A MULTI-DIMENSIONAL APPROACH IN DEVELOPING A FRAMEWORK FOR INTERNAL QUALITY ASSURANCE OF SECOND CYCLE ENGINEERING PROGRAMMES

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Abstract

The rapid growth of engineering education requires the proper maintenance of academic quality in educational institutions in order to withstand competition in the global market. External accreditation and internal quality assurance are two very important processes that are carried out in order to maintain the quality of engineering education. Accreditation is a process designed to determine whether or not an educational programme has met or exceeded the published standards of the accreditation agency, whereas the purpose of internal quality assurance is to develop a quality culture within an institution, and to implement a strategy for the continuous enhancement of quality. Although several quality assurance standards and guidelines have been established and implemented worldwide through various international, regional and national agencies; relevant literature searches show that there is no common agreement or criterion that can be used in the quality assurance of engineering education. In this article, the authors elaborate on several important issues regarding the accreditation and quality assurance of engineering education. The authors define internal quality assurance of an engineering programme as: enabled by certain *quality enablers*, a structured process of *quality analysis* (benchmarking, monitoring, evaluating, assessing, guaranteeing and improving the quality) of the *design*, *resources*, *delivery* and *outcomes* of the programme; resulting in *defect avoidance*, *strategic alignment*, *continuous improvement*, and *stakeholder trust*. A brief outline of a multi-dimensional framework for internal quality assurance of engineering programmes is provided in this article.

Keywords: Quality of education, engineering education, qualification frameworks, accreditation, internal quality assurance

Introduction

In the past, quality of engineering education was not considered an independent problem-solving area. The rules of quality assurance were relatively stable, mostly settled by the state authorities. Once an institution was founded and its educational programmes approved, it was assumed it would keep producing education of good quality (Čorejova, Drozdova, & Rostasova, 2007). In the last two decades, this approach to quality has been changing remarkably. Due to the rapid growth of engineering education and the introduction of free trade economy, the proper maintenance of academic quality in educational institutions has become mandatory for education providers in order to withstand the competitiveness of the global market. Liberalisation has been intervening into the education environment, and institutions have to adapt to the changes. They need to learn how to face the competition on the education market, not only at national but also at international levels.

The best organizations, whether public or private, understand quality and know its secret. Seeking the source of quality is an important quest. Education is also recognizing the need to pursue it, and to deliver it to pupils and students. Quality is difficult to define and is an elusive concept. While everyone is in favour of providing quality education, the arguments start when we attempt to define what quality means. It is necessary to have a clear understanding of the various meanings or there is a danger that it becomes a mere catchphrase, a word with high moral tone but little practical value (Sallis, 2005).

Relevant literature searches show that there is no common agreement or criteria that can be used in the quality assurance of engineering education. In this article, the authors elaborate on several important issues regarding the accreditation and quality assurance of engineering education. A brief outline of a multi-dimensional framework for internal quality assurance of engineering programme is been provided in this article.

Perceptions on Quality of Education

There are plenty of factors for the source of quality in education. Amongst these are: outstanding teachers; high moral values; excellent examination results; the support of parents, business and the local community; plentiful resources; the application of the latest technology; strong and purposeful leadership; the care and concern for pupils and students; and, a well-balanced and challenging curriculum (Sallis, 2005).

In the course of years, the views on the quality in education have been developing, and they are stemming from several quality concepts. Numerous scientific papers have already attempted to define quality, and most of the authors agree that it is not possible to arrive at a correct and unambiguous definition (Macukow, 2000). Pounder (1999) argues that quality is a "notoriously ambiguous term" given that it has different meanings to different stakeholders. As a result of the difficulty in defining quality, the measurement of quality has also proved to be contentious. Quality in higher education is a complex and multifaceted concept and a single correct definition of quality is lacking (Harvey & Green, 1993b). Cheng and Tam (1997) are of the view that "education quality is a rather vague and controversial concept".

Mizikaci (2006) proposed a model that suggests a systematic and comprehensive quality approach viewing the organisation as an entire system with its programmes and functions in practice. The social system requires a culture change in organisational culture (the values, norms, attitudes and role expectations); communications (quality of relationships between individual members and among groups, reward structure, symbols of power etc.); and behavioural patterns. Following six areas must be recognised: the environment, product or services, methods, people, organisational structure, and mind set of quality improvement. Harvey (1998) is of the view that, quality is a complex concept that centres on three main principles, namely, control, accountability and improvement.

- *Control* refers to how resources are utilised and maximised for outcomes.
- *Accountability* seeks ways in which stakeholders' needs are met.
- *Improvement* refers to how the necessary inputs, processes and outputs interact to meet goals and objectives.

Berry, Parasuraman, and Zeithaml (1988) stated that quality is conformance to customer specifications; it is the customer's definition of quality, not management's that counts. Middlehurst (1992) identifies four different ways that the term quality has been used in the recent higher education debate, primarily in the United Kingdom. These are quality as a defining characteristic or attribute; quality as a grade of achievement; quality as a particularly high level of performance or achievement which, by virtue of general consensus and reasonable stability over time, comes to be seen as a standard against which to judge others; and quality as fitness for purpose achieved through performance that meets specifications.

Quality in education has been defined variedly as: defect avoidance in the education process (Crosby, 1979); value addition in education (Feigenbaum, 1983); conformance to requirements, not as goodness (Crosby, 1984); a predictability degree of uniformity and dependability at low cost

and suited to the market (Deming, 1986); fitness for purpose, effectiveness in achieving institutional goals, and meeting customers' stated or implied needs (Juran, 2010); fitness for purpose (Tang & Zairi, 1998); the achievement of planned goals (Cheng, 2003); and a perception of how well the balanced needs of all stakeholders have been met or exceeded (Aikens, 2010). Aikens also identifies three main drivers for quality in education: accountability, alignment and assessment.

Angelo and Cross (1993) have described quality as the combination of factors like knowledge of a realistic goal, sufficient faculty-student contact hours, a balance of intellectual standards and academic support, frequent updating of courses, promotion of creative thinking, strong customer focus, importance given to collaborative learning and life-long learning, and a system thinking. Education quality can be viewed as the combination of the quality of input, process, and output of the education system (Eriksen, 1995). LeBlanc and Nguyen (1997) identified curriculum, physical evidence, responsiveness and access to facilities as the factors, which explain service quality of education. According to Hampton (1993), the quality of education largely depends on dimensions like teaching, campus facilities, reputation, physical evidence, administration, curriculum, responsiveness, and recognition. Widrick, Mergen, and Grant (2002) have grouped the basic parameters of quality into three areas: quality of design; quality of conformance; and quality of performance.

Quality education from a TQM perspective is "total quality management in education is multi-faceted – it believes in the foundation of an educational institution on a system approach, implying a management system, a technical system and a social system. It includes within its ambit the quality of inputs in the form of the learning and teaching activity; and the quality of outputs in the form of enlightened students that move out of the system" (Sangeeta, Devinder, & Sabita, 2003). One of the most clearly defined set of dimensions of quality for higher education has been identified by Harvey and Knight (1996). They argue that quality can be broken down into five different but related dimensions: Quality as exceptional (high standards); Quality as consistency (zero defects); Quality as fitness for purpose (fitting customer specifications); Quality as value for money, (as efficiency and effectiveness); and Quality as transformative (an ongoing process that includes empowerment and enhancement of customer satisfaction).

Dimensions of Quality in Engineering Education

The quality and relevancy of engineering education is more important than ever before (Phillips, Peterson, & Aberle, 2000). Definition of indicators of quality and the objective measurement of these indicators are

critical in the assessment of quality of engineering programmes. What is quality, quality of education especially engineering education, and how it can be achieved are of great interest to the stakeholders of engineering education. Attaining quality goals through a process of continuous improvement over time depends critically upon a firm's ability to define in specific performance terms what it means by quality and then to measure these performance variables objectively (Krishnan, Shani, Grant, & Baer, 1993).

The US National Science Foundation (NSF) Task Force on TQM has come up with the following definition for quality engineering education: "Quality engineering education is the development of intellectual skills and knowledge that will equip graduates to contribute to society through productive and satisfying engineering careers as innovators, decision makers and leaders in the global economy of the twenty first century" (Natarajan, 2000). To survive in the highly competitive environment, according to Kra´sniewski and Wo´znicki (1998), an engineering education programme must have the essential features of flexibility and adaptability. Quality engineering education demands a process of continuous improvement, dramatic innovation in student, employer and societal satisfaction by systematically and collectively evaluating and refining the system, practices and culture of engineering education institutions (Natarajan, 2000). One needs to address various current related issues such as the way to view students and employers, the role of non-technical courses, the use of technology in the classroom, and the life-expectancy of education in order to have a holistic view of engineering quality (Ibrahim, 1999).

Many opinions can be observed in the literature about the factors influencing the quality in engineering education. Some of them are: teaching process (Cropley, 2003), university – industry collaboration (Natarajan, 2003), accreditation standards (Prem, 2003), e-education (Maji, 2003), excellence of teachers (Shrivastava, 2003), student intelligence and interest (Mouly and Padmaja, 2003), role of management (Gopalan, 2003), and proper documentation of activities (Jagdeesh, 2001). Ahuja and Singh (2004) view that curriculum development based on emerging technologies is equally important like faculty development, modernization, and better utilization of infrastructural facilities. They suggest that enhanced exposure of students to industries, feedback system, networking between institutions and institution-industry interaction is crucial dimensions to the overall quality of a program. According to Sohail and Shaikh (2004), although researchers have pointed out several dimensions for quality in higher education, but among them academic programme or programme is the most important, because it is the ultimate parameter for a student for selecting an institute for higher education. A 2007 report (Barber & Mourshed, 2007) by international

consulting group McKinsey and Company proclaimed that the "quality of an education system cannot exceed the quality of its teachers".

As the researchers viewed quality as the combination of various factors, quality of engineering education cannot be defined by any single factor or dimension. The definitions of quality involve the characteristics of input, process, output and multiple constituencies of an education institution. Quality is a multi-dimensional concept and different definitions are appropriate under different circumstances (Viswanadhan, 2006). Hence, these multi-dimensional features should be taken into account while assessing the quality of engineering programmes.

Qualifications Frameworks

A framework for higher education qualifications should identify a clear and nationally-agreed set of purposes. Frameworks for higher education qualifications benefit from the inclusion of cycles and /or levels, and articulation with outcome-focussed indicators and/or descriptors of qualifications. Frameworks for higher education qualifications should explicitly link academic standards, national and institutional quality assurance systems, and public understanding of the place and level of nationally recognised qualifications. A qualifications framework provides a systematic description of the full range of qualifications within a given education system, as well as the ways in which learners can navigate between them. Qualifications therefore have to be described in such a way as to cover the full purpose of education, so the framework must be multi-dimensional (QFEHEA, 2005)

Qualifications are tools for the promotion of trust between the various parties who use these qualifications. Almost all countries necessarily have a system of higher education that includes an understanding of the roles of higher education, of higher education institutions, and of various stakeholders, such as learners, staff in higher education institutions, and social partners. The elements of such national higher education systems are often formally defined, however there may be many aspects of higher education systems that are not precisely defined but are understood within the society in which they operate. In recent years, there has been an increasing national and international debate on higher education qualifications, and in particular how they are organised, recognised and related to each other on national and trans-national bases.

In simple terms a national framework of higher education qualifications is defined as: the single description, at national level or level of an education system, which is internationally understood and through which all qualifications and other learning achievements in higher education may be described and related to each other in a coherent way and which

defines the relationship between higher education qualifications. Qualifications frameworks aim to provide a general description of what learners bearing a certain testimonial typically are competent in (in terms of knowledge, skills and attitudes) so that testimonials become comparable (Bienefeld et al., 2008). They aim to increase transparency, progression and portability as well as widening access (Fernie & Pilcher, 2009; Young, 2007).

National frameworks of qualifications are important parts of the academic architecture within which autonomous higher education institutions can flourish and be supported. They facilitate the creation of academic independence within a system of responsibility and external reference points. Higher education institutions are provided with clear parameters for the development and validation of their own qualifications. They can thus be held responsible and accountable for their activities (by internal and external quality assurance processes) whilst retaining real ownership of their curricula. Autonomous higher education institutions can then demonstrate that each of their qualifications is allocated to the appropriate level in any national framework.

Although higher education has, to a large extent, historically reflected national cultural contexts it has also always included an international dimension in the establishment of its qualifications and their standards. Similarly, the mobility of staff and students has introduced an international element to quality assurance although again this is generally based predominantly on national contexts. In both areas the contribution of such an international element may have been somewhat implicit and there has until recently been little use of clear and explicit, internationally recognised criteria for supporting quality assurance processes or making objective assessments.

The purpose of regional qualifications framework is to provide an overarching framework that will simplify mobility, transparency and recognition between national systems. At the same time, it is important to recognise that national frameworks will reflect the respective national discussions on the purposes of higher education and different agendas in higher education policy. To find the right balance between the diversities of national frameworks and the benefits of close linkages between them is the main challenge for constructing an overarching framework. The Bologna Process is such an initiative for developing a regional (European) qualifications framework in Europe. An overarching European framework has some distinctive objectives, which differ from those of national frameworks. As a meta-framework, it is intended to assist in the identification of points of articulation between national frameworks. It also

serves as a point of reference for those developing or reviewing national frameworks of qualification.

Quality Assurance Systems

Quality in the context of higher education can be defined as "a judgement about the level of goal achievement and the value and worth of that achievement. It is also a judgement about the degree to which activities or outputs have desirable characteristics, according to some norm or against particular specified criteria or objectives" and quality assurance in higher education is defined as "systematic management and assessment procedures adopted by a higher education institution or system to monitor performance and to ensure achievement of quality outputs or improved quality". Quality assurance aims to give stakeholders confidence about the management of quality and the outcomes achieved (Harman & Meek, 2000).

As per the National Quality Assurance and Accreditation Committee of Egypt (NQAAC, 2004), quality assurance is defined as "the means of ensuring that, informed by its mission, academic standards are defined and achieved in line with equivalent standards nationally and internationally, and that the quality of learning opportunities, research and community involvement are appropriate and fulfil the expectations of the range of stakeholders". The Federation of Engineering Institutions of Asia and the Pacific (FEIAP) defines quality assurance as "an all-embracing term referring to an ongoing, continuous process of evaluating (assessing, monitoring, guaranteeing, maintaining, and improving) the quality of a higher education system, institutions, or programs". As a regulatory mechanism, quality assurance focuses on both accountability and improvement, providing information and judgments (not ranking) through an agreed upon and consistent process and well-established criteria. The scope of quality assurance is determined by the shape and size of the higher education system (FEIAP, 2010).

The European Qualifications Framework for Lifelong Learning (EQF, 2008) suggests that quality assurance – which is necessary to ensure accountability and the improvement of higher education and vocational education and training – should be carried out in accordance with the following principles:

- Quality assurance policies and procedures should underpin all levels of the National / Regional Qualifications Frameworks
- Quality assurance should be an integral part of the internal management of education and training institutions
- Quality assurance should include regular evaluation of institutions, their programmes or their quality assurance systems by external monitoring bodies or agencies

- External monitoring bodies or agencies carrying out quality assurance should be subject to regular review
- Quality assurance should include context, input, process and output dimensions, while giving emphasis to outputs and learning outcomes
- Quality assurance systems should include the following elements:
  - clear and measurable objectives and standards
  - guidelines for implementation, including stakeholder involvement
  - appropriate resources
  - consistent evaluation methods, associating self-assessment and external review
  - feedback mechanisms and procedures for improvement
  - widely accessible evaluation results
- Quality assurance initiatives at international, national and regional level should be coordinated in order to ensure overview, coherence, synergy and system-wide analysis
- Quality assurance should be a cooperative process across education and training levels and systems, involving all relevant stakeholders, within Member States and across the Community
- Quality assurance orientations at Community level may provide reference points for evaluations and peer learning.

External Quality Assurance

Quality assurance has a double aspect: the internal quality assurance and development at higher education institutions and the external quality assurance (accreditation) undertaken by independent bodies. In the global arena, the accreditation and assessment process of engineering courses has become mandatory and dynamic in the quality assurance of higher engineering education. This is due to several factors, such as the increasing trend of the internationalisation and globalisation of higher and technical education, the increasing number of courses and student enrolments, the expansion of distance and e-learning education, the emergence of a multicultural workplace environment, etc. (Patil & Pudlowski, 2005).

Accreditation of an engineering educational programme is the primary process used to ensure the suitability of that programme as the entry route to the engineering profession (Collofello, 2004). Accrediting bodies are now focusing on ensuring that programmes are relevant and adapting to the changing needs. Thus accreditation is becoming synonymous to "quality" (Megat, 2010). Accreditation has been described as a public statement that a certain threshold of quality has been achieved or surpassed (Campbell et al., 2000). Although accreditation is distinct from audit, assessment and external

examining there is a degree of overlap between these different external processes (Stensaker, 2003).

The purpose and impact of accreditation goes far beyond quality assurance of an institution / programme. Major impacts of accreditation system are summarized below.

- Encourages quality improvement initiatives by institutions
- Improves student enrolment both in terms of quality and quantity
- Helps the institution in securing necessary funds
- Enhances employability of graduates
- Facilitates transnational recognition of degrees and mobility of graduates and professionals
- Motivates faculty to participate actively in academic and related institutional / departmental activities
- Helps create sound and challenging academic environment in the Institution
- Contributes to social and economic development of the country by producing high quality technical manpower.

As per the Engineering Education Guidelines of FEIAP (FEIAP, 2010), accreditation is "a process of self-study by the program and external peer review by appropriately trained and independent teams from both academia and engineering practice for quality assurance, accountability, and quality improvement of an academic program designed to determine whether or not it has met or exceeded the published standards of the accreditor and is achieving its missions and objectives".

The value of the accreditation credential depends on the clarity of the description, which defines what it ascertains, the reputation and independence of the accrediting body, the fairness and transparency of the process leading to credential granting, and the time at which the credential was awarded. It has been experienced that credentials provided by non-governmental bodies with a broad base of support by academia, professional associations, governmental agencies and industry tend to be more valuable than those granted by government-dominated bodies or bodies that are controlled by a single industry or a single corporation (IEEE, 2007). Accreditation criteria must under all circumstances embrace three key aspects: the educational environment; the program design, structure, content and assessment processes; and the underpinning quality systems (FEIAP, 2010)

Accreditation would remain an effective instrument for quality assurance in engineering education provided; outcomes assessment and continual improvement are not foreign to academic experience and culture (usually there is a high level of discomfort at the initial period), active

communication and educational efforts emphasised to both evaluators and those evaluated, a significant investment of effort to develop an effective programme of outcomes assessment and continual improvement, and no excessive documentation required. Once the programme is established, less effort is required to maintain such a system, however continued and not periodic attention is required. Outcome based education accreditation system would result in the emphasis shifting away from building a high standard of technical competence to the development of a broad range of 'softer' skills in engineering graduates is in fact a misconception but believed by some academics (Megat, 2010).

International Trends in Accreditation of Second Cycle Engineering Programmes

The Master's (second cycle) engineering education forms the core for training of future teachers and researchers, and for building up international reputation through publications, patents and entrepreneurs. These professional leaders are capable of transforming the industry.

In accordance with the precepts of the Bologna Process, the "New Structure for Engineering Education in Ireland", proposed by Engineers Ireland in 2003, envisages that the accredited Master Degree programme will replace the accredited honours Bachelor Degree programme as the education standard required for the Chartered Engineer title from programmes completed in 2013. The evolving introduction of the new standard will require a reconsideration of the definition and competences of a Chartered Engineer (EI, 2003).

In response to the issues facing undergraduate engineering education, National Academy of Engineering (NAE) in the USA has made a suite of recommendations, including the following relating to accreditation of engineering programmes (NAE, 2005).

- The B.S. degree should be considered as a pre-engineering or "engineer in training" degree.
- Engineering programs should be accredited at both the B.S. and M.S. levels, so that the M.S. degree can be recognized as the engineering "professional" degree.

The above two points indicate clearly that having a Master's degree will become quite important if one is to enter the engineering profession in the next few years.

Accreditation of engineering education worldwide is mostly focused on the Bachelor's degree level, but in recent years, many countries have ignited effort to conduct accreditation at the Master's degree. Accreditation models in the international context mainly consider the evaluation of learning outcomes and the ability of programmes to achieve the educational

objectives stated in their mission. However, it is not clear if these objectives and therefore their outcomes satisfy real national and regional needs, a critical point in engineering Master's programmes, especially in developing countries.

ENAEE (European Network for Accreditation of Engineering Education) is a European network which authorises accreditation and quality assurance agencies to award the EUR-ACE label to accredited engineering degree programmes. EUR-ACE is the European quality label for engineering degree programmes at First Cycle (Bachelor) and Second Cycle (Master) level. The EUR-ACE system encompasses all engineering disciplines and profiles, is internationally recognised, and facilitates both academic and professional mobility and provides a set of standards that identifies high quality engineering educational programmes in Europe and abroad (ENAEE, 2012).

The Washington Accord, signed in 1989, is an international agreement among bodies responsible for accrediting engineering degree programs. It recognizes the substantial equivalency of programs accredited by those bodies and recommends that graduates of programs accredited by any of the signatory bodies be recognized by the other bodies as having met the academic requirements for entry to the practice of engineering (WA, 2013). Accreditation for engineering education among the Washington Accord signatories has been focused on the Bachelor's degree level, because the Bachelor's degree level is seen as the first entry level to professional practice of engineering. In recent years, however, several full and provisional signatories are extending accreditation to the Master's degree programs. ABET, AEER, ASIIN, ECUK, EI, IEET, JABEE and NBA are examples.

The Accreditation Board for Engineering and Technology (ABET) is recognized in the United States as the sole agency responsible for accreditation of educational programs leading to degrees in engineering. For accreditation of Master's programmes, ABET prescribes the "fulfilment of the baccalaureate level General Criteria", and the "graduates have an ability to apply master's level knowledge in a specialized area of engineering related to the program area" (ABET, 2013). The eight General Criteria for accreditation are: students; program educational objectives; student outcomes; continuous improvement; curriculum; faculty; facilities; and, institutional support. In addition to the General Criteria, each programme should satisfy the Specific Programme Criteria also.

The Association for Engineering Education of Russia (AEER) is responsible for quality assurance in higher engineering education in Russia; in lines with the requirements existing in the Washington Accord signatories, ENQA, EUR-ACE project, and the Dublin Descriptors elaborated within the framework of EHEA. The AEER system for accreditation of second cycle

programmes is built up around nine criteria. They are: program objectives; program content; students and study process; faculty; professional qualifications; facilities; information infrastructures; finance and management; and, graduates. (AEER, 2011)

The Accreditation Agency for Degree Programs in Engineering, Informatics, the Natural Sciences and Mathematics (ASIIN) is an independent accreditation agency in Germany. The goal of ASIIN's accreditation activities is to ensure high standards of teaching and study and the equivalency of education. ASIIN follows an eight general criteria accreditation system where the requirements are: formal specifications; programme - content concept and implementation; programme - structures, methods and implementation; examination - system, concept and organisation; resources; quality management - further development of programmes; documentation and transparency; and, diversity and equal opportunities (ASIIN, 2012). In addition to the general criteria for the accreditation of degree programmes, ASIIN's Technical Committees have drawn up Subject Specific Criteria (SSC) for the individual disciplinary fields.

Engineering Council, United Kingdom, (ECUK) is concerned with setting and maintaining realistic and internationally recognized standards of professional competence and ethics for engineers, technologists and technicians, and licensing competent institutions to promote and uphold the standards. For accreditation of programmes, ECUK evaluates: the learning outcomes of the programme; the teaching and learning processes; the assessment strategies employed; the resources involved – including human, physical and material; internal regulations regarding compensation for underperformance; quality assurance arrangements; entry to the programme and how cohort entry extremes will be supported; and, how previous accreditation recommendations and requirements have been dealt with (ECUK, 2013).

Engineers Ireland (EI) is working closely with the universities and institutes of technology to ensure the maintenance and improvement of the quality of engineering education in Ireland. The accreditation function of Engineers Ireland is carried out by its Accreditation Board. The accreditation of a programme is based on four criteria: programme outcomes; programme area descriptors; assessment of student performance; and, programme structure and resources (EI, 2007).

Institute of Engineering Education Taiwan (IEET) was established to develop and administer accreditation of engineering programs in Taiwan. The nine criteria approved by the accreditation council of IEET for Master's programme are: educational objectives; students; program outcomes and assessment, curriculum; faculty; space and facilities; institutional support

and financial resources; discipline-based criteria; and, education for master's or beyond degrees extends from that of the bachelor's and with a more specialized focus (IEET, 2010).

Japan Accreditation Board for Engineering Education (JABEE) is responsible in Japan to evaluate whether or not a program satisfies the accreditation criteria, with the examination of the self-inspection report filled by the applicant as well as with on-site examination. The Common Criteria for accreditation used by JABEE are: learning outcomes; educational methods; achievement of learning outcomes; and, educational improvement (JABEE, 2012).

The National Board of Accreditation (NBA) is assigned with the task of ensuring the quality of education offered by various programmes, in India. The NBA has evolved a framework of quality assurance containing a robust process ensuring highest degree of transparency and credibility - with little scope of discretion and subjectivity. The criteria that are considered by NBA during the process of accreditation of a programme are determined by the NBA's definition of quality of programmes and its relevance to the profession concerned. These nine criteria are: institutional mission, vision and programme educational objectives; programme outcome; programme curriculum; students' performance; faculty contributions; facilities and technical support; academic support units and teaching-learning process; governance, institutional support and financial resources; and, continuous improvement in attainment of outcomes (NBA, 2013).

From the experiences stated above from Germany, India, Ireland, Japan, Russia, Taiwan, the UK, and the USA, it is clear that accreditation of the Master's degree programmes will be the next level of development in accreditation of engineering education worldwide. From the survey of relevant literature, it is observed that accreditation criteria for Master's degree programme prescribed by all the agencies are same as their criteria for Bachelor's programme; but with a higher level of expected outcomes and graduate capabilities. This is justifiable as Master's degree education is considered as an extension of the Bachelor's degree and with a more focused specialization and depth of knowledge.

Internal Quality Assurance

Quality assurance mechanisms are expected to yield better institutional performance for one of three possible reasons, (a) *compliance* with the external pressure from a quality assurance or funding agency, (b) *self-interest* represented for example by the desire to attract students and research contracts or (c) the *professional ethos*, which entails striving for quality as excellence (Harvey & Green, 1993a). External quality assurance might produce different institutional reactions depending on whether

providers focus on compliance, interest or ethos. The efficacy of the external quality assurance is highly dependent on an institution's internal quality system and quality culture (Kristensen, 2010). Therefore, self-evaluation is an important part of any quality system. In a self-evaluation, an institute systematically reviews and reflects on the quality of instructional and related educational services and on the outcomes they produce (OECD, 2011). The process of continual review can also be described as a 'systematic, structured and continuous attention to quality in terms of maintenance and improvement' (Vroeijenstijn, 2001).

The providers of higher education have the primary responsibility for the quality of their provision and its assurance. Consistent with the principle of institutional autonomy, the primary responsibility for quality assurance in higher education lies with each institution itself and this provides the basis for real accountability of the academic system within the national quality framework. Institutions should have a policy and associated procedures for the assurance of the quality and standards of their programmes and awards. They should also commit themselves explicitly to the development of a culture which recognises the importance of quality, and quality assurance, in their work. To achieve this, institutions should develop and implement a strategy for the continuous enhancement of quality. The strategy, policy and procedures should have a formal status and be publicly available. They should also include a role for students and other stakeholders. It is the institution's internal quality assurance or quality management system that is expected to provide key evidence that the goals for its degree programmes have been met.

As per the "Standards and Guidelines for Quality Assurance in the European Higher Education Area" (ENQA, 2005), the internal quality assurance of programmes is expected to include:

- Development and publication of explicit intended learning outcomes
- Careful attention to curriculum and programme design and content
- Specific needs of different modes of delivery
- Availability of appropriate learning resources
- Formal programme approval procedures by a body other than that teaching the programme
- Monitoring of the progress and achievements of students
- Regular periodic reviews of programmes
- Regular feedback from employers, labour market representatives and other relevant organisations
- Participation of students in quality assurance activities.

The internal quality assurance processes should be developed, through which higher education institutions can demonstrate their accountability, including accountability for the investment of public and private money. If higher education institutions are to be able to demonstrate the effectiveness of their own internal quality assurance processes, and if those processes properly assure quality and standards, then external processes might be less intensive than otherwise. Relative autonomy or negotiation power with the decision-maker is a precondition for the effectiveness of any internal quality assurance process, at any level of institutional development.

Other Quality Management Systems

Besides assessing the quality of engineering education through a formal accreditation process, there have been several attempts to use some of the quality management systems to assess and improve the existing programmes. These include: European Foundation for Quality Management, Malcolm-Baldrige National Quality Award Program, and ISO 9000.

The European Foundation for Quality Management (EFQM) has developed a model to structure and review the quality management of an organization. Self-assessment, benchmarking, external review and quality awards are the essential elements of EFQM. According to the Foundation, quality management should focus on all activities, on all levels in an organization and should be a continuous process to improve performance (Nabitz, Klazinga, Walburg, 2000). The EFQM Excellence Model (EFQM, 2011) is a generic model for quality management, which is used in all types of organizations, regardless of sector, size, structure or maturity. The essence of the approach is the model with nine dimensions, which are called criteria. The nine criteria are: leadership; people; strategy; partnership and resources; processes, products and services; people results; customer results; society results and business results. The first five criteria are grouped as “Enablers” and the last four as “Results”. The "Enabler" criteria cover what an organisation does and how it does it. The "Results" criteria cover what an organisation achieves.

A more detailed framework for quality measurement is given in the Malcolm-Baldrige National Quality Award Program. The Baldrige Education Criteria for Performance Excellence formulated by the National Institute of Standards and Technology are being used increasingly by U.S. education organizations to improve their performance. The Criteria are built upon a set of interrelated core values and concepts that are embodied in seven categories: Leadership; Strategic Planning; Customer Focus; Measurement, Analysis, and Knowledge Management; Workforce Focus; Operations Focus; and Results (NIST, 2011).

ISO 9000 is another framework, which is a procedural approach to quality assurance. Here the standard of quality is defined according to stated and implied customer requirements, with procedures written and followed to assure that customer requirements are consistently delivered. The quality management system standards of the ISO 9000 series are based on eight quality management principles. These principles can be used by senior management as a framework to guide their organizations towards improved performance. The eight principles are: customer focus, leadership, involvement of people, process approach, system approach to management, continual improvement, factual approach to decision making, and mutually beneficial supplier relationships (ISO, 2012).

Even though these frameworks proved to be effective to the industrial organizations, their applications to the educational institutions are not well publicized.

Developing a Multi-Dimensional Framework for Internal Quality Assurance of Second Cycle Engineering Programmes

Results of a survey of the relevant literature and observations indicate that various assessment models have been developed regionally, as well as nationally, in order to accredit second cycle engineering programmes. Several quality assurance standards and guidelines have been established and implemented worldwide through various international, regional and national agencies. Accreditation is a process designed to determine whether or not an educational programme has met or exceeded the published standards of the accreditation agency, whereas the purpose of internal quality assurance is to develop a quality culture within an institution, and to implement a strategy for the continuous enhancement of quality. Internal quality assurance is thus a route to accreditation. Therefore each institution should have its own quality culture and policy; and associated procedures for the assurance of the quality and standards of their programmes.

As the purpose of internal quality assurance is distinct from that of accreditation, the authors are of the view that same framework should not be used for both internal quality assurance and accreditation systems. Also it is evident from the literatures that the “quality assurance / management system” of an institution is an important factor which is assessed for accrediting an engineering programme. Thus internal quality assurance system of an institution is a subset of the accreditation process. Relevant literatures do not provide much evidence about the existence of a separate framework for internal quality assurance. From the literature review, it is observed that in a free-market economic context and international education, the accreditation of second cycle engineering programmes follows an international accreditation model, and doesn't take in account in most cases

criteria and indicators for local relevancy. Therefore design and development of a scientific framework for internal quality assurance of second cycle engineering programmes is an urgent need.

The authors identified the functional dimensions and determinants of internal quality assurance through analysis of the relevant literature, interviews and focus group discussions with experts from the fields of engineering education, engineering industry and engineering research as well as observation of procedures and processes in educational institutions and universities offering second cycle programmes in engineering. The data collected was analysed using the content analysis technique. Content analysis consists of analysing the contents of documentary materials (books, journals, reports, etc.) and verbal materials (interviews, group discussions, etc.) for the identification of certain characteristics that can be measured or counted.

Qualitative content analysis involves a process designed to condense raw data into categories or themes based on valid inference and interpretation. This process uses inductive reasoning, by which themes and categories emerge from the data through the researcher's careful examination and constant comparison. Generating concepts or variables from theory or previous studies is also very useful for qualitative research, especially at the inception of data analysis (Berg, 2001). Hsieh and Shannon (2005) discussed an approach of directed content analysis, in which initial coding starts with a theory or relevant research findings. Then, during data analysis, the researchers immerse themselves in the data and allow themes to emerge from the data. The purpose of this approach usually is to validate or extend a conceptual framework or theory.

A variety of definitions exist within the literature regarding focus groups. Broadly speaking, a focus group is defined as a small gathering of individuals who have a common interest or characteristic, assembled by a moderator, who uses the group and its interactions as a way to gain information about a particular issue. As Kruger and Casey (2000) note, the purpose of focus groups is to promote a comfortable atmosphere of disclosure in which people can share their ideas, experiences, and attitudes about a topic. Participants "influence and are influenced", while researchers play various roles, including that of moderator, listener, observer, and eventually inductive analyst (Krueger & Casey, 2000). Specifically, focus groups are unique in their explicit use of group interaction to produce data (Barbour & Kitzinger, 1998). As a method, focus groups are based on two fundamental assumptions. The first is that individuals can provide a rich source of information about a topic. The second is that the collective and individual responses encouraged by the focus group setting will generate material that differs from other methods (Glitz, 1998).

From the content analysis, the authors have identified 24 factors (referred as determinants) which are absolutely necessary for the internal quality assurance of a second cycle programme in engineering, and have grouped these determinants under 6 dimensions. The authors follow an integrated approach in developing a framework for the internal quality assurance of second cycle engineering programmes; and propose a multi-dimensional framework, taking into account all the dimensions of an engineering programme. The proposed framework, illustrated in Fig. 1, focuses on the interaction between various dimensions and the determinants there under. The dimensions of an engineering programme identified for the framework are: Quality Enablers, Programme Design, Programme Resources, Programme Delivery, Programme Outcomes, and Quality Analysis. The authors have also identified that the key performance results of the internal quality assurance framework are: defect avoidance in the educational system, alignment of the programme with the strategies of the institute, continuous improvement of the programme and development of trust among the stakeholders of the programme. The dimensions of internal quality assurance and the determinants under each dimension are shown in Table 1.

Table 1: Dimensions and Determinants of Internal Quality Assurance of Second Cycle Engineering Programmes

Dimension	Determinant
Quality Enablers	Institutional Leadership and Governance
	Institutional Strategic Planning and Development
	Autonomy, Accountability and Professional Learning
	Decentralization, Delegation and Empowerment
Programme Design	Programme Educational Objectives and Outcomes
	Support and Participation of Industry and Society
	Global Linkages with National Labs and Institutions
	Industry Relevant, Flexible and Dynamic Curriculum
Programme Resources	Programme Budget and Financial Resources
	Programme Specific Learning Resources
	Faculty: Adequacy, Competency and Development
	Student Enrolment and Student Services Facilities
Programme Delivery	Learner-Centred Instructional Systems Design
	Knowledge Management System Intervention
	Support for Creativity and Innovation
	Academic Counselling, Guidance and Mentoring
Programme Outcomes	Course and Programme Learning Outcomes
	Research, Publications and Consultancy Services
	Graduate Attributes and Professional Competencies
	Development of Personal, Social and Ethical Values
Quality Analysis	Internal and Functional Benchmarking
	360^{o} Evaluation of Programme Dimensions
	Quality Circles and Internal Quality Audits
	Continual Review of PEOs and POs

The authors define internal quality assurance of an engineering programme as: enabled by certain *quality enablers*, a structured process of *quality analysis* (benchmarking, monitoring, evaluating, assessing, guaranteeing and improving the quality) of the *design*, *resources*, *delivery* and *outcomes* of the programme; resulting in *defect avoidance*, *strategic alignment*, *continuous improvement*, and *stakeholder trust*.

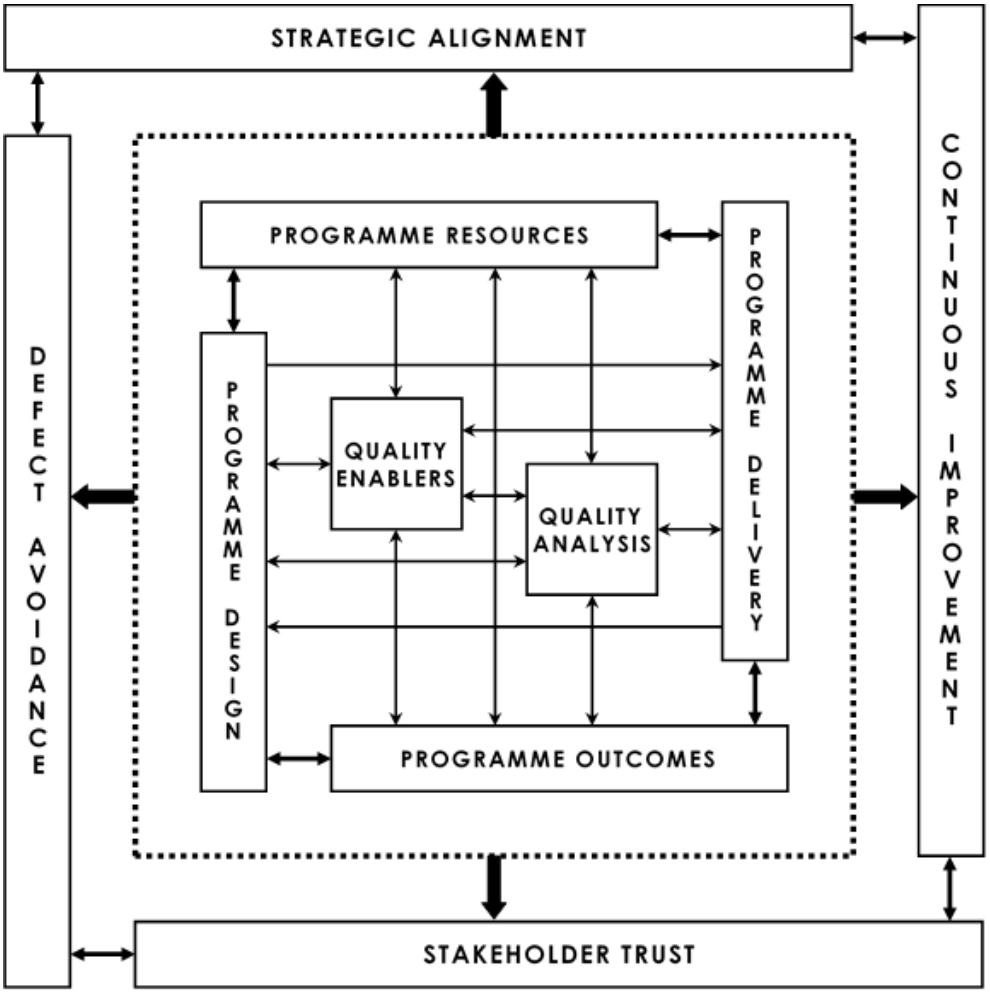

Fig. 1: Multi-Dimensional Framework for Internal Quality Assurance of Second Cycle Engineering Programmes

Further studies are being conducted for prioritizing the dimensions and determinants of internal quality assurance of second cycle programmes in engineering. Also the impediments to internal quality assurance in various categories of institutions will be assessed. Based on these studies, necessary corrections will be made in the proposed framework.

Conclusion

The development of any internal quality assurance framework must take into account the need to develop trust among the various stakeholders and confidence in the integrity of the resultant framework. The success of a quality assurance framework may be measured by the extent to which its standards and procedures are valued and used. Unless institutional leaders

are committed to them; and unless all the stakeholders understand and demand them, an internal quality assurance system will be inert and disregarded. Trust, which is closely allied to credibility and acceptance, is an essential attribute of successful qualification framework anywhere, whether conventional or otherwise.

Although finding the root problems and suggestions to solve and / or improve them is always helpful, but it can never guarantee continuous improvement. Continuous improvement needs a strong obligation to stick on quality improvement process. The process can include annual self-assessment, periodical meetings, motivating stakeholders, and the most important, making the vision of becoming the best. Committed open-minded leaders, who are always open to positive changes and improvements, can have the main effect on continuous quality improvement in engineering education institutions.

Internal quality assurance should not be reduced to formalised processes but should be linked more to a set of institutional and individual attitudes, a "quality culture", aiming at "continuous enhancement of quality.

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