Obtaining IT Competencies for Curricular Development using Q-technique

Chi-Cheng Chang
Associate Professor, Department of Information Management
Lunghwa University of Science and Technology, Taiwan
chig@mail.lhu.edu.tw

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Abstract
The purpose of this study is to explore a method to acquire the competency requirements of IT enterprises to serve as the basis for developing IT curriculum. The Q-technique and survey research were used. For this study, 24 Taiwan experts in ICT stock-listed companies were consulted to acquire competency statements that are universally required; a Q-technique was then applied. The study surveyed regional IT enterprises and collected 236 valid questionnaires to establish regional IT competencies. The study has found that IT competencies are structured along the dimensions of information ability, fault tolerance, execution ability, problem solving, learning ability, and innovation ability. The contribution of the Q-technique is it located the competency for universal need and regional need of the IT industry. Q-technique could be a method for curriculum development.

Keywords: IT enterprise, competency, Q-technique, curriculum development

Introduction

Identifying the requirements of industry, to shorten the gap between information education and employment, is one of the important issues of personnel training (Abdullah et al. 2012; Secundo et al. 2013). In order to shorten the discrepancies between competency requirements and developing training, educational disciplines must focus on the changing practical requirements of industry (Landy & Conte 2004). Only by adjusting the curriculum based on the needs of industry can students adapt and apply new technology in the changing technological environment (McCuddy et al. 2008), especially in the IT industry where changes matches the needs for being future-oriented (Metsämuuronen et al. 2013). This highlighting of the competency requirements of the IT industry is an important basis in the reform of the information education curriculum.

Looking at previous studies on the association between industry competency requirements and curriculum reform, these can be summarized through three main approaches:
Fulfilling requirements: based upon competence-based theory. The professional competencies required by a business are obtained through job analysis, duty analysis and task analysis. Once the competency requirements are obtained, curriculums are designed to develop the competencies required by business. For example Landy and Conte (2004) believed that

"competency" is organized from knowledge, skills, abilities, and personality characteristics (KSAOs). When the curriculum is established based upon competency requirements (Oloo, Mutsotso, Poipoi, 2013), this can fulfil the competency requirements of the business community regarding the competencies that engineers should have.

Workplace proximity: based upon the value-chain theoretical model. By establishing an industry-academic strategic partnership to jointly plan the curriculum, students learn through exposure and cooperation in actual workplace situations (Chang & Chang 2011). This can be through internship or cooperative education, providing part of the industrial labour force, and also cultivates the professional competencies required in the workplace. For example, consider the design-oriented learning internship program (Clements, 2009); or apprenticeship training (Oultram 2012) to develop professional abilities.

Simulation and experience: based upon work-based learning theory. This is planned around employment specialisation courses to enhance employability (Chang 2014; Moreno et al. 2012). Implementing this curriculum involves using student-centred teaching (Morse 2007; McCuddy et al. 2008). This combines the professional competency requirements of the target enterprise, creates theoretical and workplace experience-based programs, and incorporates the subject enterprise management as the instructor, so that talent is cultivated by both industry and academia.

Among these research approaches, which at their core are all intended to reduce the gap in personnel training, the top priority is in how to fully embody the professional competencies required by the job market. An overview on application methods include the DACUM (Develop A Curriculum) method (Gazman 2013), the Delphi method (Jacobs & Bu-Rahmah 2012), as well as the V-Tech method (Dede 2000) and others. But because of the rapid pace in which IT industrial expertise changes, how to efficiently obtain the expected job competencies become an important issue in current IT education. To solve this problem, this study aims to explore a method to acquire competency requirements of the IT enterprise, to serve as the basis for IT curriculum development. As the focus of the study, Phase One is to use major ICT companies listed on the Taiwan Stock Exchange, to apply the Q-technique to obtain the universal competency requirements of the IT industry. In Phase Two the competency requirements of the regional IT industry are investigated, and the characteristics of each question are analysed. The purpose is to obtain regional and individual competency requirements, to serve as the basis for curriculum development.

The biggest difference between this and other studies is that, the universal competency requirements come directly from the leaders in Taiwan's IT industry, which are representative of the mainstream of industrial development. The individual portions are obtained from the curriculum planners of regional IT vendors. When the curriculum is reformed and implemented in the future, this will help to promote the employment of graduates and enhance their ability to move across the IT profession.

Competency

It is extremely important that the labourer possesses the appropriate competency needed to execute tasks (Lim, Anderson & McGrath 2012). "Competency" can be regarded as a special vocational prerequisite, a set of performance standards, and also the ability to complete tasks (Sandberg & Pinnington 2009). According to competence-based theory, I-O psychologists generally believed that the KSAOs (Knowledge, Skills, Attitude, Others) forming the competency model are used to describe the key abilities required to execute any job (Landy & Conte 2004). Therefore, "competency" can be deemed as a set of abilities that should be possessed to engage in a particular task (Chang 2014). These competences can then be broken down into general competence, management competence, professional competency, and core competence (Hellriegel et al. 1998). Among these as far as the professional competencies expected by employers, technologies and skills can predict the job performance of technology management personnel (Hysong 2008). In this study, the definition of professional competency is (based on Sandberg & Pinnington 2009): to engage in a professional task in the field of information technology, where the labourer possesses a set of abilities to successfully execute the task.

Using competence-based theory as a guideline, in order to train the professional competency required to perform tasks, the planning and design of the curriculum must take into account the performance level required for a job task. Here a "job" is deemed to be completing the exact tasks of a particular position; a “task” describes the content of what an employee does in a particular work activity (Noe 2005). Simply put, the performance expected by an enterprise comes mainly from the expected results of employees performing production activities (Chang 2014). Therefore, describing it as the results of a series of expected jobs is probably the best statement for the professional competency of an IT employee.

Indicators of Professional Competency

The meaning of professional competency can be defined using the approach of structuralism. The structuralist sees professional competency as a set of abilities or performance standards or key competencies (Landy & Conte 2004); and is concerned about the labourer’s qualifications required by the workplace, the ability to upgrade, as well as the labourer’s required theoretical and practical knowledge (Clarke 2011). Consequently, every job opening in the industry has its corresponding competency requirements (competency model). Meanwhile every qualified labourer in the workplace plays the role of productivity (Allais 2012). When approaching this through structuralism, with regards to the indicators of professional competency, the ABET (2013) engineering education accreditation specifications include vital core competencies such as problem solving, innovation and information ability. Abdullah et al. (2012) explored the gaps in competencies, using “soft” and “hard” skills. “Soft” skills include: ICT skills, personal qualities, thinking skills, interpersonal skills, management skills, and communication skills. Cilliers (2012) observed that “soft skills” also include the ability to produce reports. “Hard skills” include "practical usage of the software tools," "circuits construction," "operate, troubleshoot systems and equipment," "process, control and installation," and "quality and reliability testing." Hatlevik and Christophersen (2013), from a systematic point of view, believed that digital competence is extremely important, its meaning including the ability to use technology; the ability to process technology, obtain and evaluate the collected information; and the ability to use digital tools and media to produce and communicate information. Jang (2009) pointed out that the expression of sensitivity, fluency, flexibility, originality and elaboration of scientific creativity are all important. Lee (2009) also believed that training the ability to be adaptable and flexible is an important dimension of IT competency. In summary, this study adopted the dimensions of its operational definition, as shown in Table 1 below.

Table 1. IT industry operational definitions of dimensions within Professional Competency

Dimension	Operational definition
Information ability	Refers to possessing the ability to use the appropriate IT software tools to develop IT products or services.
Fault tolerance	Refers to the quality of the completed task or the ratio of the successful implementation of tasks.
Execution ability	Refers to the ability to complete tasks on time in accordance with IT project planning.
Problem solving	Refers to the ability to make good use of IT professional methods to solve the problems encountered in executing a task.
Learning ability	Refers to possessing the ability to learn new IT knowledge and technologies in the workplace.
Innovative ability	Refers to possessing the ability to turn creative ideas into IT products or services with commercial value.

Methodology

Q-technique

First proposed by Stephenson (1935), this is a method to study human subjectivity, which can also be referred as the Q-method, the Q-technique or Q-sort (Barbosa et al. 1998). It can be defined as a type of combined qualitative and quantitative research method where respondents point out their own statements or opinions, based upon their own attitudes (Chang 2012). In this study, the purpose of the Q-technique is to consult leading experts within the IT industry, to obtain statements and priorities, to form the universal requirements of IT professional competency.

The Q-technique process is given as follows：

Stage 1: Establish a population of Q opinions

Analysis of literature: The purpose is to obtain the factors and connotations of professional competency, and organize various statements describing professional competency, to form a draft population of Q opinions.

Surveying of experts: The mid-level and senior leadership of IT departments from 24 ICT companies listed on the Taiwan Stock Exchange were consulted on their opinions regarding professional competencies required by employees, in which a variety of statements were obtained. This was implemented using guidance questions for the experts to ponder deeply (Barbosa et al. 1998); and selecting open inquiries on what IT companies require for professional competency? Answers were requested to be as clear and specific as possible, and then organized into statements. The results and literature analysis were combined into a total of 101 statements, forming a Q population of opinions.

Stage 2: Q sampling

Using a single-layer structured sample design based on Kerlinger (1973), from the population of opinions in accordance with the six dimensions of professional competency, purposive sampling was used, with 7-8 chosen for each of the dimensions that accurately reflect descriptive opinions about professional competency, for a total of 44 statements forming the Q samples.

Stage 3: Flat Sort

Through the principle of balance in which a total of 22 experts (P samples) from IT business leaders and academic experts provided statements organized as 17 positive, 17 negative, and 10 neutral opinions, arranged by the Q sample of experts, the Q classification was distributed 3-6-8-10-8-6-3, which conformed to nearly normal distribution requirements. After obtaining the Q classification and the Q-technique table of experts, the expert group was revised using the draft questionnaire obtained from Q-technique.

In terms of the rationality of this research method, the essence of the Q-technique is in classifying opinion from the point of view of the subject, which results in a presentation of the subjective reactions of the experts' behaviour. The sorting conforms to a nearly normal distribution, in accordance with Tang (2006) who believed that the application of the Q-technique should focus on people's behaviour. Thus the use of the Q-technique is appropriate in this study.

Investigation

Questionnaire development: A questionnaire was designed along with the Q-technique, the purpose of which was to obtain the respondent's background information, so that during the factor analysis, the characteristics of the explanatory factors are used (Barbosa et al. 1998). A draft questionnaire was compiled, fully integrating the results of literature analysis, the operational definitions of professional competencies, and the connotation of 44 statements. Each question in the questionnaire was ranked according to a 7-point scale (7 being the most important, 1 being very unimportant). In the questionnaire structure, besides the questionnaire instruction, definitions of terms, as well as basic information, the body of the questionnaire was organized according to the six dimensions of information ability (A1-A4), fault tolerance (B5-B7), execution ability (C8-C11), problem solving (D12-D15), learning ability (E16-E19), and innovative ability (F20-F23).

To test the validity and reliability, the initial draft was subjected to expert content validity to see whether the content of the questionnaire fully reflect its substance. For the overall reliability of the questionnaire, Cronbach's α was measured at 0.914, the reliability of each question from 0.90 to 0.92, so that the questionnaire as a whole as well as its dimensions all reached a good level, which demonstrated the consistency of the questionnaire attitude scale. KMO (Kaiser Meyer Olkin KMO) was measured at 0.95, so that the validity of the factors was rated at meritorious level, demonstrating that the questionnaire has a stabilizing effect. At the same time Bartlett's test of sphericity achieved a level of significance, demonstrating that the correlation matrix of the population showed the presence of common factors, making it suitable for factor analysis.

Data collection: Using the case of an academic department, and taking its cooperation with regional IT companies as a sample, including: R & D programs, student internships, workplace experience, employment of graduates, and industry-academia dual-instructor courses, a study was conducted for the management leadership of 34 IT companies. The purpose of the data analysis was to determine the regional IT company professional competency requirements and the attitude strength of each question. A total of 236 valid questionnaires were collected. Based upon the industrial sector of the respondents, the largest group comprising 51(37.5%) was in IT and communications, followed by IT entrepreneurs at 44(32.36%), followed by 20(14.7%) in the financial and insurance industry, and 21(15.44%) in professional, scientific and technical services. Based upon the company specialization, the largest group comprising 56(41.18%) was in software development, followed by network management at 36(26.47%), e-business at 32(23.53%) and databases at 12(8.82%).

Result & Discussion

Q-technique - The implications for education

In response to the need for curriculum development, it is necessary to obtain the connotation of IT industry professional competency. Traditionally the DACUM method has been used as the experts' brainstorming method to obtain a directory listing of professional skills (Gazman 2013). The Delphi method uses experts anonymously, to seek the consistency of opinions regarding professional competency (Jacobs & Bu-Rahmah 2012). The V-Tech method emphasizes the large sample survey, to obtain a requirement listing of universal professional abilities engaged in some professional competency (Dede 2000). This study uses the Q-technique, to establish a systematic personnel training cycle. In other words, the emphasis is on qualitative interviews to get close to benchmark IT company experts, to establish universal professional competency requirements; as well as quantify the surveys of regional IT enterprise groups, to obtain regional professional competency requirements. The educational implications of these findings are:

- Professional competency requirements of IT enterprises that were acquired through the collaboration of industry experts could be transformed into core abilities that should be learned by students in school.
- The overall chart (i.e. statements) describing competencies that was obtain through behaviourism included three major categories: knowledge, skill, and attitude.
- Universal IT competency progress acquired through experts in stock-listed companies, due to the application of brainstorming methods, contained the spirit of DACUM method; the progress of IT competency requirement acquired through regional enterprise surveys possessed the spirit of V-tech method.

The educational benefits of Q-technique are:

• The feedback to curriculum development can reduce what was pointed out by Secundo et al. (2013) as the gap between competency and curriculum due to technological change. Implementation of the curriculum is conducive to enhancing what Chang (2014) referred to as the student employment force, and what Hatlevik & Christophersen (2013) pointed out as digital competence.

• When a student has universal professional competencies as required by the IT profession and regional IT industry, this helps enhance what Lee (2009) pointed out as adaptable and flexible abilities. This also helps employment in local IT companies. This optimizes a talent training cycle including the obtaining of competency requirements, curriculum development and implementation, enhancing competency, and promoting employment.

Universal IT competency consultation

The sequence of priority for each statement is organized by experts; the priority of the professional items conforms to industry needs and is shown in Figure 1. The first priorities are c1, b1, and a1. These statements of competencies include interdisciplinary content in engineering education such as basic mathematics and science knowledge, application of new information technology, the ability to solve problems, the ability to design and to think, ability for systematic logic, proactive attitude in learning, and working skill in a team. The outcome is in line with the regulation of “General Criteria 3. Student Outcomes” in the “Criteria for accrediting engineering programs 2012-2013” (ABET 2013). It is also consistent with the research result of Abdullah et al. (2012) that it is necessary to cultivate students’ soft and hard skills. This is an indication that the result of this study is beneficial to the cultivation of professionals who are IT competency-based.

	b5. Being able to work with team members	
	f1. Understands the method of generating creativity.	
d7. Being able to solve problems with	c7. Has good sense of responsibilit	d6. Being able to solve internet proble

		information technology	y	ms with skills		
		b6. Being able to adopt the most effective programming method.	e8. Being able to learn new media.	b7. Being able to work with a team in harmony.		
	d5. Has logical thinking.	a7. Understands the business model of mobile commerce.	a6. Understands knowledge management.	a4. Being familiar with Android systems	e3. An attitude that humbly accepts criticism	
	e7. Understands the basic technology of cloud computing service	b3. Good ability in time management	e2. Understands the concept of continuous improvement in information system	e1. Willing to take initiative in learning the technology involved in the project.	d3. Being able to revolve the clients' problems.	
	f6. Capable of design thinking	c6. Completing assignments effectively on time.	f7. Has the potential for innovation.	c5. Being able to accurately understand the need of the clients.	b2. Reliable in implementing work assignments.	
d1. Being able to analyse questions and locate	d4. Being familiar with all kinds of methods to resolve	f4. Being able to transform creativity to	d2. Efficient use of methods in resolving problems.	a3. Capable of using software development tools.	c4. Great utilisation of resources in implementing	c1. Being able to complete assignments on time.

the key.	problems.	customer service.			assignments	
c2. Capable for intercultural interaction.	b4. High success rate in performing assignments	a8. Being familiar with iOS system	e5. Being proactive in learning new skills.	f3. Expresses creativity at work.	e4. Being proactive in learning new knowledge.	b1. Good quality in completed assignment.
a2. Has actual ability for APP	f5. Understands the potential commercial value of the products.	e6. Being able to communicate regarding work coordination.	a5. JAVA programming language.	c3. Capable of project management.	f2. Commercialisation of creativity.	a1. Good working attitude.
-3	-2	-1	0	+1	+2	+3

Figure 1. The priority of the professional items conforms to industry needs by using Q-technique

Investigation Results

Regional IT competency survey

The Q factor is an aggregation composed by a group of people who have similar opinions, beliefs and attitudes; the Q factors represent a hypothetical attitude (Lo 1985). Exploratory factor analysis is thus adopted, using orthogonal rotations (Varimax with Kaiser Normalization). The result of factor analysis, after deleting A1, C19, and A23, indicates the communalities for each question falls in the range of 0.626 to 0.970. Four factors with eigenvalues > 1 are chosen; the first factor is named as: "efficiently completing the job". This is consistent with the perspectives of Lim, Anderson and McGrath (2012) that a person shall have the corresponding competencies for the task involved to demonstrate efficient work. The second factor is "actual technical implementation and learning", which is in line with Sandberg and Pinnington’s (2009) competence-based perspectives. The third factor is the "effective implementation of the task through great utilisation of resources" is in line with the perspectives of resource-based theory. The fourth factor is "being capable of creating market value" is in line with the viewpoint of the value chain model.

Table 2. Principal Component Analysis

	Component			
	1	2	3	4
C8	.919	.002	.087	.342
A3	.783	-.214	.051	.392
B7	.779	.191	-.439	.113
D14	.731	.327	.235	-.012
B5	.657	.027	.013	.637
F22	.651	.590	.158	.058
F21	.649	.133	.616	.043
E17	.039	.932	.086	.141
E18	.133	.889	.336	.005
D13	.311	.836	.321	.182
A4	-.053	.768	-.120	.137
E16	.609	.610	.090	.247
C11	.068	.216	.911	-.073
D12	-.027	.262	.868	.134
A2	-.039	-.150	.860	-.012
D15	.519	.439	.664	-.079
C9	.560	.270	.608	.440
B6	-.052	.340	.002	.920
C10	.307	.133	.274	.760
F20	.364	.044	-.231	.713
Explained Variance	43.48%	18.51%	13.26%	8.53%
Cumulative Explained Variance	43.48%	61.99%	75.25%	83.78%

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Rotation converged in 6 iterations.

Factor Attitude

A Z-Score factor array is created, to understand the factor attitude of each respondent toward each question (Barbosa et al. 1997). Since each question is transformed from 44 representative statements, each factor, in essence, includes a group of statements. Any question that demonstrates a high factor attitude (for example +3), suggests that the professional competency included in the question contains high priority and importance. Compared to other methods such as DACUM, Delphi, and V-tech, the result has a better presentation of the explanation intensity of the factors in each question.

Table 3. The factor attitude scale of each question

Items	Factor array			
	1	2	3	4
A2. The ability to develop a new IT product	-3	-3	+3	-3
A3. The ability to develop a new IT service item	+3	-3	-3	+2
A4. The actual ability for software application	-3	+3	-3	-2
B5. High success rate in executing assignments	+3	-3	-3	+2
B6. Able to effectively utilize e-commerce	-3	-1	-3	+3
B7. Reliable in executing work assignments	+3	+1	-3	-2
C8. Able to complete assigned tasks in time	+3	-3	-3	+1
C9. Able to utilize various resources in assignment execution	+1	-2	+2	-1
C10. The ability of project management	-1	-3	-2	+3
C11. Able to conduct cross-cultural interaction among co-workers from various nationalities	-3	-2	+3	-3
D12. Able to utilize IT method to resolve problems	-3	-2	+3	-3
D13. Able to resolve internet problem with skills	-1	+3	-1	-2
D14. Possesses good logic thinking	+3	+2	-1	-2
D15. Able to effectively resolve customers’ problems in time	+1	-1	+2	-3
E16. Be proactive in learning new knowledge	+2	+2	-3	-1
E17. Be proactive in learning new skills	-3	+3	-3	-2
E18. Possesses a humble attitude in accepting criticism	-3	+3	-1	-3

F20. Possesses designing ideas	-1	-3	-3	+3
F21 Able to transform creativity into customer service	+3	-2	+2	-3
F22. Able to commercialize creativity	+2	+1	-2	-3

Conclusion

The IT industry is marked by short product life cycles, and the characteristics of rapid technological change result in a great attention upon the gap between industrial demands and the problems of personnel training. This study is based upon competence-based theory, and ideas regarding cultivating talent to meet IT business needs, to identify the method of acquiring IT competency requirements. The study used the Q-technique, through a survey of qualitative expert advice from benchmark companies to obtain the universal IT competency requirements; regional cooperative enterprises were studied, to obtain IT competency requirements, the findings of which proved effective for future curriculum development. The study found that the IT industry competency requirements covered the six categories of information ability, fault tolerance, execution ability, problem solving, learning ability, and innovative ability. The universal IT professional competencies could be generalized using 44 representative statements, of which 17 were given priority. Regional IT professional competencies were covered using the four factors of "efficient completion of work", "ability to implement and learn technology", "best use of resources to effectively achieve objectives", and "ability to create market value". Each factor is formulated according to the state of a number of high-value factors.

On the practical application of research results, the Q-technique can effectively find the universal and regional requirements for competency in the IT industry. Based on the competency requirements of the regional enterprises, the feature development need of the department, and the level of factor attitude, each department can decide the competencies that should be learned by the students in school and conduct curriculum planning. The contribution of this study is, in addition to curriculum development methods such as DACUM, Delphi, and V-tech, that Q-technique can be a method for curriculum development, offering value to improving universal and individual IT curriculum.

Regarding research limitations, this study only introduces Q-technique as a method to acquire IT industry competency requirement and does not discuss the actual reform problem of the curriculum. Nor does this study discuss the various details of curriculum development; readers who are interested can refer to the curriculum development procedure written by Zeegers (2012). Future researchers may be able to develop IT curriculum modules based on the IT competencies in this study; or apply the Q-technique in other areas of curriculum development.

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