

CDIO and Engineering Education Quality Assurance: A Global Perspective

Peter J. Gray, PhD.

United States Naval Academy

The recently published book, *Engineering Education Quality Assurance: A Global Perspective* (Patil and Gray, Springer 2009) includes a number of chapters by people affiliated with CDIO. These include topics such as CDIO standards and syllabus as essential elements in quality assurance, how they have been used to in national quality assurance schemes, and the history of quality assurance as it has developed in countries around the world.

This book provides a picture of Quality Assurance schemes from essentially every continent along with the issues related to their development and implementation. In addition, a generic Engineering Education Quality Assurance Model is described that synthesizes all of the extant approaches and provides a structure for future development.

With the rapid globalization of higher education as well as related changes in social, political, economic, and other conditions over the last 25 years there have been ever increasing expectations for higher education, in general, and Engineering Education, in particular. These expectations are often expressed in terms of the need for Quality Assurance locally, regionally, and globally.

In some cases, there is a long tradition of independence and self-regulation of higher education institutions and programs. In other contexts, there has been considerable governmental regulation and disciplinary direction over time. The authors in this volume represent essentially all continents and 15 different countries. The common issues that they raise and their accounts of past, present, and future challenges provide a *snapshot* of the current state of Quality Assurance in higher education and Engineering Education.

This volume begins with an overview of the history and background of Quality Assurance in higher education and Engineering Education over the last century. The discussion of the historical, philosophical, political, and social background of Quality Assurance sets the stage for the other chapters. Following this broad brush stroke introduction, in the next part of the book, authors describe the general issues and challenges facing Quality Assurance in the twenty-first century from both regional and national perspectives. These authors have extensive experience in the area of Quality Assurance and have observed its growth and develop first hand over many years.

Next is a set of ten chapters that focus on individual countries. These chapters are written by leaders in Quality Assurance who know well the issues and challenges faced by their countries as they strive to meet both internal and external demands for Quality Assurance. It is clear from these chapters that there is much in common regarding the current state of Quality Assurance around the world.

In the last part of the book, a variety of strategies and techniques are described that can help develop and implement effective Quality Assurance approaches. The volume closes with a discussion of a conceptual framework for organizing internal and external Quality Assurance

approaches for improvement and accountability. This chapter and the other chapters in the last part of the book are intended to provide Engineering Educators with a broad view of the tools and techniques available to meet a variety of expectations regarding Quality Assurance.

Contributions by people affiliated with CDIO include: The background of quality assurance in higher education and engineering education; CDIO and quality assurance: Using the standards for continuous program improvement; Quality assurance of engineering education in Sweden; Quality assurance in higher education in Chile: National and engineering dimensions; Toward consensus global standards for quality assurance of engineering programmes; Taxonomies of engineering competencies and quality assurance in engineering education; and Internal and external quality assurance approaches for improvement and accountability: A conceptual framework.

The book is written for higher education and engineering education researchers, educators, administrators and graduate students as well as higher-education policy makers, accreditation and program evaluation experts, educational auditors, and government officials.

Chapters include:

Engineering Education Quality Assurance: A Global Perspective brings together leading academics and professionals from fifteen different countries who share their wealth of experience and insights. Their collective expertise provides a snap-shot of the current state of Quality Assurance in higher education and Engineering Education, an explanation of how we got to where we are, and a road-map for the future.

The Background of Quality Assurance in Higher Education and Engineering Education

Peter J. Gray , Arun Patil , and Gary Codner

This chapter presents a review of the historical, philosophical, political, and social background of Quality Assurance of higher education, in general, and engineering education, in particular. Such a review can help us appreciate how the Quality Assurance movement got to where it is today and the tensions that are inherent in it, as well as provide guidance for its future development. Suggestions for advancing Quality Assurance in Engineering Education are provided at the end of the chapter.

Quality Assurance in European Engineering Education: Present and Future Challenges

John Cowan

This chapter focuses on the Quality Assurance (QA) of higher engineering education in UK and Europe, by considering eight challenges which are predicted by the writer to be of increasing importance in the years ahead. QA in higher education is taken here as a process that sets out to assure society, and responsible bodies within it, about the quality of educational provision for students. The purpose of the chapter is to identify the present and forthcoming challenges and changes in QA in engineering education in UK and Europe, in the light of present circumstances as well as of the historical context.

EUR-ACE: The European Accreditation System of Engineering Education and Its Global Context

Giuliano Augusti

The EUROpean ACcredited Engineer (EUR-ACE) project (2004/06) formulated Framework Standards for the European Accreditation of Higher Education Programs in Engineering. The EUR-ACE accreditation system is now being implemented. The European Network for Accreditation of Engineering Education has been established to run the system and six agencies have been accredited and have started awarding the EUR-ACE label in six countries (France, Germany, Ireland, Portugal, Russia, and UK). Contacts are also in progress with accrediting agencies outside the European Higher Education Area.

Toward Consensus Global Standards for Quality Assurance of Engineering Programmes

Hu Hanrahan

This chapter contributes to the quest for a generic Global Model of Engineering Quality Assurance to guide future developments in engineering education Quality Assurance. Any Quality Assurance system requires two essential components: first, accreditation criteria, including exit-level outcomes, and second, policies and procedures for the programme evaluation process. This chapter describes a set of programme outcomes and level indicators, called Graduate Attributes (GA), developed by the International Engineering Alliance (IEA). The GA are related to a set of generic professional competency (PC) statements also developed by the IEA for the registration level. The GA and PC provide an understanding of the distinctive educational attributes and professional capability of the members of the engineering team: engineers, technologists and technicians. The chapter reviews the successes and limitations of the GA and how they could evolve.

Quality Assurance in the Preparation of Technical Professionals: The ABET Perspective

George D. Peterson

Accreditation provides public recognition that an educational institution or program has met certain standards or criteria regarding students, curriculum, faculty, facilities, and support, ensuring a quality educational experience. Quality Assurance organizations generally adhere to the fundamental principles that accreditation is a nongovernmental process of peer review that educational institutions or programs may voluntarily undergo to determine if they are in compliance with standards set by the organization. There are two types of accreditation in USA – institutional and programmatic. The accreditation process requires a self-study undertaken by the institution, department, or program on a continuous basis, with frequent reviews, normally site visits, taking place every 5 to 10 years. Accreditation and certification are sometimes confused. In general, institutions, departments, and programs are accredited, and individuals are certified.

Quality Assurance in Engineering Education and Modernization of Higher Education in Russia

A. Chuchalin , O. Boev , and A. Kriushova

The paper discusses the Russian Federation system of higher education regarding the implementation of the key aspects of the Bologna process. Some recent legislative initiatives aimed at the modernization of higher education in Russia in accordance with the main Bologna principles are also presented. The issues of Quality Assurance and, in particular, differences between state and professional accreditation are described. Most importantly, the role of the Russian Association for Engineering Education in developing the national system for

professional accreditation in engineering education and its contribution to establishing a pan-European system for Quality Assurance in engineering education being created within the European Higher Education Area (EHEA) are described.

Quality Assurance in Vietnam's Engineering Education

Hao V. Le and Kim D. Nguyen

The chapter first provides an overview of engineering education in Vietnam, and then describes the historical background of Quality Assurance in higher education in Vietnam and the role of government and its policies in regulating Quality Assurances practices at universities and colleges. Then, the current Quality Assurance scheme in higher education in Vietnam including engineering is presented. Strengths and weaknesses in implementing this scheme into engineering education are discussed. Initial efforts in applying international standards in engineering education, especially ABET criteria, at some universities are also considered. At last, recommendations for the future of Quality Assurance in engineering education in Vietnam are provided.

Quality Assurance for the Engineering Paraprofessional in Thailand

Kalayanee Jitgarun , Paiboon Kiattikomol , and Anuvat Tongsakul

This chapter focuses on Quality Assurance in a context of industrial education and engineering paraprofessionals in Thailand. Presently, there are no defined Quality Assurance standards or competencies for these individuals in Thailand. In this chapter, we review the development of quality standards for vocational education in this country. We then review four different perspectives on Quality Assurance and competencies for engineering education. We discuss these in relation to the engineering paraprofessional in Thailand. We conclude with some suggestions for future directions for the development of competencies for engineering paraprofessionals in Thailand and developing countries. We suggest that these competencies must embrace lifelong and flexible learning but also that there must be an emphasis on soft skills related to attitudes and ethics. Distance education will also play an important role in Quality Assurance for the engineering paraprofessional.

Quality Assurance in Higher Education in Chile: National and Engineering Dimensions

Mario F. Letelier , Patricio V. Poblete , Rosario Carrasco , and Ximena Vargas

This chapter describes the evolution of Quality Assurance in the Chilean higher education system . It emphasizes three relevant critical elements including the processes for conferring autonomy to private universities, the pilot project lead by the Ministry of Education, and the official status of the national higher education Quality Assurance system. There is also an analysis of the evolution of the Quality Assurance concept and related assessment mechanisms that during the past two decades have shifted in focus toward continuous improvement. The accreditation process for engineering programs and a brief case-study that highlights the effects of accreditation at the School of Engineering of the country's oldest University are described as well. In addition, this chapter presents a brief overview of Quality Assurance experiences in other Latin American countries and concludes by pointing out further directions for development.

Quality Assurance of Engineering Education in Sweden

Johan Malmqvist and Aija Sadurskis

The chapter describes the past and future for Quality Assurance programs in Sweden. The Swedish National Agency for Higher Education is the government agency responsible for the evaluation of the quality of university education in Sweden. One of the purposes of the most recent national evaluation of Swedish engineering degree programs in 2005 was to compare the programs and find examples of good practice. In the evaluation, the conceive–design–implement–operate (CDIO) self-evaluation model was introduced to the universities as a model for engineering education development and as an instrument for continuous self-improvement. The next generation of Quality Assurance in Sweden, to be applied in the 2011, is described, focusing on new and changed aims of the Quality Assurance program.

Assessment of Engineering Education Quality: An Indian Perspective

R. Natarajan

This chapter explores the differences in perception of Quality in the Manufacturing, Services, and Education sectors in India. The anatomy of an Engineering Institution is then examined. Some characteristics of institutions of excellence are highlighted and the frameworks for Quality Assurance currently used in India are analyzed. This is set within the context of the criteria and weights employed by several assessments of ranking of Academic Quality within India.

Quality Issues Facing Malaysian Higher Learning Institutions: A Case Study of Universiti Teknologi Malaysia

M. Puteh , S.M. Daud , N.H. Mahmood , and N.A. Azli

This chapter analyses the extent to which Malaysian universities have responded to the pressing call for enhancing institutional quality and advocating academic excellence. Malaysian universities have been challenged by both internal and external assessments that suggest that they are not on a par with their international competitors. As a result there have been great demands for an urgent remedy. This chapter explores the progress that has been made in responding to those demands and the limitations that have been encountered. In so doing it provides a case study that focuses on engineering programmes in particular. The chapter is intended to answer the question: can institutional quality improvement deliver the human capital that Malaysia needs in order to remain globally competitive?

Quality Assurance in Engineering Education in the United States

Lance Schachterle , Chrysanthe Demetry , and John A. Orr

In USA there is not a federal system of higher education, but a diverse and independent nationwide set of public and private institutions. Consequently, for the last 100 years, Quality Assurance in US higher education has been performed not by the federal government but by the voluntary regional and disciplinary accrediting agencies such as the Accreditation Board for Engineering and Technology (ABET 2008). Through the involvement of their members these agencies set standards (most recently *Engineering Criteria 2000*) and then use these standards as part of a peer-review process to accredit engineering education programs. *Engineering Criteria (2000)* focuses considerable attention on student learning and, while it has been in effect for less than a decade, early studies point to its success in improving engineering education. The experience of Worcester Polytechnic Institute in three ABET accreditation cycles (1996, 2002, 2008) is used to illustrate the impact of *EC2000*.

Quality Assurance in Engineering Education: An All-round Perspective

Kin Wai Michael Siu

This chapter discusses Quality Assurance in engineering education from an overall perspective. It advocates that engineering curricula should be revised to nurture all-round engineering designers, so that they can meet new social, industrial and educational needs. The chapter reviews the limitations of current engineering education practices, and argues that they are biased either toward the acquisition of engineering and technological knowledge and skills at the expense of critical thinking skills or toward the nurturing of creative thinking, while ignoring the ability to conduct in-depth investigations. This chapter uses Hong Kong as a case study to further identify new social, industrial and educational needs. To meet these needs, the chapter proposes Eight Cs as evaluative criteria for all-around engineering curricula. They are: competent, comprehensive, critical, creative, curious, continuous, collaborative, and compulsory.

Engineering Education Quality Assurance: The Essential Pillar of Higher Education Reform in Lithuania

A.V. Valiulis and D. Valiulis

The purpose of this chapter is to present a review of Lithuanian engineering education and its related evaluation and accreditation systems. Lithuanian engineering education has changed dramatically in recent years: initially in 1991 after Lithuania separated from the Soviet Union, then in 1999 when Lithuania accepted the Bologna process and very recently in 2004 upon Lithuania's entry into the European Union. This chapter examines the strengths and weaknesses of the current educational system and, in particular, the assessment of engineering education in the hope that it will enable the further integration of Lithuanian engineering education into the European Higher Education Area. With the 2010 deadline for implementation of the Bologna Process approaching Lithuanian higher education, it is attempting to provide responses to the following questions: What current challenges will persist well into the next few years? Where is European higher education heading? What opportunities is Lithuania facing in an increasingly globalised World?

Using a Measure of Student Holistic Development for Quality Assurance

Larry A. Braskamp

Engineering is a global profession and engineering education has been charged to prepare engineers accordingly. Students' knowledge and acquisition of technical skills in the field of engineering are necessary but insufficient in the preparation of future engineers. Personal and interpersonal skills and attitudes are also worthy and essential requirements in the preparation of engineers. Professional and other accrediting and Quality Assurance agencies which have the responsibility for the Quality Assurance of engineering programs are asking institutions to be held accountable for meeting these expanded and inclusive requirements. However, dimensions and domains of student and human development are some of the more difficult to be assessed, and are thus not well represented in the arsenal of instruments and strategies that focus on student development, more broadly defined. This chapter describes the work done in constructing an instrument, the Global Perspective Inventory that assesses students' progress in their journey in becoming global citizens.

CDIO and Quality Assurance: Using the Standards for Continuous Program Improvement

Doris R. Brodeur and Edward F. Crawley

The CDIO Initiative is a world-wide collaboration of engineering programs at universities in more than 16 countries in the Americas, Europe, Africa, Asia, and Australia. Collaborators have developed a set of 12 standards, or best practices, that characterize the CDIO approach to engineering education and provide the basis for program evaluation. This standards-based program evaluation extends the evaluative criteria of ABET's EC2000 and other outcomes-based approaches. Evidence of overall program value is collected from multiple sources, using both quantitative and qualitative methods. Evidence and results, forming the basis of decisions about the program and its plans for continuous improvement, are important components of most Quality Assurance schemes.

Using Soft Systems Thinking to Confront the Politics of Innovation in Engineering Education

Henk Eijkman , Obada Kayali , and Stephen Yeomans

Engineering curriculum innovators face a range of formidable barriers which, singly or in combination, have thwarted countless attempts at sustainable curricular quality improvement initiatives regardless, of their educational efficacy. The often ignored elephant in the room of programmatic quality improvement is the politics of change. The essential point of this chapter is this: a whole-of-programme curriculum innovation demands an intervention strategy capable of effectively responding to multiple stakeholder perspectives and therefore to the politics of change. It is argued that Soft Systems Methodology embedded within a Systemic Action Research approach will give engineering educators that capability.

Real-Time Quality Control Methods in PBL-Based Engineering Education

Egon Moesby and Palle Qvist

Traditionally post-semester evaluations are most often used to measure and report higher education quality. The demands for Quality Assurance, quality control and quality development due to the Bologna Declaration and subsequent institutional and programme accreditation and audit demands will expand the use of evaluations. However, traditional post-semester standardised, summative evaluations are not an effective way to monitor quality as the students' progress in their studies through the semester. Instead, there is a need for a system that enables the institution to measure quality and performance of the instruction and learning by the students as they occur, and to respond accordingly. The School of Basic Studies at Aalborg University, Denmark, operates such a system. The chapter describes the setup of a real-time evaluation system that allows students to have a democratic influence on their education.

Enhancing the Quality of the Engineering Student Experience

Chenicheri Sid Nair and Arun Patil Institutions of higher education all over the world are abuzz with concerns over quality, Quality Assurance, continuous quality improvement and rankings of quality. These concerns have been stimulated by increasing internationalisation and globalisation, increasing student enrolments, the expansion of distance and e-learning education, changing funding patterns for higher education, etc. Students' feedback is an integral part of the continuous quality improvement and assurance process. This chapter reports the process of designing and implementing the Monash Experience Questionnaire which was used to gather student views of their experience while studying engineering at Monash. The lessons learned from this process helped the authors to identify best practices regarding the role of student opinion surveys in Quality Assurance schemes.

Taxonomies of Engineering Competencies and Quality Assurance in Engineering Education

L. C. Woollacott

This chapter reviews both literature and theory related to the identification and articulation of graduate attributes and competencies that are relevant to engineering education. Such attributes and competencies form the basis for Quality Assurance in engineering education. This chapter includes but looks beyond the sources that are normally reviewed in creating statements on graduate attributes. The review was part of the work done in developing the taxonomy of engineering competencies. Given its somewhat unique genesis, context, and perspective, this particular taxonomy provides an interesting case study of how literature, theory, and research-based evidence can be combined to form statements of graduate attributes for a specific educational discipline.

Internal and External Quality Assurance Approaches for Improvement and Accountability: A Conceptual Framework

Peter J. Gray and Arun Patil

The keys to advancing Quality Assurance are to, first, strike a balance between Internal/External and Improvement/Accountability emphases; second, recognize the value of various Quality Assurance approaches, for different purposes; and, third, acknowledge the trade-offs and tensions inherent in various approaches. The changes implied by Quality Assurance must start at the local level, i.e., individual courses and programs of study such as Engineering Education. The task of documenting such changes and, thereby, recognizing the impact of Quality Assurance policies and practices (Accreditation and Evaluation or Assessment) makes it necessary to use different metrics at different levels of a higher education institution. This is where the value of the conceptual framework described in this chapter can be seen, since it acknowledges a wide range of Quality Assurance approaches, thus providing a means of engaging all stakeholders in a constructive way about how to define quality, how to document it, and how to make needed improvements.