

**Review Article**

# A Review of Science and Engineering Curriculum Design for Testing, Inspection and Certification Industry

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**Abstract:** Testing, Inspection and Certification (TIC) is a method of providing services to companies operating across various industrial verticals for the purpose of improving productivity, efficiency, and manufacturing process for manufacturers to meet with globally recognized standards, regulations, and policies set by governments to improve the quality of a product. Testing and inspection have increased the efficiency and productivity of various automotive organizations by reducing the cost and time for delivery, managing and controlling supply chain at each manufacturing stage, improving aftermarket sales and distribution, increasing the safety, and reducing the impact on environment. TIC plays a vital role in guaranteeing quality and credibility when dealing with these global challenges. There are substantial increasing figures indicated that there was continuous growth of the TIC industry because of its important role in the daily life of the Hong Kong community and in external trade. Although there is no further detailed explanation of these professionals' requirements, it acknowledges that technical knowledge and skills are essential to support the development of the TIC Industry to cope with the manpower demand. The major sources to supply the manpower or professionals should be the graduates in science and engineering disciplines in higher education institutes. Hence, there is a need to review the job competency required by the TIC stakeholders, the competency standards for TIC industry, the curriculum in higher education institutes in order to find out if there is skill mismatch in TIC. This paper studies four main areas: testing, inspection and certification industry, curriculum design, competency and employability skills. It is concluded that TIC may encourage ever more students to pursue science or engineering during their undergraduate study. However, the problems in skill mismatch and skill gaps are reflected by the TIC stakeholders. Hence, greater attention may need to be given to the readiness and the extent of the current science and engineering curricula in higher education of support for undergraduates entering the TIC industry by considering the job competency requirements for TIC.

**Keywords:** Testing and Certification, Curriculum, Employment, Qualifications Framework, Competency

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## 1. Introduction

Testing, inspection and certification is an industry with good development potentials. Over the years, the industry has established a good foundation, based on a robust accreditation system, high professional standards and an excellent reputation. In support of the product compliance and testing services, TIC industry in Hong Kong provides high volume of testing and inspection services for consumer products manufactured in Hong Kong and the Pearl River Delta Region of Mainland China, particularly for toys, electrical and electronic goods, textiles, garments and footwear. The

industry also provides certification service for the management systems of the relevant factories and companies. Through providing assurance to overseas buyers on the quality and safety of products sourced in the region, the industry underpins Hong Kong's position as an international trading hub [1].

According to the fact sheet published by the Information Service Department (2014) of HKSAR, the Hong Kong Council for Testing and Certification (HKCTC) was established to advise the Government on the industry's overall development strategy and introduce new measures to support its growth [1]. HKCTC comprises members from the TIC industry, business sector, and professional organisations, as

well as the relevant public bodies and government departments [2]. Owing to the scale and diverse nature of the TIC industry, the Report of the Hong Kong Council for Testing and Certification defined the nature of the industry's work and divided it into three core business areas [2]:

- a) Testing: the determination of one or more characteristics of an object according to a procedure.
- b) Inspection: the examination of a product design, product, process, or installation and the determination of its conformity to specific or general requirements on the basis of professional judgment.
- c) Certification: a third-party attestation related to products, processes, systems, or persons.

## 2. Testing and Certification

Testing and certification services industry plays an important role in daily life of the Hong Kong community as well as in our external trade, e.g. medical testing support in the diagnosis of illnesses, and testing and inspection services for consumer products manufactured in Hong Kong and the Pearl River Delta Region. It also provides certification services for management systems. According to statistics published by the Census and Statistics Department of the HKSAR Government in 2017, the value added of the industry was \$15 billion in 2017 (or 0.5% of GDP). On the other hand, employment stood at 13960 persons in 2016 (or 0.4% of total employment), increased by 2.4% from 18280 persons in 2017 [3]. These substantial and increasing figures indicated that there was continuous growth of the TIC industry because of its important role in the daily life of the Hong Kong community and in external trade. Although there is no further detailed explanation of these professionals' requirements, it acknowledges that technical knowledge and skills are essential to support the development of the TIC Industry to cope with the manpower demand. The major sources to supply the manpower or professionals should be the higher education institutes. Hence, there is a need to review the job competency required by the TIC stakeholders, the competency standards for TIC industry, the curriculum in higher education institutes in order to find out if there is skill mismatch in TIC.

## 3. Competitiveness and Higher Education

Reviewing the competitiveness of a nation often means studying its ability to succeed in international markets, to achieve high levels of productivity and to create an attractive business environment [4]. According to the Global Competitiveness Index report in 2014, the competitiveness of Hong Kong moved up from the 11th to the 7th position from 2011 to 2014 out of 30 countries. A recent study by the International Institute for Management Development (IMD) published the World Competitiveness Yearbook 2016, assessing the competitiveness of 61 economies worldwide. In the report, Hong Kong is again ranked as the world's most competitive economy, improving from the fourth place two

years ago. Hence, there is no doubt that Hong Kong is a highly competitive society worldwide with a high rank in competitiveness. However, a number of studies identify the challenges faced by the competitive society of Hong Kong. The Bauhinia Foundation commissioned Strategic Access Ltd. to undertake a project titled 'Hong Kong's Competitiveness: A Multidimensional Approach' in 2012. The study revealed that Hong Kong has high competitiveness as it does a very good job in the basic policy and related matters, including rule of law, basic macro policies and infrastructure. However, the study criticized that Hong Kong has a relatively poor performance in 'higher order' features, such as education, which has a high impact on employment. The report prompts me to question how education influences employment. The report fails to further elaborate such issue. According to the Hong Kong Economic Report published in 2016, there is an increasing proportion of graduates with higher education, but the proportion of graduates who take professional jobs has been decreasing in recent years. More graduates need to take lower-skilled occupations instead of knowledge-based or professional jobs. Considering all these pieces of evidence, the learning objectives for higher education should be directed towards employment, particularly in a competitive society and industry.

## 4. Skill Mismatch

Worldwide, whether the higher education sector is providing graduates with the requisite skills and knowledge to match employment needs is a concern [5]. Pegg (2010) is concerned about the transition of young full-time students to the world of work because they enter employment with no work experience and with skills deficits [6]. According to Yusuf (2014), the skills expected from employees change dynamically with technological and economic developments, the emergence of new industries, and change-of-work processes [7]. These developments require a review of higher education programs at regular intervals and a harmonisation of the skills that graduates must have to meet the expectations of the business world.

Mismatches arise in the supply and demand of skills in labour markets since people in the education system and work life cannot respond to these changes at the same pace. If we accept this point for the mismatches, the relationship between higher education and employment would seem to be increasingly problematic. Wade (2015) argues that the reasons and the impact of skills mismatches need to be understood [8]. He further points out that stronger links between businesses and universities are a key foundation for addressing skills mismatches. Such concern has been known by the Hong Kong government. The report on 'Challenges of manpower adjustment in Hong Kong' issued by the Legislative Council Secretariat in 2016 highlights the issue of skills mismatch among graduates with higher education. The fact is that the proportion of local workforce with higher education has more than tripled from 9% to 29% from 1994 to 2015, but less than half of them could take professional jobs in recent years. As

the creation of high-end jobs cannot keep pace with manpower supply amidst slow progress in structural change in the local economy towards knowledge-based activities, more graduates with higher education need to take lower-skilled occupations in recent years.

## 5. Skill Gaps

The Hong Kong Council for Testing and Certification has recently consulted different stakeholders of the industry to collect their views on the competency required of the practitioners working in the TIC industry. The findings of the consultation/interviews are summarized as follows. (i) Most of the practitioners in consumer products testing and environmental testing have acquired the necessary academic qualifications (e.g. Bachelor degrees, higher diplomas, diplomas, etc.) before employment. However, some interviewees commented that there were skills gaps between the academic qualifications and the job competency requirements which presents in Table 1.

**Table 1.** Job Competency Requirement in TIC Industry (HKCTC, 2015).

Item	Job competency and skill sets
A	Specific techniques of product testing including safety tests and electromagnetic compatibility tests
B	Interpretation of technical standards and regulatory requirements on product testing
C	Test method development for new or revised standards and/or regulatory requirements in overseas countries
D	Field sampling techniques
E	Laboratory testing techniques
F	Technical skills in instrumental analysis
G	Microbiological techniques
H	Testing of construction materials
I	Work flow of a testing laboratory
J	Use, calibration and maintenance of testing equipment
K	Result verification and reporting
L	Quality system and requirement
M	Research and development for new initiatives or new testing methodologies
N	Code of conduct: professional ethics and integrity

In view of the existing skill gaps, it is worth to review the status of science and engineering curriculum in cope with the employability and job competency.

## 6. Science and Engineering Curriculum

Several studies on the science curriculum and its relevance to employment have been conducted over the decade [9-12]. It is assert that the science curriculum emphasises content. It lacks relevance to pupils' interests and attention to contemporary science issues, and the way scientific knowledge is presented is disconnected from technical know-how. Because of the rapid-changing technologies, the way that knowledge is acquired is also changing. They further stress that the growth of knowledge has been largely 'vertical' in that once the fundamentals are established; new knowledge is added in a gradual, increasingly specialized way. One of the possible implications is that the science curriculum needs to

be reformed to meet the needs of the rapidly changing technology in the real world. Rae (2007) indicates that one of the main problems faced by universities is the choice of a degree subject and its relevance to the employment market [13]. He mentions that universities have the freedom to offer degree courses for which they have capacity and they consider they can attract a viable number of students. Doggan and Gotta (2007) argue that universities are not required, either individually or collectively, to offer degree programs that meet employer skill or workforce planning needs [14]. They further discusses that the imbalance between the drive to attract students and the lack of any direct need to relate courses to employer demand has resulted in the growth of courses that reflect student fashion and the decline of courses such as sciences, technology and engineering, for which there was employer demand but decreasing student attraction. With this, Malcolm, McInnis and Hartley (2010) explain that science and technology is a dynamic and ever-changing field [15]. The difficulty in predicting the direction of scientific advancement and the economic opportunities that arise in areas of that advancement, as driven by market demand, increasingly challenges the capabilities and flexibilities of science education agencies and testing laboratories. A recent report by the European Commission of the Expert Group on Science Education suggests that higher education institutions should boost the understanding of the importance of science education as a means of acquiring key competencies to ease the transition from 'education to employability' (E2E) by strengthening connections and synergies between science, creativity, entrepreneurship and innovation. Collectively, the thoughts of the earliest researcher as well as the current researchers inspire me to ascertain that the design of science and engineering curriculum should consider the job competence and skills requirements for preparing undergraduates entering the TIC industry.

## 7. Competency

It is worth noting whether graduates in Hong Kong are well equipped to meet manpower demands in the TIC industry and what sorts of skills are required. One possible implication of the required skills relates to the nature of work in the TIC industry. One source of information on this topic is the Qualifications Framework, which established competence standards for the TIC industry.

### Qualifications Framework

A guide to the Hong Kong Qualifications Framework describes 'framework' as [16] formal structures which are adopted by countries to define their qualification systems. Generally they identify a hierarchy of qualification levels in ascending order and state the generic requirements for qualifications to be awarded at each of these levels. The frameworks show what qualifications are at the same level and indicate how one qualification may lead to another either at the same or a higher level. They describe a continuum of learning which allows any new qualifications to be placed within the educational system. Assigning levels to

qualifications promotes the accurate and consistent description and marketing of qualifications by those who award them. (p. 4)

The Qualifications Framework Steering Committee has developed a set of specifications for competence standards in the TIC industry, which serves as a guideline to such training providers as universities for developing recognised training programmes. Thus, it is the essential tools for curriculum developer when design the course contents.

Indeed, competence standards have been established in several countries, including the United Kingdom [17], other European countries [18], and Australia [19]. The requirements of these standards vary according to the conditions set by the government agency. Similarly, the Qualifications Framework (QF) of Hong Kong's Education Bureau developed the Specification of Competency Standards (SCS) for the testing, inspection, and certification industry in 2014. The SCS is a set of core competencies for the identified work functions with specifications on integrated outcome performance for the industry. These competency standards are the industry requirements for the skills, knowledge, and attributes required to satisfactorily perform a job at a certain qualification level.

Hong Kong's QF consists of a seven-level hierarchy, where level 1 is the lowest and level 7 is the highest [16]. Qualifications in the academic sector are correlated with QF levels in Table 2.

**Table 2.** *QF Levels for Qualifications in the Academic Sector HKQF, 2015).*

Qualifications in the Academic Sector	QF Levels In Hong Kong
Doctorate	7
Master's Degree	6
Bachelor's Degree	5
Associate Degree	4
Diploma of Secondary Education	3
Secondary Level Certificate	2
	1

Various skill functions are presented as units of competency (UoCs) in the SCS. The QF elaborates that UoCs are competency-based, contextual, and outcome criteria-referenced. Each UoC represents an inseparable, self-contained set of competencies required to perform a specific task. The UoCs can be grouped into building blocks for serving different purposes. Since my research is concerned with those entering the TIC industry after graduation, the UoCs, as laid down by the QF for qualification levels 4 and 5 (associate and bachelor's degree holders), will be the focus of my study.

## 8. Employability Skills

Taken together, these findings suggest a possible link between competency and employability skills. The issue of employability skills has received considerable critical attention. Wickramasinghe and Perera argue that employability skills are job-specific, but certain skills cut horizontally across all industries and vertically across all jobs from entry level to chief executive officer [21]. This view is

supported by Guy, Sitlington, Larsen, and Frank, who highlight that employability skills are those basic skills necessary for getting, keeping, and succeeding in a job [22]. According to the US Department of Health and Human Services, competencies often serve as the bases for skill standards that specify the level of knowledge, skills, and abilities required for success in the workplace and as potential criteria for assessing competence attainment [23]. A similar view has been put forward by Sturgis, who states that competence is the capability to apply or use a set of related knowledge, skills, and abilities required to successfully perform jobs or tasks in a specific work environment. He further indicates that people who possess the required knowledge, skills, and abilities are eligible to engage in the following three main job categories [24]:

1. Entry level (getting a job)
2. Performance level (keeping a job)
3. Fluent or professional level (doing well in a job)

Whether undergraduates are well equipped to get a job in the TIC industry is the main concern of my study, so the entry requirements for the TIC industry will be the focus, whereas how well graduates perform in their jobs is beyond the scope of my research.

## 9. Conclusions

This paper reviewed the development of the testing and certification industry in Hong Kong, discussing job requirements and the purpose of the Qualifications Framework. The TIC industry's growth is likely to increase the demand for manpower, especially for those with postsecondary degrees in science or engineering-based disciplines. This vision of impending technological growth may encourage ever more students to pursue science or engineering during their undergraduate study. However, the problems in skill mismatch and skill gaps are reflected by the TIC stakeholders. Hence, greater attention may need to be given to the readiness and the extent of the current science and engineering curricula in higher education of support for undergraduates entering the TIC industry by considering the job competency requirements for TIC.

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