Study on accreditation of marine engineering programs

B. Butman & J. Harbach
US Merchant Marine Academy, USA

Abstract

The intermediate results of a research study on accreditation of marine engineering programs are presented in this paper. Similar to other higher education curricula, undergraduate marine engineering programs are routinely accredited by national accreditation bodies. Various methods of program approval and accreditation are analyzed in this ongoing project, but the program assessment by a specialized accreditation board or panel is the principal objective of the study. This accreditation of an engineering program is intended to improve its quality on one side, and to bring it on the level with other engineering specialties like mechanical, civil, aeronautical, and others. Obviously, only the programs that offer an engineering degree together with or without a maritime license are the subjects of the study. Yet the project recommendations might contain conditions and requirements for converting a strictly license program into a combined license/degree engineering curriculum.
Keywords: accreditation, marine engineering program, accreditation institution, conditions of accreditation.

1 Introduction

Due to the specifics of marine engineering programs, some of them undergo a triple tier accreditation:

1. as college level programs - by the National Higher Education Body, like a Ministry of Higher Education in many countries, or the Middle States Association of Colleges and Schools, like in the case of the US Merchant Marine Academy in New York.

2. as a marine engineering license programs – by the STCW associated Government Body, like the US Coast Guard in the USA, Technical Panel for Maritime Education in the Philippines, or Russian Ministry of Transport.
3. as an engineering program – by a Government or non-Government Accreditation institution, like American Accreditation Board for Engineering and Technology (ABET), or the UK Engineering Council.

2 Survey of existing methods and institutions

The survey of IAMU member institutions has not produced sufficient data for the project. Internet sources have been used and provided substantial data on maritime educational institutions. Various publications have been also analyzed, including those of the Conferences dealing with maritime education.

2.1 Certification of license component of programs

The component of the marine engineering program which contains the subject courses and other educational activities required for a mariner's license is a subject of a substantial scrutiny by national and international organizations. First of all, it has to comply with the regulations and requirements of the National Maritime Authority, like Ministry of Transport in some European countries, USCG and similar Government bodies in other countries. These authorities approve the programs (and individual courses, when required, mainly for the continuing education), initiate and conduct the license examinations, set the requirements for training institutions.

For instance the Commission on Higher Education of the Republic of Philippines has created a Technical Panel for Maritime Education which in turn formed several inspection teams to evaluate the compliance of maritime schools with the new policies and standards for maritime education programs.

Another type of certification, which has become quite popular, is provided by the Classification Societies. For instance, DNV has developed a standard for certification of Maritime Academies. This standard has been developed in close co-operation with several institutions. According to DNV "*the standard will ensure that all educational aspects are carried out under controlled conditions and in a consistent way, also that the Maritime Academy is operated according to established practices and specific requirements. It can be applied to all Maritime Academies offering education and training up to mandatory certificate level and to the industry in general. The standard supports the requirements and objectives of the ISM code and the revised STCW-95 Convention.*"

The international certification of the license component of marine engineering programs has been initiated by IMO. The International Maritime Organization (IMO) as a specialized Agency of the United Nations prescribes the international standards concerning maritime and environmental safety. The IMO has developed a comprehensive series of conventions to establish a framework of international law covering the subject. Bearing in mind that the most important

element in the safe operation of any ship is the competence and experience of its crew, a key component of this legal framework is the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), which was adopted in 1978 by the IMO. The Convention lays down minimum standards of competence for all ranks of seafarers. In 1995 the STCW Convention was substantially revised and updated to clarify the standards of competence required and provide effective mechanisms for enforcement of its provisions.

The STCW Convention prescribes minimum mandatory requirements for training, vocational qualifications, assessment and certification of seafarers. It sets the minimum levels of proficiency to be achieved by candidates, for the proper performance of functions on board ship, in order to obtain certificates of competency. These requirements apply to all officers and ratings. The international maritime training and certification requirements of the STCW Convention were introduced into legislations of all maritime countries, setting the minimum level of training of seafarers.

Realizing that the demand for competent seafarers will grow in the years to come, structured education and training are vital elements to meet this demand and expectations to the shipping industry. This has also been acknowledged in the revised STCW 95 Convention, which incorporates requirements to quality assurance principles in all mandatory maritime education and training and in the operation of related facilities. The need for a uniform standard within the area is essential. The standard has been developed to meet this need, and become a foundation of certification of the license component of a marine engineering program. The current list of STCW certified maritime academies includes 53 institutions, including 36 from the Philippines and 8 from Norway.

2.2 Accreditation of degree oriented component of programs

The principal method of accreditation, or rather certification, common for most maritime academies and schools is the mandatory approval of a program by the Governmental or non-government accreditation agency. In most of the countries a Ministry or a Department of Higher Education evaluates programs for compliance with the set requirements and allows their implementation.

In the U.S. a non-government body assesses the engineering programs. Actually, there are several such bodies formed base on the territorial principle. The U.S. Merchant Marine Academy, for instance, is accredited by the Middle States Association of Colleges and Schools. This accreditation is founded on the program outcome assessment, and in this regard it is similar to the process carried out by the engineering accreditation boards and/or councils in some countries.

Engineering programs in the U.K. are accredited by the Engineering Council (ECUK) through 36 engineering Institutions (Licensed Members), who are licensed to put suitably qualified candidates on the ECUK's list of accredited engineering programs. The Institute of Marine Engineering, Science and Technology (IMarEST) is one of the most active members. IMarEST is

accrediting marine engineering academic programs in the United Kingdom, as well as in other countries.

Accreditation Board for Engineering and Technology (ABET) is the American counterpart of ECUK. ABET is the organization that accredits engineering, engineering technology, applied science and computer science programs in the United States. ABET is not an agency of the U.S. government, but a private organization made of members from over 20 professional societies. Society of Naval Architects and Marine Engineers (SNAME) is the one that is responsible for accreditation of marine engineering programs. ABET publishes a set of criteria developed by representatives from the member societies that programs must satisfy. Accreditation by ABET involves periodic (not less than every six years) audits that include preparation of documentation by the institution and an on-site visit by a team of volunteers from the member societies. There are over 30 marine engineering programs which are ABET accredited in the U.S.

3 Content and advantages of engineering accreditation

Accreditation in engineering education is a mechanism to certify a degree the programs are meeting a certain set of standards. Globalization has increased the tendency of engineering practice to be international in scope. Accreditation of engineering education programs had evolved as the primary basis upon which mutual recognition across national borders is based – both for educational equivalency, and increasingly for practice mobility.

Accreditation is also increasingly seen as an appropriate means of enhancing the quality of engineering education in countries where major changes in the education pattern are occurring, and in developing countries where improvement in the quality of engineering graduates is seen as a major way of building an indigenous technological base upon which economic growth in the world marketplace can be achieved. A quick review of developments in engineering accreditation in several countries around the world can illustrate various ways in which it is having major impacts upon engineering education.

a. In Germany, in response to declining interest in engineering study and to pressures to harmonize its programs with those of other developed countries, universities are developing new engineering education systems in the bachelors plus masters pattern. To assist in the development of these new programs, and to evaluate and certify their quality, a new Accreditation Agency for Programs in Engineering and Computer Science (ASII) has been established.
b. The economic downturn in Japan in recent years has made job security a thing of the past, and globalization has made it imperative that Japanese engineering graduates are prepared for more self directed career development. A new Japan Accreditation Board for Engineering Education has been established to provide quality assurance as new engineering programs are developed and implemented.

c. The Accreditation Board for Engineering and Technology (ABET) has been the major quality assurance mechanism for engineering education in the US since the 1930's. It also has served as a model for engineering accreditation developments in other countries, and it has developed major international thrusts such as substantial equivalency reviews of engineering programs in foreign countries where it has been invited. In the past several years, ABET has made a major change in its evaluation criteria – moving from technique specifications to outcomes assessment. Its 'Criteria 2000' is based upon institutional self study and goal setting against which it will be evaluated, continuous improvement requirements for accredited programs, and detailed assessment of the outcomes of the engineering programs as the fundamental criterion for accreditation.
d. As engineering programs have developed in Latin American countries, several countries have moved toward the establishment of accreditation programs. Both ABET and the Canadian Engineering Accreditation Board (CEAB) have conducted workshops and training efforts in Latin America to assist in the development of engineering accreditation systems there.

4 Comparison and analysis of accreditation process

Accreditation is a process in which degree programs are reviewed by independent and knowledgeable evaluators on a regular multi-year cycle. As an example, the accreditation by ABET is discussed below. The criteria required for programs to be accredited are defined by the Engineering Accreditation Commission – EAC – which is an elected body of volunteers representing each of the engineering professional societies. ABET evaluators are appropriately trained volunteers who are typically professors and practicing engineers. They review the self-study reports submitted by the program under review. Then the evaluators come to the university or college whose engineering programs are being reviewed. Following this site visit, the evaluators report their recommendations to the Engineering Accreditation Commission. At their annual meeting, EAC reviews the recommendations from all the evaluators for all the programs being reviewed that year and makes a decision on each program regarding its accreditation. Accreditation is for a designated period after which the program must be reviewed for re-accreditation. The maximum term of accreditation is six years. If there are severe shortcomings – and that is rare – evaluators will recommend that the program not be reaccredited. For programs to be reaccredited, terms of less than six years can be recommended to synchronize the next evaluation of several programs at that institution. If evaluators determine there are shortcomings that are not severe, they may recommend an accreditation term shorter than six years so that the institution's progress at remedying those shortcomings can be evaluated sooner.

To be accredited programs must have defined *Program Educational Objectives* developed with input from their key constituents (typically current

students, alumni, and employers); they must regularly evaluate their progress at achieving those objectives; and must continuously improve their educational program based on that evaluation.

5 International engineering accreditation

5.1 General comments

Engineering education has become an international enterprise, following the major internationalization trend in engineering practice itself over recent decades. Graduates of an engineering program in any given country practice across national borders. This situation has especially deep impact on the maritime industry. This international mobility of marine engineering graduates has enhanced interest in the accreditation of the institutions and programs, which educate them. Employers, maritime schools, and licensing boards all have a keen interest in the quality of education received by marine engineering graduates who are looking for an employment in another country.

In the engineering professions where, like in marine engineering, professional licensure is required for engineering practice, the credentials of engineering graduates who want to practice engineering in a country other than their home country become extremely important. The engineering education which such engineers have obtained is subject to scrutiny by foreign licensure boards, and any assurance that the school or education system from which the foreign engineer has graduated has been subjected to accreditation makes acceptance of the foreign education credential much more likely.

Aside from improving the program quality, engineering colleges accredit their programs for some other reasons, like making the program more attractive for the candidates, as well as for the employers. Accreditation might be a useful tool for a general assessment of the program and its outcome.

5.2 International agreements on engineering accreditation

International agreements on engineering education and practice have been developed in recent years, based upon engineering accreditation. One such agreement, establishing full reciprocity for engineering graduates between ABET in the US and the CEAB in Canada, has been in place for several decades. A much broader mutual recognition agreement, the Washington Accord, was developed several years ago among several developed countries. While there are significant differences in the engineering accreditation systems in these countries, it was agreed – after extensive reciprocal visits – that the resulting engineering graduates were essentially equivalent. Thus graduates from each of the Washington Accord countries are accepted in all of the other countries as equivalent, for purposes such as graduate study and licensure applications.

The Accord applies only to accreditations conducted by the signatories within their respective national or territorial boundaries: Australia, Canada, Hong Kong, Ireland, Japan, New Zealand, South Africa, United Kingdom and USA. The admission of new signatories to the Accord requires the unanimous approval of

the existing signatories. Admission is preceded by a period of provisional status during which the applicants accreditation criteria and procedures are examined. Applicants must be nominated by two of the existing signatories and are accepted by a positive vote of at least two-thirds of the existing signatories. Germany, Malaysia, and Singapore currently have provisional status.

Educational equivalency agreements can be the basis for cross-border practice agreements, and the group of countries involved in the Washington Accord have set in motion a parallel effort – the Engineers Mobility Forum – which is developing an international register of engineers approach. In Europe, the European Federation of National Engineering Associations (FEANI) has established an international practice system, based upon a seven year formation process for engineers, which leads to EurIng status. In North America, the three countries which have entered into the North American Free Trade Agreement (NAFTA) have attempted to develop a mechanism for the mobility of practicing engineers across their borders. Canada and Mexico have agreed on such a system of mobility, but efforts to include the United States have been stymied by licensure issues controlled at the state level by 55 separate jurisdictions. In the Asia-Pacific area, several countries have developed an agreement on engineering practice mobility, the APEC Engineer Register.

Accreditation is a valuable mechanism for effecting and assuring ongoing quality in engineering programs within a given country. When the quality of engineering programs in two or more countries has led to similar results in graduates, accreditation programs can provide the basis for mutual recognition of graduates across national borders.

5.3 ABET international activities

While ABET does not directly accredit programs in countries other than the United States, it does recognize the equivalency of some non-US programs in two ways: through mutual recognition agreements such as the Washington Accord and through a program termed Substantial Equivalency.

Programs that are not included in the Washington Accord can request that ABET conduct a review for "substantial equivalency". ABET defines substantial equivalency as comparable in program content and educational experience, but such programs may not be absolutely identical in format or method of delivery. It implies reasonable confidence that the graduates possess the competencies needed to begin professional practice at the entry level. While these evaluations follow similar policies and procedures used for accreditation, no accreditation action is taken, nor is there any inference that a program is undergoing accreditation or will be accredited as a result of such review. The activity is an evaluation (program review) in which ABET, through selected representatives, acts on a consultancy basis, and leads to an assessment of "substantial equivalency" of the program under review with accredited programs in the United States.

Substantial equivalency evaluations are conducted with the current ABET criteria used to accredit equivalent US programs. Current ABET criteria are outcomes-based and require evaluation of program objectives and outcomes.

ABET provides a Consultation Report with suggestions for improvement shortly after the visit. It is not uncommon for the institution to be asked to prepare a focused report regarding any recommendations made in the report. Based on positive results from the initial consultancy review, the institution will be provided with the full evaluation package and asked to prepare the complete self-study reports. After an on-site visit a "preliminary statement" is prepared by ABET and submitted to the institution for comment. The institution has 30 days to report back to ABET on errors of fact or other reported observations pertaining to the items addressed in the statement. All the available information will be reviewed by INTAC and the final recommendation approved at its annual meeting. "Substantial Equivalency" will be granted to programs that meet or exceed the minimum requirements. Term of the equivalency status is usually two to six years. A return visit and review is necessary before the term expires to extend the equivalency status.

5.4 IMarEST accreditation procedures and international activities

The IMarEST as a licensed member of the Engineering Council (UK) and the UK Science Council is required to establish education and professional development standards and procedures in compliance with the national standards set by EC(UK). Accreditation is undertaken by the Institute's Professional Affairs and Education Committee (PAEC) who initially scrutinize the applications from academic establishments against IMarEST's standards and requirements. If a prima facie case is perceived a Visiting Panel is appointed to visit the establishment. During the visit, the Panel's focus is on aspects of the program where they need clarification. The institution's facilities including workshops, laboratories, and library are visited, and examination papers and scripts, and also project reports are examined and assessed against the Institute's standards.

The visit report is first submitted to the academic establishment to check for accuracy and then considered by the PAEC in committee who make the final decision on the outcome and any recommendations or conditions to be made. The Institute then formally informs the EC(UK) and the academic establishment of the outcome.

The EC(UK) is a signatory to the Washington Accord, Sydney Accord and Dublin Accord, the Engineers Mobility Forum (EMF) and the Engineer Technologist Forum (ETMF) international agreements, and programs that the IMarEST accredits are therefore accepted internationally as meeting the academic and/or professional development standards for the three categories of professional engineer.

6 Analysis of impact of accreditation requirements on academic process and core curriculum

In order to have a marine engineering program accredited by either a national accreditation board, or by any International Institution, a very substantial changes should be made. Compliance with all requirements might require adding

new courses and projects, repackaging existing courses, and dropping certain subjects and courses. Table 1 presents the excerpts of the requirements of the IMarEST to a marine engineering program.

Table 1: Specific learning outcomes expected from BEng degrees.

Subject Area	Specific Outcomes
Mathematics and Science	Knowledge and understanding of: - scientific principles and methodology necessary to underpin their education in their engineering discipline; - mathematical principles necessary to underpin their education in their engineering discipline; - other engineering disciplines to support study of their own engineering discipline.
Engineering Analysis	Understanding and ability to apply: - engineering principles; - the performance of systems and components through the use of analytical methods and modelling techniques; - quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems; - a systems' approach to engineering problems.
Design	Knowledge, understanding and skills to: - Investigate and define a problem and identify constraints; - Understand customer and user needs; - Identify and manage cost drivers; - Use creativity to establish innovative solutions.
Economic, social, and environmental context	Knowledge and understanding of commercial and economic context: - management techniques to achieve engineering objectives; - requirement for engineering activities for sustainable development; - potential impact of marine engineering on the marine environment; - framework of relevant legal requirements; - high level of professional and ethical conduct in engineering.
Marine Engineering Practice	Knowledge and understanding of: - particular materials, equipment, processes, or products; - operations, maintenance, technology development, etc; - use of technical literature and other information sources; - awareness of nature of intellectual property and contractual issues; - appropriate codes of practice and industry standards; - awareness of quality issues; - design processes and methodologies.

Engineering education as a whole, particularly in developed countries, has in recent years focused on outcomes assessment for quality assurance and evaluation of educational programs. This trend has been driven both by educators and by publics interested in quality education – parents, legislators, funding agencies, etc. ABET has been a leader in moving to outcomes assessment as the primary mechanism for accreditation of engineering programs, in its "Criteria 2000".

The following statement of outcomes from the ABET criteria was developed with substantial input from employers of engineering graduates, and other organizations concerned with quality assurance in engineering education:

"Engineering programs must demonstrate that their graduates have:
a) an ability to apply knowledge of mathematics, science and engineering;
b) an ability to design and conduct experiments, analyze and interpret data;
c) an ability to design a system, component, or process to meet desired needs;
d) an ability to function on multi-disciplinary teams;
e) an ability to identify, formulate, and solve engineering problems;
f) an understanding of professional and ethical responsibility;
g) an ability to communicate effectively;
h) the broad education necessary to understand the impact of engineering solutions in a global and societal context;
i) a recognition of the need for, and an ability to engage in life-long learning;
j) a knowledge of contemporary issues;
k) an ability to use the techniques, skills, and modern engineering tools".

7 Conclusion

This is an ongoing study. The specific recommendations related to preparation of the marine engineering program for engineering accreditation will be developed on the final stage of the project.