of professional societies, IEET handles the recruiting and training of the program evaluators centrally.

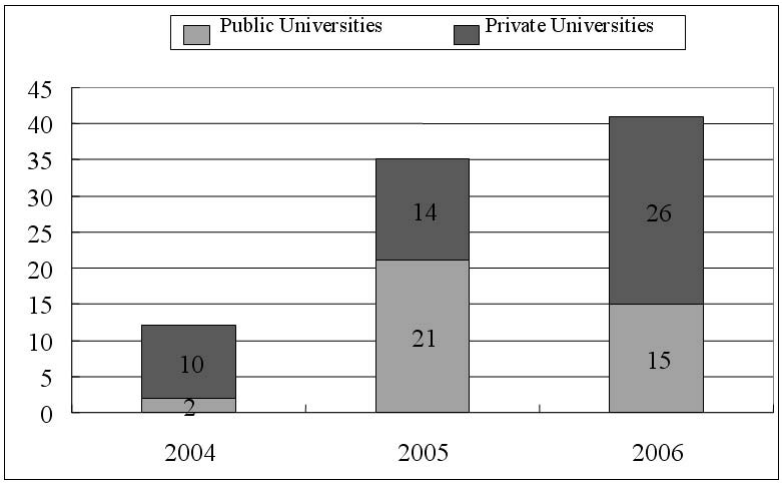

Fig. 6. Growth of programs participated in accreditation on engineering education in Taiwan, 2004–2006.

This practice is actually viewed positively by many, because it assures consistency in training and the expectations of the program evaluators.

In general, a program under review will be visited by a team of two to three program evaluators that include at least one senior academic and one industry representative. The combination of academics and industry representatives is to strive for a balanced review.

Accreditation actions

Similar to the ABET system, the IEET accreditation system has six accreditation actions:

1. Accredited
2. Conditionally accredited (interim visit not required)
3. Conditionally accredited (interim visit required)
4. Provisional accredited
5. Accreditation continues, and
6. Not to accredit.

As mentioned above, IEET has been invited to observe the ABET EAC Summer Commission Meeting since 2004. This has provided IEET with a tremendous opportunity to learn how best to deliver accreditation actions. The EAC of the IEET is a body with a mission to deliver annual accreditation actions, and the voting members include the EAC commissioners and the team chairs. Once the accreditation visits have finished and all the reports are done, the Commission usually meets in late May or early June to review the accreditation reports and deliver accreditation actions. Once the accreditation actions are delivered, IEET usually put out a press release on its website and to the press to announce the year's accreditation actions.

Current status of accreditation of engineering education in Taiwan

In its inaugural accreditation cycle, IEET accredited 12 programs at four institutions. The following year, year 2005–2006, the number of programs accredited rose almost three-fold, from 12 to 35. Although the total number of 47 accredited programs is still relatively small, it represents a significant growth. This year, more than 40 programs are under review, which means almost a quarter of the four-year engineering program in Taiwan have participated in accreditation. This statistic shows the growing interest and confidence in the accreditation system on engineering education.

The programs that have participated in accreditation represent a cross-section of postsecondary education institutions in Taiwan (Fig. 6). Of the 47 programs accredited by 2005, 23 are in public institutions, and 24 are in private ones. Despite its voluntary nature, flagship universities in Taiwan, namely the National Taiwan University, the National Cheng Kuang University, and the National Tsing Hua University, all have programs participating in accreditation. This is unlike many flagship universities in other countries that remain reluctant. Their participation also gives an encouraging sign to other institutions. As a result, accreditation will soon be recognized by all institutions in Taiwan.

POLICY IMPLICATIONS

As mentioned above, for more than thirty years the Ministry of Education has implemented an evaluation system to assure the accountability of higher education institutions. Due to the government mandate and its implication for government financial support, colleges and universities could not but accept the review. Certainly, this evaluation system has resulted in the closure of some inferior institutions and their programs. Others have improved accordingly. As a result, the role of government in keeping up the quality of higher

education is set to continue. Having said that, the Ministry of Education in Taiwan is reconsidering the value of a government-lead evaluation system for financial reasons, as well as looking at reasons to promote independent organizations to do the job. The Ministry of Education is actually supporting non-profit-making organizations in their bids to implement evaluation systems. This transformation is to allow more autonomy and to encourage self-evaluation for higher education institutions. The question remains, however, as to how much authority these non-profit-making organizations will have when they are working with higher education institutions, which have been used to dealing with government mandate.

There are several non-profit-making organizations in Taiwan now with a mission to conduct the evaluation of higher education institutions. IEET is one of them, and since it was founded, three years ago, it has enjoyed substantial government support. However, it is moving toward financial independence, partly due to government withdrawal and partly because of the maturity of the accreditation system. Still, one of the difficulties IEET faces is to persuade higher education institutions that it is a creditable organization. With the Ministry of Education's endorsement, IEET thus gained confidence among the higher education institutions. This is to show that government support is still crucial to the growth of non-profit-making organizations.

In the years ahead, the government will not withdraw altogether from assuring the quality of higher education institutions in Taiwan. However, it will certainly reduce its presence and give way for independent, non-profit-making, professional organizations to do this job. What would happen is that the Ministry of Education would no longer take part in the actual evaluation of higher education institutions, but oversees the quality of the accreditation agencies. That is, quality assuring will be left to the accreditation agencies, and the government will instead be responsible for reviewing the quality of accreditation agencies.

What does this mean for higher education institutions and their programs in Taiwan, however? The change in government policy is likely to encourage higher education institutions to value self-evaluation and submit themselves to voluntary accreditation. Ministry of Education used to invest financial resources in conducting the evaluation system. Institutions, on the other hand, had no significant financial responsibility in this process. In the future, however, colleges and universities will be required to pay for the evaluation themselves. This transformation will induce higher education institutions to engage in more positive and active self-improvement process in a consistent manner. As a result, real improvements will result. Consumers of higher education, namely parents and students will then be able to use accreditation as indicators to select quality institutions and programs.

CONCLUDING REMARKS

The purpose of this paper is to introduce an emerging quality assurance system, accreditation in engineering education, in Taiwan. Although quality control is by no means a new concept, accreditation is a new type of quality assurance system. It has emerged mainly out of an environment where the industry has a high demand for a high-quality labor workforce and the quality control system for higher education is in need of reform. For a very long time, over thirty years to be specific, a government-lead evaluation system has been imposed on higher education institutions. To a certain extent, this practice has indeed achieved its goal in keeping up the quality of colleges and universities. However, higher education in Taiwan is going through a tremendous change, partly due to government policy. Our observations are that the government is, on the one hand, releasing its tight control over access to higher education by approving the establishment of new institutions and elevating the status of some junior colleges to university level. Although the access problem has been alleviated, quality control becomes an even more crucial exercise. On the other hand, the government is planning to reduce its dominance in leading the quality control system. To that end, it has been supporting a number of new, independent, non-profit-making organizations to do the job.

The accreditation system was formally introduced to engineering education through the establishment of the Institute of Engineering Education Taiwan (IEET). In fact, IEET is perhaps the first organization to practice "accreditation" in Taiwan. Since its establishment, IEET has had the goal of becoming a Washington Accord signatory, so that its accreditation system could be recognized by other countries. The reason for this has to do with the real aim of promoting the internationalization of engineering education in Taiwan. Over the past three years, IEET has worked very closely with ABET, as well as other Washington Accord members, to create a substantially equivalent accreditation system. This paper described the elements of the IEET accreditation system. Although the IEET system has pretty much similar characteristics to that of the Washington Accord signatories, IEET continues to seek advices from its mentors to fine-tune and strengthen its accreditation system. Despite its youth, IEET is determined to shape its accreditation system to be a healthy, effective, and mature system as quickly as possible.

In the meantime, IEET will devote resources to developing a master's degree accreditation system. A very high percentage of college graduates enter graduate schools for master's degree, and this has created the need for accreditation. IEET has received a lot of requests for master's degree accreditation, and it will start planning this year. As we understand it, Ireland, Japan, and Germany

have all started accreditation of master's degrees, and IEET will build on their experience in creating a system that is of international standard and that reflects the local culture and history.

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Che-Ho Wei received his Ph.D. degree in Electrical Engineering from the University of Washington, Seattle, in 1976. From 1979 to 1982 he was the engineering manager of Wang Industrial Company in Taipei. He was professor and Chairman of the Department of Electronics Engineering of NCTU from 1982 to 1986. Between 1990 and 1992 he was on leave at the Ministry of Education and served as the Director of Advisory Office. He served as Dean of Research of NCTU from 1993 to 1995, and Dean of College of Electrical Engineering and Computer Science from 1995 to 1998, and Vice President of the university from 1998 to 2001. He was Chairman of the National Science Council, Republic of China, from March 2002 to May 2004. He is now a chair professor emeritus of NCTU. He also serves as the president of the Institute of Engineering Education Taiwan.