International Journal of Engineering Education Vol. 28, No. 3, pp. 599–605, 2012
Printed in Great Britain
0949-149X/91 $3.00+0.00

The Working Competency Items for Energy Technology: A Three-Stage Empirical Method*

WEN-JYE SHYR and TSUNG-CHIN LO
Department of Industrial Education and Technology, National Changhua University of Education, No. 1, Jin-De Road, Changhua 500, Taiwan, R.O.C. E-mail: shyrwj@cc.ncue.edu.tw

This study employed a three-stage empirical method to establish a set of working competency items considered important for energy technology based on industrial requirements. Stage I was conducted to develop an initial list of competencies, comprised of Behavioral Event Interviews (BEI) with three energy technology field engineers. In Stage II the Delphi Technique involved three rounds of questionnaire surveys of ten field experts and scholars followed by the Kendall Coefficient of Concordance Analysis examining the consistency of respondent opinions to check to see whether they reach a level of significance. A list of 45 competencies in 3 domains was then developed. In Stage III these competencies and domains were verified quantitatively by surveying 32 learners studying energy technology followed by a nonparametric Mann-Whitney U Test. The research findings reveal the practical competency requirements for students in a technology university program.

Keywords: Delphi technique; competency analysis; energy technology

1. Introduction

The teaching objective of energy technology education is to increase student competency. It further cultivates their attitude towards active employment based on the interactions of competency in operating actions, competency in taking actions, competency in taking continuous action and competency in stimulating actions [1]. Researchers have sufficient competency to propose innovative thinking and put it into practice [2–3].

Competency may mean the intellectual or physical ability to perform some task. A broader definition of this term, which is used in this context, includes attitudes as well as skills and knowledge. Thus, for example, Spencer and Spencer [4] referred to such competencies as knowledge, skills, positive attitudes, personal values and self-motivation, which can be both observable and non-observable.

Huang [5] indicated that, in the long-term, technology education must satisfy the demands of industry and society. However, to address rapid social and industrial changes, the curricula of technological education should be adjusted and amended in a timely fashion [6]. Kang [7] mentioned that technological education curricula must perform four essential functions: (1) prepare students to participate in the job market and perform their duties efficiently; (2) consider the number of students, content, materials, and facilities and match the demands of the job market; (3) connect with industries and make the best use of social resources that contribute to the career development of students; and (4) evaluate curricula changes needed to enhance student knowledge, skills, attitudes, and value in school and their job performance employment prospects once they have graduated.

This study proposes practical competencies required for jobs needed in the energy technology industry. To meet this purpose, the research started with a literature review and behavioral event interviews. Working competency items and job requirements were analyzed by the Delphi Technique to assess the feasibility and accuracy of the proposed measure of working competency development. Descriptive analysis was adopted for means, modes, standard deviations, Z-values for the K-S Test (Kolmogorov-Smirnov Test), and results from the nonparametric Mann-Whitney U Test. Field scholars in engineering education and energy technology experts were invited to assess the fitness of the competency items [8].

This study attempts to identify a set of competencies for students of energy technology and confirm the structural features of these competencies using empirical data. The aim of this is to contribute to a better understanding of the competencies needed for energy technology learning, to offer technology institutions practical guidelines for learner support and retention measures, and to help students of energy technology improve their completion rates.

2. Energy technology

Energy technology is an interdisciplinary engineering science having to do with efficient, safe, environmentally friendly and economical extraction, conversion, transportation, storage and use of energy, targeted towards yielding high efficiency

* Accepted 10 January 2012.

while skirting side effects on humans, nature and the environment [9].

Energy sources are classified as renewable and nonrenewable. Renewable energy sources can be replenished within a short period of time, while nonrenewable sources may take millions of years to form, and their supplies are limited. The 12 energy sources can be classified into two categories: (1) Renewable Energy: wind, solar, hydropower, geothermal, biomass, hydrogen and ocean wave; and (2) Non-renewable Energy: petroleum, natural gas, uranium, coal and propane. At least 12 major energy sources are currently in use throughout the world today: wind, solar, hydropower, geothermal, biomass, hydrogen, ocean wave, petroleum, natural gas, coal, uranium, and propane.

All energy sources have environmental, economic, and societal costs. Advocates, governments, and bureaucracies place differing emphases on the relative importance of these factors. The availability and cost of energy are determining factors in the economic health and growth of societies. The sooner clean, nonpolluting renewable energy provides a significant proportion of energy needs, the sooner all can benefit from cleaner air and a stable climate [10].

3. Function of competency analysis

Competency analysis identifies the behaviors required for professionals to perform job-related tasks. Identified behaviors included motive, characteristic and skill; or knowledge of the fundamental characteristic. Specifically, competency refers to the employee performance required to work effectively, especially when adequately playing a role or undertaking a task [11]. Thus, competency is not only an aggregation of knowledge, skills, and attitudes, but also a dynamic concept of putting theory into practice.

More specifically, competency also refers to the ability to achieve an outcome in a specific situation [12]. In order to efficiently achieve the industrial requirements of energy technology, what needs to be done first is to analyze the content of the competency in an energy technology course, so that the items and standards concerning measuring competencies can be determined. A technological university program should be implemented according to industry requirements, and the competency analysis process should identify whether students have attained the competency standards. The main purpose of competency analysis is to identify essential work knowledge, attitudes and skill [13–14].

McClelland [15] suggested the term competency as a criterion for judging successful performance. Competency frameworks have been applied in various settings—for example, for assessing company managers and employees, as training and recruitment tools [16–17], and for educational professionals such as instructors, instructional designers and evaluators for the purposes of staff development, recruitment and curriculum design [18–20]. So [21] characterized these as attempts to define the human resource needs of a knowledge-based and capitalist society. Some see competency being defined from certain stakeholders' perspectives and interpreted in different ways according to the different interests [22–23]; some see it as fuzzy despite its usefulness in bridging the gap between education and job requirements but many agree that defining competencies explains what persons engaged in various occupations or tasks are expected to do to be regarded as performing well [24].

4. Behavioral event interview

Several methods have been adopted for defining and developing competencies. The most commonly applied of these is the Behavioral Event Interview (BEI). It arrives at definitions of competencies by comparing outstanding performers with average or ordinary performers. McClelland [25] explained that BEI is an adaptation of the critical-incident interview for noting differences between high and typical performance. Competencies are defined through structured interviews in which successful and ordinary performers describe what they did, said and thought; and then using content analysis to compare the various statements and identify the critical competencies in the setting under investigation. Empirical data collection and systematic content analysis are seen as the main advantages of the BEI [26].

Several alternatives to the BEI Method have been undertaken in various contexts. Gregory [27] conducted competency interviews with highly-regarded communicators to identify the competencies of public relations practitioners. In the context of education, Marrelli [28] and Marrelli et al. [29] suggested applying the BEI only to superior performers. This method seems to be a useful means of identifying the competencies needed in formal education where goals are usually preordained, specific and subject to assessment and evaluation.

5. Delphi technique

The Delphi Technique is widely used and accepted for gathering data from respondents within their domain of expertise. The technique is designed as a group communication process for achieving a convergence of opinion on a specific real-world issue.

The Delphi Process has been used in various fields of study, including program planning, needs assessment, policy determination and resource utilization, to develop a full range of alternatives, explore or expose underlying assumptions, as well as to correlate judgments in many disciplines. The Delphi Technique is well suited as a technique for consensus building by using a series of questionnaires delivered using multiple iterations to collect data from a panel of selected subjects. Any staff member who assigned a rank derived by 10 or more points from the corresponding first Delphi median rank was requested to state the rationale for the dissenting opinion in the space below the problem [30]. Concerning the appropriate number of subjects for performing the Delphi Technique, researchers should use the minimally sufficient number of subjects and should verify the results by follow-up explorations. The number of experts used in a Delphi Technique is generally determined by the number required to constitute a representative pooling of judgments and the information processing capability of the research team. However, the literature reveals no consensus as to the optimal number of subjects required to perform the Delphi Technique. Researchers suggest that 10–15 subjects could be sufficient if the background of the Delphi Technique subjects is homogeneous [31–32].

6. Methodology

6.1 Questionnaire design

To fulfill research objectives, a questionnaire was designed to collect data in 3 domains: (1) knowledge, (2) attitude, and (3) skill; and to collect 45 working competency items in energy technology industry-related domains. Each competency was rated by its importance to job performance in the energy technology industry. A Likert Scale was used in this questionnaire. Members of the Delphi Group were asked to assess each competency according to the following 5-point scale: "5-very important," "4-more important," "3-somewhat important," "2-less important," and "1-least important" in their job performance.

This study drew on the findings and experience outlined above and employed a three-stage method for data collection and analysis. Stage I involved using the BEI to initially define competencies in three energy technology field engineers. Stage II involved the Delphi Technique using ten field experts and scholars with several years of experience in order to examine the consistency of the BEI findings. Stage III involved quantitatively verifying the results of Stages I and II with a group of energy technology learners.

There were several reasons for adopting this method. One was that it involved gauging the competencies in energy technology field engineers at the very first stage, and the BEI was seen as the best way of doing this. Finally, the qualitative data collected and clustered in the first and second stages needed to be quantifiably verified with a group of energy technology learners so that the results could be validated and generalized [33].

6.2 Participants

Three energy technology field engineers were involved in the BEI in Stage I. The participants in the Delphi Technique in Stage II were five professors and five researchers with an average of 8 years of experience in energy technology teaching, research, and development. Six of these had doctorates in education, educational technology or engineering. The participants in the survey in Stage III were 32 energy technology students from technology universities in Taiwan.

6.3 Instruments

For the BEI in Stage I, questions were developed and verified with three energy technology field engineers as to content validity. Forty-five questions for the Delphi Technique in Stage II were examined. These mainly concerned the experts' experiences in energy technology teaching and research and their thoughts and experiences. The survey instrument used in Stage III contained three items: two on personal information including gender and age and one asking respondents to assign an importance rating to each of the 45 competencies leading to energy technology learning and its relationship to their own study. The pilot version of this instrument was reviewed by four educational technologists and in the light of their feedback; revisions were made several times to all items considered confusing or ambiguous in order to establish consistency of wording and format.

6.4 Procedure

The three stages of the study were carried out between January 2011 and February 2011. In Stage I, before the BEI was carried out with the three energy technology field engineers, they were each sent emails explaining the purposes of the study, the nature of the interview process and the questions that they would be asked. The actual face-to-face interviews took an average of 1.5 hours per engineer. During these interviews, the interviewees were asked to respond to questions and provide detailed accounts of how they handled critical study situations in response to questions. The interviews were audio-recorded with the permission of the learners.

In Stage II, emails were first sent out to the ten

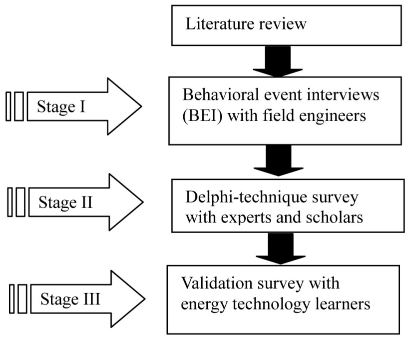

Fig. 1. Three-stage competency development process.

experts and scholars explaining the purposes of the Delphi Technique Surveys. Three rounds of Delphi Technique Surveys were then conducted to determine the working competency items for energy technology.

Stage III involved the administration of the 3-items survey. The respondents were volunteers who had learned about the survey primarily by email from their instructors at a technology university. Fig. 1 illustrates the three-stage competency development process.

Table 1. Consistency data analysis of energy technology competency items for K-S test

Competency items	M	SD	Z-value
1. Knowledge			
1.1. Can describe the major energy in Taiwan	4.90	0.316	2.846**
1.2. Can describe all kinds of energy supply structurally in Taiwan	4.80	0.422	2.530**
1.3. Can describe worldwide policy of energy	4.30	0.483	2.214**
1.4. Can describe all kinds of non-renewable energy sources	4.40	0.516	1.897**
1.5. Can describe all kinds of renewable energy sources	4.70	0.483	2.214**
1.6. Can describe advantages and disadvantages of non-renewable energy sources	4.30	0.483	2.214**
1.7. Can describe advantages and disadvantages of solar energy	4.80	0.422	2.530**
1.8. Can describe advantages and disadvantages of wind energy	4.60	0.516	1.897**
1.9. Can describe advantages and disadvantages of biomass energy	4.10	0.316	2.846**
1.10. Can describe advantages and disadvantages of water energy	4.10	0.316	2.846**
1.11. Can describe advantages and disadvantages of hydrogen energy	4.10	0.316	2.846**
1.12. Can describe advantages and disadvantages of fuel cells	4.30	0.483	2.214**
1.13. Can explain the greenhouse effect	4.80	0.422	2.530**
1.14. Can describe a way to deal with greenhouse effect	4.90	0.316	2.846**
1.15. Can describe a way to popularize energy saving and carbon reduction	4.70	0.483	2.214**
1.16. Can describe solar energy equipment translating process	4.10	0.316	2.846**
1.17. Can describe wind energy equipment translating process	4.00	0.000	
1.18. Can describe water energy equipment translating process	4.00	0.000	
1.19. Can describe hydrogen energy equipment translating process	4.20	0.422	2.530**
1.20. Can describe fuel cell equipment translating process	4.20	0.422	2.530**
2. Attitude			
2.1. Can determine value of different energy technologies	4.70	0.483	2.214**
2.2. Can identify energy technology and bring new ideas	4.80	0.422	2.530**
2.3. Can attend energy saving and carbon reduction events	4.40	0.699	1.581*
2.4. Can replace vehicle with walking or biking	4.70	0.675	2.530**
2.5. Can extend energy saving and recycling ideas	4.80	0.422	2.530**
2.6. Can prioritize choice products with energy conservation markers	4.60	0.516	1.897**
2.7. Can execute recycling of garbage and garbage sorting	4.80	0.422	2.530**
2.8. Can execute temperature adjustment of air conditioner to save energy	4.80	0.422	2.530**
2.9. Can care about global energy information	4.30	0.483	2.214**
2.10. Can understand that energy saving and carbon reduction is everyone's responsibility	4.50	0.527	1.581*
2.11. Can care about energy developing issues	4.30	0.483	2.214**
2.12. Can read manual before operating brand new household appliance	4.50	0.527	1.581*
2.13. Can use natural power and reduce use of household appliances	4.90	0.316	2.846**
2.14. Can support development of efficiency products	4.90	0.316	2.846**
2.15. Can use eco-friendly products	4.90	0.316	2.846**
2.16. Can guarantee reduction of wasted energy	4.80	0.422	2.530**
2.17. Can care about global environment and climate issue	4.30	0.483	2.214**
3. Skill			
3.1. Can operate energy technology related equipment appropriately	4.30	0.483	2.214**
3.2. Can understand how energy technology works	4.30	0.483	2.214**
3.3. Can operate solar energy module	4.30	0.483	2.214**
3.4. Can operate wind energy module	4.20	0.422	2.530**
3.5. Can operate biomass energy module	4.10	0.316	2.846**
3.6. Can operate water energy module	4.00	0.000	
3.7. Can operate hydrogen energy module	4.10	0.316	2.846**
3.8. Can operate fuel cell module	4.20	0.422	2.530**

* $p < 0.05$, ** $p < 0.01$.

6.5 Data analysis

For the Stage II data analysis, descriptive analysis was adopted for means (M), standard deviations (SD), and the Z- value of the K-S Test. After the questionnaires were received, the correlation analysis for relationships between two sets of second round and third round of Delphi technique were carried out.

For Stage III data analysis, the nonparametric Mann-Whitney U Test was used to confirm the importance of the 45 competencies in this study.

7. Results

The results of the three rounds of Delphi technique expert questionnaires are shown in the Table 1, including knowledge, attitudes, and skills. The K-S test found that a value equal to 0.05 was statistically significant and that participants considered the items more important and consistent. In terms of the importance of job performance, the mean score for 45 working competencies in three domains in the energy technology industry were above 4, which indicated that the Delphi group considered the competencies listed in the questionnaire to be 'more important'. The Kendall coefficient of concordance test was applied to evaluate the relationship between the Chi-Square (χ^2) value of 211.111 and the items that participants considered important.

Further analysis was conducted to confirm whether field experts and learners differed in mean ratings for the importance of the competencies. The nonparametric Mann-Whitney U test was used and the results are presented. With respect to knowledge domain, it includes the 20 items (Table 2). As for attitudes domain, it includes the 17 items (Table 3). With respect to skills domain, it includes the 8 items (Table 4). The level of significance α was selected to be 0.05. The corresponding two-tail critical value was ±1.96. Except for items #1.2, #1.16, #1.17, #1.18 and #2.17, the mean ratings of the field experts regarding the importance of the competencies did not significantly differ from the learners.

8. Discussion

There are three important outcomes of this study. First, the results contribute to and enrich the literature by presenting a set of working competency items and their relative importance based on empirical data. Second, the identified energy technology working competencies can contribute to the development and improvement of learner support programs. And third, the study helps to inform and improve a competency research methodology by piloting a three-stage method involving qualitative and quantitative approaches.

The findings indicate the kinds of industry-based competency and intrinsic and extrinsic motivation institutions need to provide in order to ensure efficient energy technology learning. As indicated by Simpson [34], comprehensive and ongoing learner support systems are needed to help students persist in their studies. The findings prove that there is some value in the three-stage method as a systematic and reliable methodology for identifying

Table 2. The results for knowledge domain

	Experts (n = 10)		Learners (n = 32)		
Competencies items	**M**	**SD**	**M**	**SD**	**M-W U test**
1.1. Can describe the major energy in Taiwan	4.90	0.316	4.66	0.483	–1.472
1.2. Can describe all kinds of energy supply structurally in Taiwan	4.80	0.422	4.28	0.457	–2.882*
1.3. Can describe worldwide policy of energy	4.30	0.483	4.38	0.492	–0.427
1.4. Can describe all kinds of non-renewable energy sources	4.40	0.516	4.38	0.492	–0.140
1.5. Can describe all kinds of renewable energy sources	4.70	0.483	4.47	0.507	–1.263
1.6. Can describe advantages and disadvantages of non-renewable energy sources	4.30	0.483	4.34	0.483	–0.253
1.7. Can describe advantages and disadvantages of solar energy	4.80	0.422	4.47	0.507	–1.815
1.8. Can describe advantages and disadvantages of wind energy	4.60	0.516	4.31	0.471	–1.615
1.9. Can describe advantages and disadvantages of biomass energy	4.10	0.316	4.28	0.457	–1.161
1.10. Can describe advantages and disadvantages of water energy	4.10	0.316	4.28	0.457	–1.161
1.11. Can describe advantages and disadvantages of hydrogen energy	4.10	0.316	4.31	0.471	–1.318
1.12. Can describe advantages and disadvantages of fuel cells	4.30	0.483	4.34	0.483	–0.253
1.13. Can explain the greenhouse effect	4.80	0.422	4.84	0.369	–0.320
1.14. Can describe a way to deal with greenhouse effect	4.90	0.316	4.63	0.492	–1.622
1.15. Can describe a way to popularize energy saving and carbon reduction	4.70	0.483	4.66	0.483	–0.253
1.16. Can describe solar energy equipment translating process	4.10	0.316	4.62	0.492	–2.864*
1.17. Can describe wind energy equipment translating process	4.00	0.000	4.44	0.504	–2.531*
1.18. Can describe water energy equipment translating process	4.00	0.000	4.50	0.508	–2.808*
1.19. Can describe hydrogen energy equipment translating process	4.20	0.422	4.50	0.508	–1.653
1.20. Can describe fuel cell equipment translating process	4.20	0.422	4.28	0.457	–0.504

* $p < 0.05$.

Table 3. The results for attitudes domain

	Experts (n = 10)		Learners (n = 32)		
Competencies items	**M**	**SD**	**M**	**SD**	**M-W U test**
2.1. Can determine value of different energy technologies	4.70	0.483	4.50	0.508	–1.096
2.2. Can identify energy technology and bring new ideas	4.80	0.422	4.56	0.504	–1.334
2.3. Can attend energy saving and carbon reduction events	4.40	0.699	4.59	0.499	–0.734
2.4. Can replace vehicle with walking or biking	4.70	0.675	4.72	0.457	–0.328
2.5. Can extend energy saving and recycling ideas	4.80	0.422	4.78	0.420	–0.125
2.6. Can prioritize choice products with energy conservation markers	4.60	0.516	4.66	0.483	–0.320
2.7. Can execute recycling of garbage and garbage sorting	4.80	0.422	4.56	0.504	–1.334
2.8. Can execute temperature adjustment of air conditioner to save energy	4.80	0.422	4.59	0.499	–1.174
2.9. Can care about global energy information	4.30	0.483	4.59	0.499	–1.604
2.10. Can understand that energy saving and carbon reduction is everyone's responsibility	4.50	0.527	4.69	0.471	–1.067
2.11. Can care about energy developing issues	4.30	0.483	4.59	0.499	–1.604
2.12. Can read manual before operating brand new household appliance	4.50	0.527	4.62	0.492	–0.695
2.13. Can use natural power and reduce use of household appliances	4.90	0.316	4.75	0.440	–0.997
2.14. Can support development of efficiency products	4.90	0.316	4.78	0.420	–0.825
2.15. Can use eco-friendly products	4.90	0.316	4.81	0.397	–0.640
2.16. Can guarantee reduction of wasted energy	4.80	0.422	4.66	0.483	–0.848
2.17. Can care about global environment and climate issue	4.30	0.483	4.72	0.457	–2.352*

* $p < 0.05$.

Table 4. The results for skills domain

	Experts (n = 10)		Learners (n = 32)		
Competencies items	**M**	**SD**	**M**	**SD**	**M-W U test**
3.1. Can operate energy technology related equipment appropriately	4.30	0.483	4.38	0.492	–0.427
3.2. Can understand how energy technology works	4.30	0.483	4.34	0.483	–0.253
3.3. Can operate solar energy module	4.30	0.483	4.41	0.499	–0.597
3.4. Can operate wind energy module	4.20	0.422	4.28	0.457	–0.504
3.5. Can operate biomass energy module	4.10	0.316	4.28	0.457	–0.504
3.6. Can operate water energy module	4.00	0.000	4.28	0.457	–0.504
3.7. Can operate hydrogen energy module	4.10	0.316	4.28	0.457	–0.504
3.8. Can operate fuel cell module	4.20	0.422	4.28	0.457	–0.504

energy technology working competencies. Various methods have been applied individually or in combination to identify and validate the competencies of various professionals and were found useful at various stages of competency development [19, 35–36]. The three-stage method used in this study integrates three carefully chosen methods—BEIs, the Delphi Technique and a survey in synergetic and cost-efficient methods. These competencies were then clarified, elaborated on, validated and classified by the field experts and experienced researchers. Finally, the defined competencies were validated by surveying a group of energy technology learners to finalize the competency list.

It is worth noting that the selection of Taiwan participants who are well-versed in energy technology use and accustomed to instructor-led classes may limit the generalized ability of our findings.

Further studies with learners with different technology proficiencies and different learning experiences are needed. The three-stage empirical method adopted in this present study is found to be a useful method which can be applied to develop and elaborate competencies in a wide variety of educational and training contexts.

9. Conclusions

All 45 working competency items that were ultimately identified revealed importance and consensus to be incorporated into a technology university energy technology course. The analyses found that the consensus-building process of the three-stage method did progress as anticipated and that it was successful in identifying and validating the technological competency items demanded by the energy technology industry. The data analysis revealed decreased standard deviation and increased means, which are both indicative of an increase in consensus. In short, the results of this study were defined to include the following: (1) analysis of the practical competencies required for students in energy technology based on industry requirements, and (2) development of working competency items for students to enhance the practical energy technology competencies as they graduate.

Acknowledgments—This research was based on work supported by the National Science Council of Taiwan, Republic of China, under contract NSC 99-3113-S-018-004.

References

1. J. E. McGee, M. Peterson, S. L. Mueller and J. M. Sequeira, Entrepreneurial self-efficacy: refining the measure, *Entrepreneurship Theory and Practice*, 2009, pp. 965–988.
2. J. Heinonen and S. A. Poikkijoki, An entrepreneurial-directed approach to entrepreneurship education: mission impossible? *Journal of Management Development*, **25**(1), 2006, pp. 80–94.
3. L. M. Spencer and S. M. Spencer, Competence at work, New York: Willy, 1993.
4. C. J. Huang, The proclaiming of future in vocational education, *Technology and Vocational Education Bimonthly*, **55**, 2000, pp. 57–60.
5. C. M. Chou, C. H. Shen, H. C. Hsiao and S. C. Chen, A study on constructing entrepreneurial competence indicators for business department students of vocational and technical colleges in Taiwan, *World Transactions on Engineering and Technology Education*, **8**(3), 2010, pp. 316–320.
6. C. P. Chuang, The anticipation of vocational education in next century, *Technology and Vocational Education Bimonthly*, **55**, 2000, pp. 68–69.
7. T. L. Kang, The development of leadership behavior inventory for the vocational schools in Taiwan, *Journal of Human Resources Management*, **1**, 2001, pp. 43–57.
8. J. R. Wen and W. L. Shih, Exploring the information literacy competence standards for elementary and high school teachers. *Computers and Education*, **50**(3), 2008, pp. 787–806.
9. Wikipedia (2011), Energy technology, http://en.wikipedia.org/wiki/Energy_technology
10. W. J. Shyr, Integrating laboratory activity into a junior high school classroom, *IEEE Transactions on Education*, **53**(1), 2010, pp. 32–38.
11. W. K. Shang, Singapore's experiences in developing and implementing competency-based training. Proceeding of Conference on Competency-Based Training, Taipei, Taiwan, 2000.
12. C. Y. Chao, W. C. Liao, F. E. Chien and Y. L. Huang, Construction of a competency analysis model for vocational high schools, *World Transactions on Engineering and Technology Education*, **2**, 2003, pp. 121–124.
13. G. Heitmann, A. Avdelas and O. Arne, Innovative curricula in engineering education, Firenze University Press, Firenze, Italy, 2003.
14. D. Rebolj, K. Menzel and D. Dinevski, A virtual classroom for information technology in construction, *Computer Application in Engineering Education*, **16**, 2008, pp. 105–114.
15. D. C. McClelland, Testing for competence rather than for intelligence, *American Psychologist*, **28**, 1973, pp. 1–14.
16. K. I. Rifkin, M. Fineman and C. H. Ruhnke, Developing technical managers: first you need a competency model. *Research Technology Management*, **42**(2), 1999, pp. 53–57.
17. M. Foxon, R. C. Richey, R. Roberts and T. Spannaus, *Training manager competencies: the standards* (3rd edn), Syracuse, NY: ERIC Clearinghouse on Information and Technology, 2003.
18. R. Richey, D. Fields, M. Foxon, R. C. Roberts, T. Spannaus and J. M. Spector, *Instructional design competencies: the standards* (3rd edn), Syracuse, NY: Eric Clearinghouse on Information and Technology, 2001.
19. J. D. Klein, J. M. Spector, B. Grabowski and I. Teja, *Instructor competencies: standards for face-to-face, online and blended settings* (3rd edn), Greenwich, CT: Information Age Publishing, 2004.
20. D. Russ-Eft, M. Bober, I. Teja, M. Foxon and T. Koszalka, Evaluator competencies: standards for the practice of evaluation in organizations. San Francisco: Jossey-Bass, 2008.
21. K. H. So, An investigation on new approaches to curriculum design for the knowledge-based society, *The Journal of Curriculum Studies*, **24**(3), 2006, pp. 39–59.
22. J. Burgoyne, The competence movement: issues stakeholders and prospects, *Personnel Review*, **22**(6), 1993, pp. 6–13.
23. T. Hoffmann, The meanings of competency, *Journal of European Industrial Training*, **23**, 1999, pp. 275–285.
24. F. D. Le-Deist and J. Winterton, What is competence? *Human Resource Development International*, **8**(1), 2005, pp. 27–46.
25. D. C. McClelland, Identifying competencies with behavioral-event interviews, *Psychological Science*, **9**(5), 1998, pp. 331–339.
26. S. Y. Hong and I. S. Jung, The distance learner competencies: a three-phased empirical approach, *Educational Technology Research Development*, **59**, 2011, pp. 21–42.
27. A. Gregory, Competencies of senior communication practitioners in the UK: an initial study, *Public Relations Review*, **34**, 2008, pp. 215–223.
28. A. E. Marrelli, An introduction to competency analysis and modeling, *Performance Improvement*, **37**(5), 1998, pp. 8–17.
29. A. E. Marrelli, J. Tondora and M. A. Hoge, Strategies for developing competency models. *Administration and Policy in Mental Health*, **32**(5/6), 2005, pp. 533–561.
30. N. Dalkey and O. Helmer, The use of experts for the estimation of bombing requirements-a project delphi experiment. The Rand Corporation; 1951; RM-727-PR.
31. A. L. Delbecq, V. Ven and D. H. Gustafson, Group techniques for program planning: a guide to nominal group and delphi processes. Scott Foresman and Comp., Glenview, IL. 1975.
32. W. J. Shyr, Development of working competence items for mechatronics with graphical monitoring and control, *Computer Applications in Engineering Education*; August 11, 2009 on-line first; 2011.
33. D. M. Gayeski, T. P. Golden, S. Andrade and H. Mason, Bringing competency analysis into the 21st century. *Performance Improvement*, **46**(7), 2007, pp. 9–16.
34. R. B. Johnson and A. J. Onwuegbuzie, Mixed method research: a research paradigm whose time has come, *Educational Researcher*, **33**(7), 2004, pp. 14–26.
35. O. Simpson, *Student retention in online, open and distance learning*, London: Kogan, 2003.
36. A. D. Lucia and R. Lepsinger, *The art and science of competency models*, San Francisco: Jossey-Bass, Pfeiffer, 1999.

Wen-Jye Shyr is a professor at the Department of Industrial Education and Technology at National Changhua University of Education, Taiwan. His current research is in the mechatronics, graphical human interface, sensors, energy education and engineering education.

Tsung-Chin Lo is a doctoral student at the Department of Industrial Education and Technology at National Changhua University of Education, Taiwan.