Exploring an industry-based basic technological competence indicator system of electrical technology for students at a technological institute

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ABSTRACT: The main purpose of this study was to establish an industry-based basic technological competence indicator system of electrical technology for students at a technological institute. To establish these standards, 12 people were interviewed, whose detailed comments were collected to establish the content for basic competence indicators in electrical technology industries. Then, numerous small business enterprise (SME) CEOs, directors and practical engineering technologists were invited - a total of 20 people from electrical-related industries rated the importance by using mode, mean, standard deviation, Kolmogorov-Smirnov one sample test, Kruskal-Wallis one-way analysis of variances by ranks and sign test. After two rounds of Delphi technique surveys, a competence indicator system was established. Three levels (dimensions, standards and indicators) and three dimensions (knowledge, skill and attitude) were identified. It is hoped that the proposed basic competence indicator system would serve as the basis for curriculum planning, development, accreditation and evaluation for electrical technology of a technological institute in Taiwan.

INTRODUCTION

With the booming high technology of the Taiwanese economy, the transformation of the industrial sector has accelerated rapidly. However, the scale of industrial expansion and the speed of R&D have surpassed the educational system. In addition, increases in the demand for a high quality labour force, and the requirements of planning, training, and deploying technology professionals in ways that comply with future national economic and technological developmental objectives has currently become an important core subject of discussion [1]. The present industrial sector has entered a highly technologically intensive, automated, and directional aspect of ascendancy and development. The diagram representing the requirements of such a technological intensive labour force has gradually shifted from a pyramid to the current structure resembling a lantern in Figure 1. This trend clearly shows a decrease in the demand for low tech labourers, but an accelerated demand for intermediate and high tech (service) professionals [2].

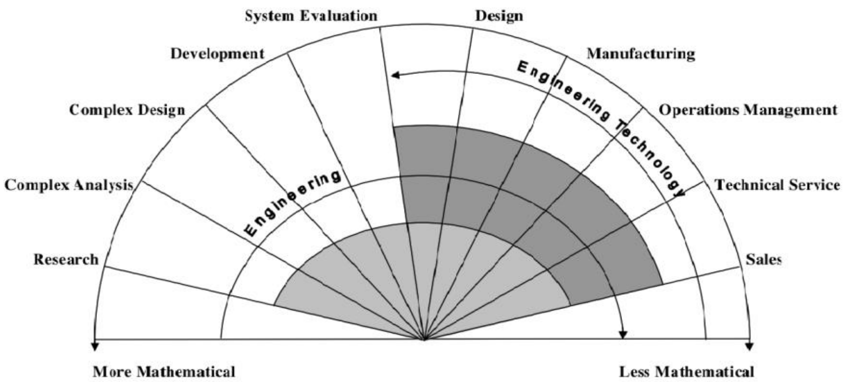

Figure 1: Duty scope of engineering and engineering technology (adopted from [3]).

The value of technological and vocational systems lies in the practical learning and exercises verifying the theory behind it. A student's sense of achievement through study can best be gained by the development of skills. Thus, technological and vocational education (TVE) should strive to maintain this key point in competency learning (i.e. learning of skills). As for the levels of competence in technology, distinctions can be based on the five-stages of the skills dimension in teaching objectives by Harrow, which start from the simplest stage of imitation to the most complex stage of naturalisation [4]. For that reason, the competence in specialised technologies being taught in Taiwanese technological institutes should begin from courses developed through the promotion of professional practices in technology; in other words, a series of programmes that teach basics to core technological competencies.

The Council for Economic Planning and Development (CPED), Executive Yuan, has issued a report on *Taiwan technology manpower supply and demand analysis from 2005 to 2015*. It points out that studies in the field of electrics (including electrical, electronics, telecommunications, information engineering and information management) show an increasing number of junior colleges have restructured into technological colleges, leading to substantial growth in the number of university institutes, with a resulting growth in the student body. The original junior colleges were equipped with their own electrical, information management and other related fields of study, which added to the number of bachelor-level electrical engineering and information science students [1]. The active promotion of the Taiwanese Two Trillion, Twin Star (T3S) industry (the four industries of semiconductor, display sectors, digital content and biotechnology), has driven the need for labour in the field of electrical engineering and information science at a much higher level. One could reasonably expect the growth of newly graduated electrical engineering students to fill this need, but the voices whispering about the lack of intermediate and high level technology professionals can still be heard from time to time. The reason appears to be that changes in the value chain of the industry have created a need for technology professionals to perform highly specialised duties. Unfortunately, new graduates from technological institutes do not have the skills to meet these new industry requirements. In the context of these aforementioned problems and requirements, the basic technological competencies of institutes in electrical engineering technology were selected as the target for this study.

The above analysis elucidates the question of how to achieve technological and vocational education (TVE) objectives through curriculum reform, to meet satisfactorily the evolving needs of the labour force. This is a question that the technological institutes in Taiwan urgently need to address. Based on this urgent awareness, the labour force requirements of the industry were used as a guide to analyse the basic competencies of professionals in electrical engineering technology - competencies which technological institutes are supposed to cultivate. It was hoped to develop a basic system of competence indicators in the field of electrical engineering to serve as a guide for the planning and development of curricula for programmes in technological institutes. It also hoped to provide a reference for the Institute of Engineering Education Taiwan (IEET) Amendment AC2004 regarding certification criteria for the accreditation of institutes offering courses in the fields of engineering technology.

LITERATURE REVIEW

The research began by ensuring that the meanings of competence, basic competence and industry-specific skills were properly defined. The criteria for accreditation of current educational programmes in engineering and technology were compiled along with data on basic competencies in the electrical technology industry from home and abroad. It was done for a basic initial draft of the criteria for competence in electrical engineering technology - competence with which technological institutes should equip their students.

Definition of Basic Competence in the Technology Industry

Before endeavouring to define basic competence within the context of technology industries, the definition of competence itself must first be elaborated. Having checked the precepts, one can move on to define clearly basic competencies in industry-specific skills.

Definition of Competence

In this study, the views of a number of researchers, who considered competence as an external behaviour comprising various dimensions of knowledge, skills and attitude, were examined [5-10]. From their perspectives, displays of competence can be diverse and multi-faceted with a number of competencies considered innate, while others are acquired through learning. Competence indicates an individual, who has acquired (through study or experience) the knowledge, skills and attitude required to perform particular functions in various aspects of life. In this regard, the definitions of *competence* and *skills* are connected.

The Meaning of Basic Competence in Industry-Specific Skills

Basic competence is the critically important core ability fundamental for survival. It is also a comprehensive, all-encompassing and physical ability necessary for living well. Basic competence deals with both knowledge and skills, without limiting the content of knowledge. Basic competence emphasises internalisation in the practice of living, working, learning and personal growth [11]. In this study, the term *industry-specific skills* was used to indicate *professional competence*. Professional competence is related to specific work or job-related capabilities, including professional knowledge, skills and attitude. Professional competence is an important indispensable factor, required when one seeks to successfully complete a task [5]. Peak and Brown have defined professional competence as the *relevant skills, knowledge, and attitude required for the sake of successfully performing tasks* [12]. Li also has advanced the idea of professional competence, when discussing individuals, who possess behavioural characteristics of knowledge, attitude and skills, which can lead to the successful performance of a task with a certain defined level of proficiency [13].

In summary, the researchers have divided competence in electrical technology industries into *basic competence* and *professional advanced competence*. *Basic competence* must cover the three dimensions of *knowledge*, *skills* and *attitude*. Basic competence in industry-specific skills is the industry-specific basic key competence (such as the electrical industry), which is considered crucial or difficult to replace. In other words, basic competence is the most basic relevant professional knowledge, skills and attitude one must possess to function in the industry. Professional advanced competence refers to industry-specific skills. It enhances one's expertise in a particular technology or within an industry-specific area (such as the electric power, control, electronics, optoelectronics, semiconductor, HVAC).

Content of Industry-Specific Skills in Electrical Industry Technology

The electrical industry covers a wide range of disciplines. In terms of technological and vocational school education, the fields related to electrical and electronic subjects are favoured by a high proportion of students, who are either pursuing or have expressed a willingness to pursue, a career in this field. Their establishment and the occupational classifications within this field are complex and diversified. They include personnel in seven areas of advanced technology: electronic engineering, electrical engineering; telecommunications engineering; information engineering; control engineering; refrigeration and air conditioning engineering; and optical engineering. In this study, the proposed details of basic competence in the electrical technology industry refers precisely to the aforementioned most basic professional knowledge, skills and attitudes with which one must be armed to function in the various fields of the electrical industry.

To assemble the requisite elements of basic competence in the electrical technology industry that is industry-based, researches have compiled numerous studies relevant to basic competence research in electrical industry technology. By referring to the Accreditation Board for Engineering and Technology (ABET) engineering Criteria EC2000 and IEET's AC2004 Accreditation Criteria, the following applies:

Plans for an Integrated Curriculum for Technological and Vocational System

In 1998, Taiwan's Ministry of Education began promoting integrated curriculum programme planning for Technological and Vocational Education (TVE). With regard to the subject areas of electrics in technological institutes, a planning group was scheduled to formulate objectives for the cultivation and education of the labour force. The group included middle- to senior-level technology personnel from electronic, electrical, telecommunications, information, control, air conditioning and refrigeration, optical engineering and other fields. Based on the findings of this group and the results of this study relevant to electrical and electronic subject areas, the university of science and technology determined that the necessary competencies for the labour force include: 1) *workplace and interpersonal relationships*; *ability to utilise technology*; *learning attitude*; *ability to utilise information technology*; management skills and other ability dimensions for a total of 23 indicators; 2) professional competencies, these include: *ability to utilise tools*; *ability to utilise devices*; *basic field expertise*; and other ability dimensions, for a total of 17 indicators [14].

Plan for Professional Competence in Electrical and Electronic Subject Areas in Technological and Vocational Education (TVE)

Liou used occupational analysis and content analysis to compile a list of professional duties and abilities required by technology personnel in electrical and electronic industries [2]. He pointed out that the training of personnel in advanced technologies at the level of technological colleges or science and technology universities focused primarily on predetermined professional competencies in design, management, development, application, testing and the analysis of electrical and electronic equipment and products.

In his research, he categorised the abilities required to perform five functions, including the ability to operate electrical and electronic tools and equipment, the ability to analyse digital logic circuits and electronic circuits, the ability to run computer software and utilise the Internet. These functions were combined with 25 other related skills to form the common core of competencies. A more general category of group competence contained five duty functions and 91 technology-related competencies.

ABET Engineering Criteria 2000

Since 1932, various major engineering societies in the United States bundled together to establish ABET for the purpose of certifying the quality of education in engineering and technology. The accreditation board has made annual adjustments to its Criteria for Accrediting Engineering Technology Programs. The 2008-2009 Criteria for Accrediting Engineering Technology Programs identified five indicators from electrical (electronic) engineering technology and other similar programmes for its evaluation criteria [15]:

1. ability to analyse, design, and implement control systems, instrumentation systems, communications systems, computer systems or power systems;
2. ability to apply project management techniques to electrical/electronic(s) systems;
3. ability to utilise statistics/probability, transform methods, discrete mathematics or applied differential equations in support of electrical/electronic(s) systems;

4. application of circuit analysis and design, computer programming, associated software, analog and digital electronics, and microcomputers to building, testing, operating, and maintaining electrical/electronic(s) systems;
5. application of physics or chemistry to electrical/electronic(s) circuits in a rigorous mathematical environment at or above the level of algebra and trigonometry.

IEET Accreditation Criteria 2004

Through the co-operation of engineering and technology educators in Taiwan, the IEET was created in 2003, to establish a *Taiwanese engineering and technology education certification programme*. This was done with the strong support of Ministry of Education and the National Science Council, and its main purpose was to raise the quality of education in Taiwan to a certification level *on par* with international standards. In September of 2003, the Ministry of Education and the National Science Council formally authorised IEET as the country's official certification organisation, serving as a window to international affairs. In June 2007, it became a member of the Convention on International Trade in Endangered Species (CITES) [16]. The recently revised Accreditation Criteria in IEET AC2010 stipulates in Article 3: *Assessment of the effectiveness of Department of Education in its plan for self-assessment, development, and improvement* that graduating students would be required to possess the following eight core competencies [17]:

1. ability to apply knowledge of mathematics, science and engineering;
2. ability to design and conduct experiments, as well as to analyse and interpret data;
3. ability to use techniques, skills and tools necessary for engineering practices;
4. ability to design an engineering system, component or process;
5. ability to manage projects, communicate effectively and function in a team;
6. ability to identify, analyse and solve problems;
7. knowledge of contemporary issues; an understanding of the impact of engineering solutions in environmental, societal and global contexts; the ability to cultivate habits of life-long learning;
8. ability to understand professional ethics and social responsibility.

Wang and Li attempted to understand the importance of core competence to employment as laid down in the IEET Accreditation Criteria, and, whether or not it met the demands of the job market for quality high-tech professionals. Through their survey, they determined that the industry generally agreed with the notion that core competence as defined in AC 2004 Accreditation Criteria was important to employment, but not necessarily adequate to meet the needs of the job market [18]. Abilities in the area of management and leadership, foreign languages, work attitude, emotional management, innovation, time management and others were other competencies required for development of the job market and careers.

In summary, despite the fact that industry representatives were included in surveys conducted by Li et al or Liou, most of the subjects were mainly from academia [2][14]. Categories of competencies developed so far have tended to favour the views of schools and teachers, standing some distance from the needs of industry. Accordingly, the formulation was initiated of the categories based on the results of the above-mentioned studies and the integration of ABET EC2000, to draft the indicators for the basic technological competence of electrical technologies for students of technological institutes. The core competencies as defined in IEET AC2004, ABET2008-2009 Criteria of Identifying Electronic Technology Curriculum, and proposed amendments by Wang and Li on core competencies as defined in AC2004 for IEET Accreditation Criteria, were used [18]. This comprised a total of three dimensions (knowledge, skills and attitude) and two levels (standards and indicators) for a total of 14 competence standards and 63 competence indicators.

METHODOLOGY

Expert interviews and Delphi technique surveys were employed in this study. The methodology and data analysis of this study is described in the following sections.

Modified Delphi Technique

The research commenced by reviewing summarised analysis in the general literature to draw up a *fitness interview and questionnaire survey on basic competence indicators in electrical technology industries*, compiling a total of 63 closed-end questions. In order for the competence indicators constructed in this study to actually meet industry demands, numerous SME CEOs, directors and practical engineering technologists were interviewed - a total of 12 people from electrical-related industries (including electric work, control, semiconductor, water and electricity/air conditioning, optical communications, etc), between March and April 2009. Their detailed comments were collected to establish the content for basic competence indicators in electrical technology industries.

According to the results from the above-mentioned fitness interviews and questionnaire surveys, *the construction of basic competence indicator system* was compiled and edited, using the Delphi questionnaire survey. Again, between May and June 2009, numerous SME CEOs, directors and practical engineering technologists were invited - a total of 20 people from electrical-related industries (including electric work, control, semiconductor, water and electricity/air conditioning, optical communication, etc), for a second round of surveys, using the modified Delphi survey. For each round of the survey, the experts were invited to assess and grade the level of importance for each indicator, using a Likert's 5-point scale. Attached to the second round of questionnaire surveys were responses from experts in the previous round of surveys, opinions from experts groups and other descriptive statistics (mode, mean and standard deviation). This provided a reference for experts during the second round of the survey response. It was the researchers' intention to focus on the convergence of public opinion to achieve consistency among the responders.

Data Analysis

After the first round of questionnaire survey response data were collected, expert assessment of the fitness level for each indicator was interpreted, based on the frequency distribution of each level. The content of the revised indicators based on expert opinion of the fitness level of each competence indicator was integrated and assessed. The second and third round data were analysed, using descriptive statistics (mode, mean, standard deviation, etc) to reveal the views of the experts. Kolmogorov-Smirnov one sample test in nonparametric statistics was used to analyse the consistency of agreement for each view expressed by the experts, in response to second and third round questionnaire surveys. Kruskal-Wallis one-way analysis of variance by rank was used to test separately the existence of any level of significance, regarding the differences in views expressed by the experts in various positions and occupations within the target industry. Finally, a sign test was used to compare the SD of views from the experts on each subject in the first and second round of the survey to determine the level of significance regarding differences, and to determine whether a trend toward a consensus of opinions existed among the experts.

RESULTS

Competence Indicator Fitness Analysis

First, the results from the structured interviews and questionnaire surveys were collected to reveal the views of experts regarding the fitness level of each detailed indicator for basic competence in electrical technology industries within technological institutes. As shown in Table 1, less than a third of the detailed indicators were assessed as unfit by the experts (i.e. 4 times); therefore, it was determined that the detailed indicators used in this study should be retained.

Second, based on the proposed amendments to each detailed indicator provided by various industry experts during their interviews, their views regarding further adjustments to the questionnaire survey were determined. Finally, a basic indicator system for technological competence of electrical technology for students of technological institutes was created, including a total of three dimensions (knowledge, skills and attitude) and two levels (standards and indicators), for a total of 14 competence standards and 65 competence indicators.

Analysing the Importance of Competence Indicators

Analysis of Consistency

As seen in Table 1, the Kolmogorov-Smirnov one sample test revealed that 63 of the 65 indicators of basic electrical technology competence reached a significant level ($p<0.05$) with regard to perceptions of importance. This indicated that during their third round of the questionnaire survey on the issue of importance of perception, the experts in this study had very similar views on basic competence indicators. The expert views that a significant level of consistency was not reached with regard to competence indicators during the third round of the questionnaire survey included *English presentation ability*, *the ability to use general machinery and equipment* and *the ability to explain and translate technical terms*.

Expert Background Variable Difference Analysis

As seen in Table 1, Kruskal-Wallis one-way analysis of variance by rank revealed that experts' perceptions of importance regarding various aspects of *technological basic competence of electrical technology for students of technological institutes* for the 65 competence indicators did not reach a level of significance ($p<0.05$) with regard to difference. On the other hand, except for *English presentation ability*, the views of other experts in various industries revealed no significance in the differences regarding the perception of importance on the remaining 64 indicators of competence.

Analysis on the Formation of Consensus Views

As seen in Table 1, in terms of SD in terms of the importance regarding the 65 competence indicators between the first and second round of the questionnaire surveys, seven showed a decrease, 5 showed no change, and four showed a slight increase. The sign test revealed that the standard deviation generated from the two rounds of the survey reached a level of significance with regard to difference.

This indicated that during the second round of the Delphi survey, the views of experts regarding the importance of various competence indicators addressing issues of *technological basic competence of electrical technology for students of technological institute* revealed a trend towards consensus.

Table 1: Statistical analysis of results of the Delphi questionnaire survey.

Dimensions	Standards and Indicators	Mean	Mode	SD	K-S	χ^2 (duty)	χ^2 (industry)	△SD
Knowledge	1-1 Professional languages							
	1. Ability to read Chinese language professional technology documents.	4.81	5	0.40	3.25***	0.39	3.73	—
	2. Ability to write Chinese language professional technology documents.	4.50	5	0.63	2.25***	2.88	3.46	—
	3. Chinese language presentation ability.	4.44	4	0.51	2.25***	2.14	6.43	—
	4. Ability to read English language professional technology document.	4.44	5	0.63	2.00***	4.77	2.43	—
	5. English language presentation ability.	3.75	3	0.93	1.08	6.35	8.26*	○
	1-2 Scientific knowledge							
	1. Ability to apply mathematical methods to solve problems in electrical technology.	4.00	4	0.82	1.92***	1.24	3.24	—
	2. Ability to apply knowledge in physics to practical situations in electrical technologies.	4.25	4	0.58	1.75***	0.87	2.25	—
	3. Ability to apply knowledge in chemistry to practical situations in electrical technologies.	3.13	3	0.72	1.92***	1.82	3.03	—
	1-3 Relevant laws and regulations							
	1. Knowledge of various relevant international electrical professional certifications (e.g. CNS, CE, UL, JIS ... etc).	4.13	4	0.62	1.50*	1.99	1.43	—
	2. Knowledge of industrial safety laws and regulations.	4.69	5	0.48	2.75***	0.82	1.60	—
	3. Knowledge of the environmental protection laws and regulations.	4.44	4	0.51	2.25***	2.14	1.17	—
	4. Knowledge of relevant intellectual property rights.	4.25	4	0.58	1.75**	0.02	3.72	—
	1-4 Developments in industry							
	1. Understanding the environmental, social and global implications of electrical technologies.	4.25	4	0.68	1.50*	2.60	1.58	○
	2. Understanding overall developments in current electrical industries.	4.31	4	0.60	1.75**	1.61	0.48	—
	3. Ability to analyse factors affecting development of the electrical industry.	4.06	4	0.57	1.50*	1.95	2.35	—
	4. Understanding green energy industry trends affecting development of electrical industry.	4.88	5	0.34	3.50***	2.14	5.50	—
	1-5 Problem-solving							
	1. Ability to think innovatively and laterally.	4.69	5	0.60	3.00***	2.26	2.41	—
	2. Ability to explore issues.	4.69	5	0.48	2.75***	2.46	4.20	—
	3. Ability to collect and analyse data.	4.63	5	0.50	2.50***	1.00	2.61	—
	4. Ability to think systematically.	4.88	5	0.34	3.50***	6.43	2.25	—
	5. Ability to reason logically.	4.88	5	0.34	3.50***	2.14	2.25	—
Skills	2-1 Use of tools							
	1. Ability to use hand tools.	4.38	5	0.86	2.50***	0.74	0.41	—
	2. Ability to use power tools.	4.44	5	0.81	2.50***	0.97	3.04	—
	3. Ability to use electrical tools.	4.44	5	0.81	2.50***	0.97	3.04	—
	4. Ability to use measurement tools.	4.81	5	0.40	3.25***	1.15	4.20	—
	5. Ability to identify instrument specifications in standard or metric system.	4.06	4	0.57	1.50*	0.55	1.75	

$^{*}p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$

Table 1: Statistical analysis of results of the Delphi questionnaire survey (cont.).

Dimensions	Standards and Indicators	Mean	Mode	SD	K-S	χ2 (duty)	χ2 (industry)	△SD
Skills	2-2 Use of devices							
	1. Ability to use ordinary electrical measuring instruments.	4.50	5	0.63	2.25^{***}	0.92	2.10	－
	2. Ability to use ordinary electric instruments.	4.50	5	0.63	2.25^{***}	0.92	7.94	－
	3. Ability to use general information technology equipment.	4.31	4	0.60	1.75^{***}	0.54	4.70	－
	4. Ability to use general machinery.	4.00	4	0.73	1.00	0.70	3.50	○
	2-3 Basic field expertise							
	1. Ability to use electrical and electronic components.	4.38	4	0.50	2.50^{***}	0.50	4.53	＋
	2. Ability to use computers to draw circuit diagrams.	4.81	5	0.40	3.25^{***}	4.23	3.14	－
	3. Ability to assemble power circuits and industrial wiring.	4.25	4	0.77	2.42^{***}	1.61	3.55	－
	4. Ability to analyse and design electronic circuits.	4.25	4	0.77	2.42^{***}	1.21	6.75	－
	5. Ability to analyse and apply digital logic circuits.	4.38	5	0.81	2.42^{***}	5.30	6.23	＋
	6. Abilities in circuit model construction and system integration.	4.25	4	0.77	2.42^{***}	1.61	2.56	－
	2-4 Information technology							
	1. Ability to use the internet.	4.63	5	1.09	3.50^{***}	2.15	5.50	○
	2. Ability to operate computer applications.	4.88	5	0.50	3.75^{***}	3.00	5.50	－
	3. Abilities in general programming (e.g. VB).	4.13	4	0.50	1.75^{**}	4.45	4.63	－
	4. Ability to use information media professional competence aids.	4.25	4	0.58	1.75^{**}	1.32	0.17	－
	2-5 Leadership and management							
	1. Abilities in organisation planning.	4.69	5	0.60	3.00^{***}	2.58	0.30	－
	2. Abilities in task management.	4.63	5	0.50	2.50^{***}	0.50	1.17	－
	3. Ability to resolve conflict and inspire morale.	4.44	5	0.63	2.00^{***}	0.81	0.88	＋
	4. Ability to adapt to changing environments.	4.69	5	0.48	2.75^{***}	0.82	0.63	－
Attitude	3-1 Interpersonal communication							
	1. Ability to communicate effectively with others.	4.88	5	0.34	3.50^{***}	2.14	3.14	－
	2. Ability to act as the driving force behind teamwork.	4.94	5	0.25	3.75^{***}	3.00	5.50	－
	3. Ability to explain and translate technical terms.	4.19	4	0.66	1.50	1.26	0.39	○
	4. Ability to affect harmonious social relationships.	4.69	5	0.60	3.00^{***}	2.26	2.50	－
	5. Ability to effect emotional management.	4.88	5	0.34	3.50^{***}	2.14	3.14	－
	3-2 Lifelong learning							
	1. Possess a strong desire and initiative to learn.	4.88	5	0.34	3.50^{***}	3.43	1.96	－
	2. Ability to think independently.	4.81	5	0.40	3.25^{***}	3.46	1.96	－
	3. Ability to take the initiative to explore and study issues.	4.75	5	0.58	3.25^{***}	1.15	2.06	－
	4. Possess the habit of thinking systematically and laterally.	4.56	5	0.81	2.75^{***}	0.42	1.32	○
	5. Ability to effect realisation and execution necessary for lifelong learning.	4.50	5	0.63	2.25^{***}	0.83	1.50	－

$^{*}p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$

Table 1: Statistical analysis of results of the Delphi questionnaire survey (cont.).

Dimensions	Standards and Indicators	Mean	Mode	SD	K-S	χ2 (duty)	χ2 (industry)	△SD
Attitude	6. Ability to keep up with international affairs and see from an international perspective.	3.88	4	0.62	1.50*	2.98	2.35	－
	3-3 Professional ethics							
	1. Knowledge of professional ethics and responsibilities pertaining to technology.	4.38	4	0.50	2.50***	0.50	0.63	－
	2. Ability to comply with the law and possess a high degree of democratic civic maturity.	4.19	4	0.83	2.17***	0.89	1.36	－
	3. Ability to respect life and care for the community.	3.94	4	0.68	1.25***	2.31	0.00	－
	4. Ability to take positive initiative and be a sociable professional.	4.50	5	0.63	2.25***	0.83	0.00	－
	3-4 Occupational safety and health							
	1. Good work habits and discipline.	4.81	5	0.40	3.25***	1.15	3.33	－
	2. Good environmental protection tendencies.	4.44	5	0.81	2.42***	0.06	1.32	－
	3. Knowledge of workplace evacuation procedures.	4.44	5	0.81	2.50***	0.35	0.86	－
	4. Ability to use firefighting and prevention equipment.	4.38	5	0.81	2.25***	0.34	0.30	＋
	5. Ability to identify and guard against toxic substances in the workplace.	4.50	5	0.82	2.75***	0.68	2.49	－
	6. Knowledge of how to correctly handle electricity and the ability to provide first-aid treatment.	4.50	5	0.82	2.75***	0.68	2.49	－

$^{*}p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$

「＋」 represents Standard Deviation (SD) increase in the second and third round of survey

「－」 represents Standard Deviation (SD) decrease in the second and third round of survey

「○」 represents Standard Deviation (SD) unchanged in the second and third round of survey

Table 2: Mean and sorting by importance in competence dimensions and standards.

Dimensions	Standards	Mean of Standard	Rank of Standard	Mean of Dimension	Rank of Dimension
Knowledge	Professional language	4.39	9	4.39	3
	Scientific knowledge	3.75	13		
	Relevant laws and regulations	4.38	11		
	Industry development	4.38	11		
	Problem-solving	4.75	1		
Skills	Tool use	4.43	8	4.44	2
	Device use	4.44	7		
	Basic field expertise	4.39	10		
	Information technology	4.47	6		
	Leadership and management	4.61	3		
Attitude	Interpersonal relationship	4.72	2	4.53	1
	Lifelong learning	4.56	4		
	Professional ethics	4.25	12		
	Occupational safety and health	4.51	5		

Sorting Analysis on Importance Perceptions

As seen in Table 2, using analysis based on three dimensions of competence as proposed by Bloom et al [19], the item of highest importance as expressed by industry experts towards basic competence indicators in electrical technology industries was the dimension of attitude (M=4.53), with the dimension of skills (M=4.44) in second, and the dimension of knowledge (M=4.39) last; however, little difference was found between the three. With regard to perceptions of importance related to competency standards, *problem-solving ability* was the highest (M=4.75) within the dimension of knowledge; *leadership and management* was the highest (M=4.61) within the dimension of skills; *people relationship* was the highest (M=4.72) within the dimension of attitude. Finally, based on the results of the above-mentioned analysis sorting by perceptions of importance, it was learned that the perception of highest importance expressed concerning employees in today's electrical industry was the dimension of attitude.

CONCLUSIONS

Industry-Based Basic Technological Competence Standards of Electrical Technology

Based on reviews of literature and three rounds of Delphi surveys, it was confirmed that the indicator system for basic technological competence of electrical technologies as it pertains to students of a technological institute contained three dimensions (knowledge, skills and attitude), and two levels (standards and indicators) for a total of 14 competence standards and 65 competence indicators. With regard to the dimension of knowledge, five standards of competence were found, in professional language, scientific knowledge, relevant laws and regulations, industry development and problem-solving, as well as 21 indicators of competence. With regard to the dimension of skills, the researcher found five standards of competence in ability to use tools, ability to use equipment, basic field expertise, abilities to utilise information technology and abilities in leadership, as well as 23 indicators of competence. With regard to the dimension of attitude, the researcher found four standards of competence in interpersonal communication, life-long learning, professional ethics, and occupational safety and health, as well as 21 indicators of competence. The structure of the basic competence indicator system is shown in Figure 2.

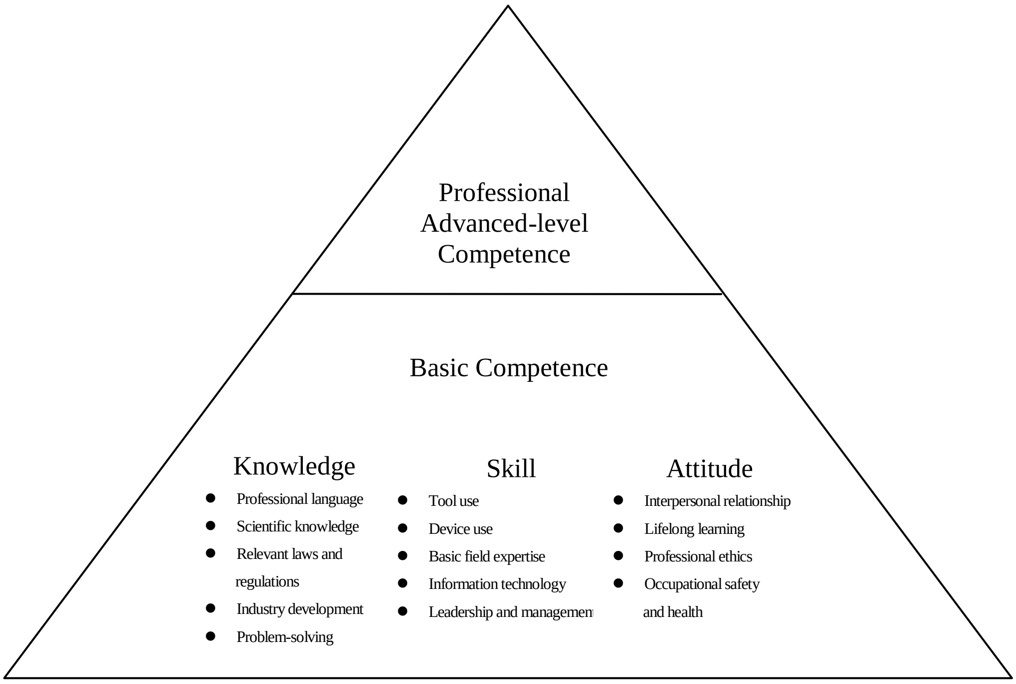

Figure 2: Indicator system for basic technological competencies in electrical technologies for students of technological institutes.

Technological Institute's Curriculum Programme and IEET Accreditation Criteria

Analytic results showed that problem-solving abilities, leadership and management skills, and interpersonal relationship skills were the standards of competence perceived to have the highest level of importance within their respective dimensions. With regard to basic competence in electrical industry technologies, formal and extracurricular courses, as well as training students with the basic practical professional skills expected by the industry, should be utilised to strengthen the development of the critical core competencies. This research suggests that departments of electrical technology in technological institutes should assess the position of their schools, market segmentation, student quality, regional industry characteristics and other related factors, by carefully consulting the indicator system.

To summarise the results, it was learnt that, in addition to the core competencies subscribed by the AC 2010 Accreditation Criteria, professional language skills (reading, writing and presentation), understanding relevant laws and regulations, application of information technology, and leadership and management abilities are also core competencies that industry believes are necessary to meet the demands of the job market. Higher Technological and Vocational Education (HTVE) is the last school education that students receive before entering the job market. Therefore, it is essential that such institutes equip students with the core competencies demanded by the job market. In this study, research was carried out with a single objective to determine the basic competencies required to function in electrical technology industries. It is recommended that IEET, in its overall evaluation, decides whether or not to include the above-mentioned competencies in its list of core competencies for accreditation criteria, to cultivate competitive top-level technology professionals for the electrical industries of Taiwan.

Similar to using examinations as a guide in the teaching process; the demand for core competencies to meet the accreditation criteria requirements is taken as a model to be followed by various engineering and technology departments in Taiwan. It will also guide in setting up educational objectives, thereby affecting the direction of HTVE, with far reaching consequences. Therefore, it is recommended that IEET considers ABET practices separately, so as to establish engineering and technology curriculum programme evaluation indicators for different professional fields; and, through timely amendments, draft a set of accreditation criteria that suit the national situation and industrial structures of Taiwan.

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