ICIC Express Letters
Part B: Applications
Volume **8**, Number **11**, November **2017**

ICIC International ©2017 ISSN 2185-2766
pp. 1545–1552

A RESEARCH ON ESTABLISHING OCCUPATIONAL COMPETENCY CURRICULUM FOR KEY POSITIONS IN ELECTRICAL AND ELECTRONIC INDUSTRIES

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Received May 2017; accepted August 2017

Abstract. *In this paper, the competencies of key positions such as test engineers on electrical and electronic industries have been carefully investigated. The purpose of this study is to develop an occupational competency standard (OCS) and a competency curriculum map based on iCap OCS, and to explore the learning performance and the level of satisfaction with the evaluation of course service quality using resource allocation mode (RAM) of data envelopment analysis (DEA). The analytical process developed in this study is applicable for other industries to develop OCS and competency course planning. The results can be directly applied to human resource management for the selection, training, promotion, retention, and cultivation of talents for organizations.*
Keywords: Occupational competency standard (OCS), Competency curriculum map (CCM), Resource allocation mode (RAM), Data envelopment analysis (DEA)

1. **Introduction.** Under the background of ever-changing technology, the most challenging issue for upgrading process technique and developing industry transformation is talent cultivation. The gaps between the abilities required for different positions and different occupation would result in the difficulties for expending training programs. Occupation competency standard (OCS) and competency-oriented course are the benchmarks for talent cultivation. Industry founded countries, such as England, European Union, Australia, USA, Japan, Singapore and Taiwan have recently declared national qualification framework to encourage educators/industry/vocational training centers to establish OCS and develop competency courses [1].

McClelland [2] firstly came up with the concept of "competency" and claimed that competency exercised greater influences on trainees' learning performances and incorporated the attitude, cognition, and personal traits behind their actions. Enterprises often apply competency to the aspects of workforce planning, recruiting, performance management, career development and successor management in order to enhance companies' performances and competitive advantages [3]. Later, competency represents a person's explicit and underlying characteristics is suggested by [4]. Further research [5] considered that competency is more than knowledge, skill and ability, and it also includes other personal characteristics.

Resource allocation is the assignment of available resources to various uses based on the needs of organization internal production factors. Cook and Kress [6] adopted the notion of new input variables for allocating new cost budget. They considered the new cost as a resource and proposed an allocation mode for new resource. Their study raised a reasonable resource allocation plan on the premise that the reallocation will not impact the original efficiency evaluated by each decision making unit (DMU). Later, an allocation mode with data envelopment analysis (DEA) for constant cost and budget was proposed by [7]. Literature regarding efficiency improvement did not focus on the cost incurred before an operation unit achieved its efficiency frontier. The resource allocation mode is applicable even though the inefficient unit reaches efficiency frontier and satisfies the goal of enhancing efficiency [8].

Integrated competency and application platform (iCAP) by Workforce Development Agency, Ministry of Labor, ROC [9] declared a standard, ADDIE to determine the occupational competency standards (OCS) for various position jobs in various industries in Taiwan. Detailed description of ADDIE (Analysis, Design, Development, Implementation, Evaluation) can be found in the official website [9]. Based on ADDIE, many procedures to develop OCS and associated competency-oriented course have been recently established [10-12]. However, a competency curriculum map (CCM) consisting of a series of competency-oriented courses for all level of key position jobs has not been explored. Preliminary investigation on electrical and electronic industries disclosed that 1) the most desired talents are those with engineering expertise; 2) the talents of software engineers and hardware test engineers are the hardest to be engaged and replaced; 3) the expertise (professional knowledge) of test engineers cannot be positioned and is difficult to cultivate within a short-term training program. Hence, the goal of this research is to establish an OCS and a CCM for all level test engineers in electrical and electronic industries in Southern Taiwan.

2. **Research Process.** The research process in this study is shown in Figure 1.

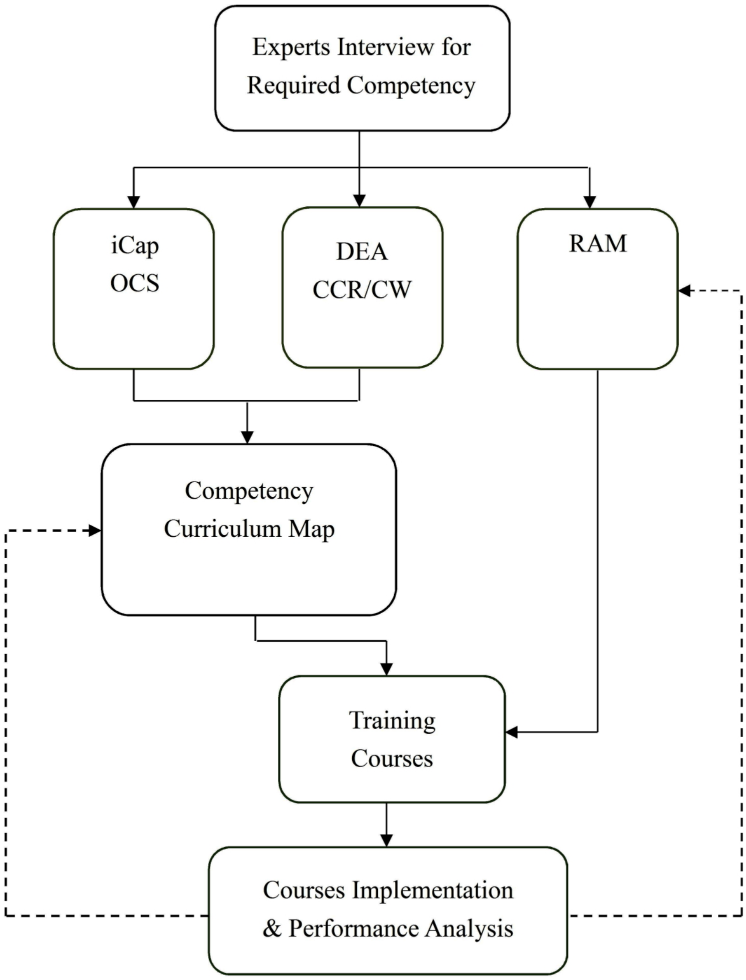

FIGURE 1. Research process used in this study

2.1. **Evaluation model for course service quality.** DEA combined with the PZB model [13] is employed to develop an evaluation model for courses service quality. The PZB model proposed that all types of services should exactly and completely satisfy customers' needs and that five service gaps in the models should be identified and eliminated to meet requirements. Therefore, all trainees had graded the 5 service gaps based on their "expectations before training" and "actual feelings" as input variables and output variables for satisfaction evaluation model. Detailed information and equations can be found in [14].

2.2. **Resource allocation mode (RAM).** In this paper, RAM based on minimization overall efficiency variance is proposed to determine the courses content, time and teaching necessaries. In DEA method, each DMU added a new input variable while every DMU remained its original conditions, and the efficiency value should not be less than its previous value before adding the variable. Detailed equations can be found in [8]. Thus, DEA-based resource allocation modelling is able to improve the operational efficiencies of professional services [15].

3. Results and Discussion.

3.1. **iCAP OCS.** 15 experts from industry-government-academia-institute-vocational training were invited to attend an "Expert Specialized Meeting" and propose the initial draft of competency analysis. The meeting was also held twice to recognize the determined OCS and course with CCM after in-depth interview with test engineers. Test engineers have been categorized into three groups based on their service and working experiences: assistant level with 1-3 years, advanced level with 3-5 years, and the senior level serving over 5 years. This research adopts the iCap standard and employs the CCR/CW of DEA to develop OCS and formulate a CCM for all level of test engineers. In total, 4 assistant engineers, 4 advanced engineers and 7 senior engineers form 6 public traded electronic companies accepted in-depth interview for OCS and competency-oriented courses. In addition, 1 of 11 courses was selected to study the effects of the urgency-importance competency. For comparison of pre-post training, all trainees filled in courses service quality questionnaires to analyze the effectiveness and improvements of the trained course.

3.2. **In-depth interview results.** Based on interview results, the OCS required for three levels of test engineers is summarized as follows.

The responsibilities of assistant test engineers are to guarantee product quality, perform functional tests, solve the customer-filed problems, design/maintain testing tools, and resolve on-line equipment problems. Advanced test engineers are focusing on establishing test environment, planning test processes, discovering test issues and optimizing test procedures. Advanced test engineers are also handling new products verification and mass production implementation to ensure product quality and test tooling introduction, maintenance and correction, and to devote to the improvements of test processes. Senior test engineers not only have to assume the main liabilities of advanced engineers, but also need to drive automation projects, monitor performances and responsible for projects success.

Expertise (professional knowledge) required for assistant, advanced and senior test engineers is 11 courses listed in Table 1.

The essential skills for assistant test engineers include the equipping and testing abilities for electrical circuits, products quality, problems analysis and solution, communication and cooperation, and customer-oriented requirements. Advanced test engineers should be familiar with and equip with the effective connection, ability of planning and performing products tests. The mandatory ability of senior test engineers is project planning and management.

Table 1. The importance-urgency index of competency courses

No.	Importance	Competency Courses	Urgency
C1	0.751	Practical Electronic Circuit Technology	0.893
C2	0.763	Testing Technology	0.865
C3	0.726	Machine Operation Practice	0.902
C4	0.978	Statistical Process and Quality Control	0.853
C5	0.571	Practical SMT Process Technology	0.984
C6	0.987	Practical English of Electronic Assembly Industry	0.920
C7	0.677	Practical Programming Language Design	0.837
C8	0.844	ESD Protection	0.907
C9	0.430	Digital Logic Practice	0.979
C10	0.578	AOI Machine Vision	0.891
C11	0.855	Cost Analysis and Management Practice	0.865

The essential attitudes for assistant test engineers are cautious, careful, self-monitored, and understand the key elements of tooling design. Besides, they should be motivated and capable of enduring pressures, and have the sense of teamwork. Advanced test engineers further require the ability of communication and cooperation, so as to senior test engineers.

3.3. **Competency courses evaluation.** While measuring urgency, researchers take the significance ranking as outputs and the prevalence ranking as inputs. The importance and urgency indexes of competency courses were separately calculated. Higher index score indicates that the courses are of greater importance and urgency. The calculation results are listed in Table 1. It should be noted that core modules of each course were also recognized by the representatives of the 2nd "Expert Specialized Meeting".

A competency course matrix diagram illustrated in Figure 2 demonstrates course urgency and course importance. It can be easily pointed out that C6 (Practical English of Electronic Assembly Industry) would be the most important-urgent course for training of test engineers.

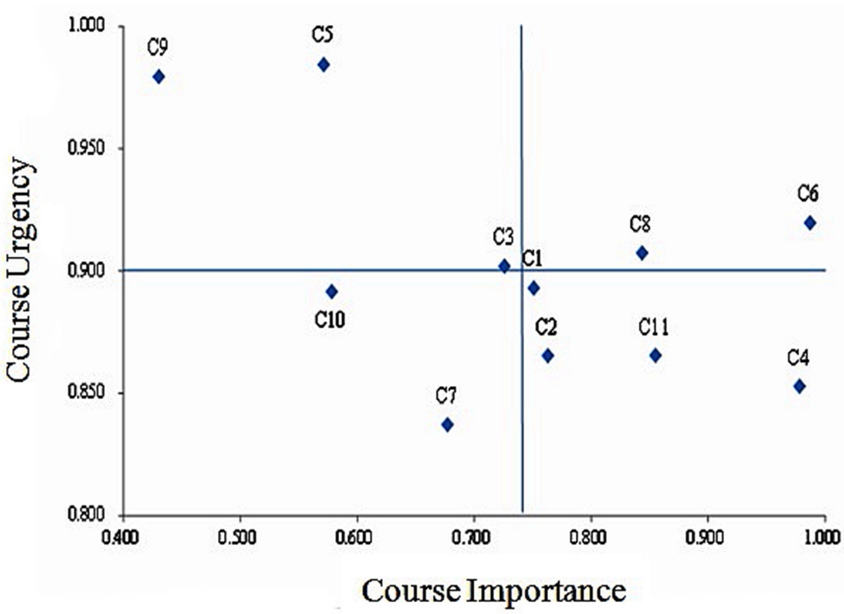

Figure 2. Competency course matrix diagram

3.4. **Competency curriculum map (CCM).** In the 2nd "Expert Specialized Meeting", representatives from industry mentioned that senior engineers usually have to perform the works of advanced engineers at the same time; moreover, senior engineers focus on project planning, implementation and the operation of the sector which are difficult to be trained in class. Therefore, the competency courses only consider assistant test engineers and advanced test engineers. An occupational CCM is summarized in Figure 3 which consists of three domains, namely general courses, introductory courses and medium-advanced courses.

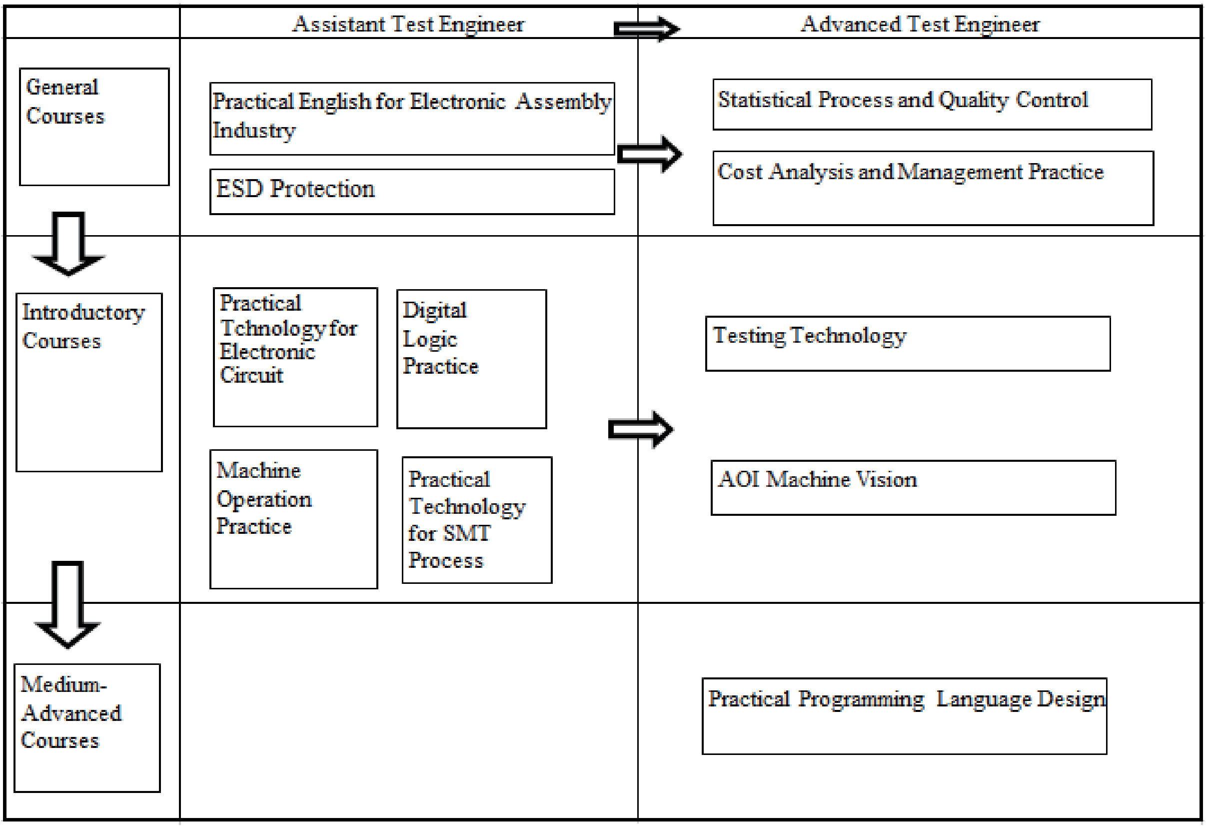

FIGURE 3. Competency curriculum map (CCM) for test engineers at all levels

3.5. **Competency course commencement.** "Practical English of Electronic Assembly Industry" offers two modules: English Terminology for Electronic Assembly and English Communication Practice for Electronic Industry. The former covered 2 units: 1) English terms for PCB and SMT process (3 hours); 2) English terms for function test and reliability test (3 hours). The latter incorporated 5 units: 1) English writing for business letter (3 hours); 2) Writing skills for business email (3 hours); 3) English phone etiquette (4 hours); 4) Conference English (4 hours); 5) Presentation English (4 hours). Training time course is 24 hours.

Training institutions certified by government with valid TTQS (Taiwan Talent Quality System) certification would be qualified centers. Facilities required for language training are computer-language lab with Internet. The qualification of course instructor should have 6-year (minimum) working experience in electronic assembly industry.

The capacity of class remains small-size with 20 persons. Therefore, 16 test engineers from OSE Corp. in Nanzih Export Processing Zone, Kaohsiung City attended this course.

3.6. **Course service quality evaluation.** Course service quality was evaluated to discover the gaps between training programs and trainees' expectations and the potential causes of these gaps for future improvements. The definition of 5 quality-expectation gaps is listed below:

Gap1: the difference between trainees' expectations and actual situations regarding the competency course contents, scheduling, and connections among courses offered by training institutions.

Gap2: the difference between trainees' expectations and actual situations in respect to the teaching materials, applicability, and trainers' expertise for specific fields provided by training institutions.

Gap3: the difference between trainees' expectations and actual situations concerning the grievance system, trainers' assistance for trainees, and the course space offered by training institutions.

Gap4: the difference between trainees' expectations and actual feelings about the information of traffic convenience, dining convenience, neat teaching environment and clean surroundings for learning provided by training institutions.

Gap5: the difference between trainees' expectations and actual situations as for the teaching methods, materials and equipment which can enhance learning performance offered by training institutions.

Evaluation of the 5 gaps from 16 trainees is listed in Table 2. As can be seen, Gap2 obtained the highest index, indicating that the course teaching contents, applicability and instructor's expertise achieved the highest satisfactory level; in contrast, Gap3 received the lowest index, indicating that training institution did not reach an efficient level.

Table 2. The index of service quality

Gap	Service Quality Index	Order
Gap1	0.969	2
Gap2	1.000	1
Gap3	0.912	5
Gap4	0.936	4
Gap5	0.940	3

The index of course satisfaction level of trained course is shown in Table 3. "Conference English" and "English Phone Etiquette" received higher scores. However, "English Writing for Business e-mail" received the lowest index. Course instructor shall refer this result for modifying and improving course contents.

Table 3. The index of course satisfaction

Course Unit	Satisfaction Index	Order
English Phone Etiquette	0.999	2
Conference English	1.000	1
Presentation English	0.975	4
English Writing for Business Letter	0.953	5
English Writing for Business e-mail	0.889	7
English for PCB and SMT Process Terms	0.985	3
English for Function Test and Reliability Test	0.931	6

3.7. **Follow-up learning effects.** Learning effects (outcome) were carefully evaluated by trainees and their immediate supervisor as well as HR. Questionnaire survey and interview were conducted one year after trained. It should be noted that all 16 trainees from OSE Corp. were still remained in the same positions at that time. Table 4 lists the learning effects for work performance. Trainees unanimously agree with the improvement of conference English.

Table 4. The index of learning effects

Item	Performance Index	Order
Enhance professional expertise	0.973	2
Achieve organization goals	0.896	8
Increase the usage of English terms for SMT process/PCB in work	0.919	7
Increase the usage of English terms for reliability test in work	0.934	5
Increase the usage of English terms for functional test in work	0.936	4
Improve English presentation skills in work	0.929	6
Improve English conference skills in work	1.000	1
Improve English e-mail writing skills in work	0.959	3

3.8. **Course benefits for trainees in workplace.** Training benefits for trainees in workplace were included in this study. Training course beneficial index is listed in Table 5. Index "Enhance expertise in workplace" received the highest score, indicating trainees are able to put the professional knowledge learned from competency course into the real field of test engineers, i.e., knowledge practical application would be the greatest profit for trained course. Trainees were learned to apply knowledge, skills and ability (KSA) to job after training. The supervisor would be responsible for trainee's job performance and HR agreed with trainee's attitude.

Table 5. The beneficial index on courses

Item	Benefit Index	Order
Enhance English communication skills	0.976	3
Enhance expertise in workplace	1.000	1
Improve English communication in workplace	0.987	2
Reinforce the sense of organizational commitment	0.864	6
Increase personal satisfaction in workplace	0.928	5
Benefit for personal career planning	0.954	4

4. **Conclusions.** Occupation competency standard (OCS) and competency-oriented course are the benchmark for talent cultivation. In this research, based on iCAP, the insight of OCS and competency curriculum map (CCM) for test engineers have been explored and the associated knowledge, ability and attitude (ability) have also been disclosed. The developed procedure to establish OCS and competency course is one of fourteen qualified techniques announced in iCAP official website [9]. 286 OCS for various jobs in different industries have been declared and 85 competency-oriented courses have been qualified in June 2017 [9].

This study determines the importance-urgency matrix of each competency-oriented course and develops a CCM for general, introductory and medium level courses at all level positions.

The selected course for competency training was conducted and its effectiveness for trainees was assessed after trained. This research demonstrated that course service quality can be evaluated to locate the training gaps and disclose the reasons of these gaps.

A follow-up training effect has been surveyed after 1 year trained. For the benefit analysis of courses, trainees are able to integrate the course contents into their works, and to reflect learned knowledge, skill and ability into key position occupation.

In summary, the OCS and CCM established procedure in this research are qualified for staffing, training and retaining for other key positions and ready to apply to other industries.

Acknowledgment. The authors would like to express their appreciation to the Workforce Development Agency, Ministry of Labor in Taiwan for financial supports.

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