International Journal of Engineering Education Vol. 33, No. 1(B), pp. 430–440, 2017
Printed in Great Britain
0949-149X/91 $3.00+0.00

Development and Validation of Energy Technology Competency Survey for Vocational High School Student in Taiwan*

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This study developed and validated of competency required for the education of energy technology for vocational high school students in Taiwan. The energy technology competency survey developed through this research is based on a conceptual framework that emphasizes the current definition of the field. Following the conceptual framework, behavioral event interviews and the Delphi technique were used to ensure consistency in the indicators, while the Kolmogorov-Smirnov one sample goodness of fit test was used to ensure consistency in the opinion of experts. This study identified sixty competency indicators covering knowledge, skills and attitudes domains. These competencies were validated by thirty students and ten domain experts by a nonparametric Mann-Whitney U test. The proposed competency indicators are applicable to the development of curriculum for industrial vocational high school in Taiwan.

Keywords: behavioral event interviews (BEI); Delphi technique; Competency analysis

1. Introduction

Engineering involves the manipulation of materials, energy, and information for the benefit of humankind [1]. Energy education programs deal with the use of energy by humans, issues arising from the development and utilization of energy resources, and practices in resource management. Energy education stresses the application of critical thinking and the responsible use of energy. Initiatives are used in schools to promote awareness of energy-related issues and inspire changes in behavior [2]. Technical and vocational education is considered efficient as long as it assists students in meeting the competency levels required by industry [3, 4].

The aim of education in energy technology is to develop the competency of students in operating action, taking action, taking continuous action, and stimulating action [5]. Chou et al. [6] claimed that students must possess competency sufficient to foster innovative thinking and facilitate implementation. Education in energy technology must satisfy the demands of industry as well as society. However, rapid changes in society and industry have necessitated the implementation of changes in this area. Kang [7] outlined four essential functions required for the curricula of energy technology: (1) prepare students for participation in the job market and on the job; (2) match to the demands of the job market to the number of students and teaching materials; (3) interact with industry to clarify options in the career development of students; and (4) update curricula to benefit the knowledge, skills, attitudes, and values of students both at school and following graduation.

Energy education is an ideal topic for vocational high school classrooms. Teachers could use a unit on renewable resources to teach basic scientific principles, such as the conversion of energy from one form to another, or methods used in the generation electricity. Teachers could also incorporate laboratory activities on renewable energy into a unit on the environmental impact of energy use [8]. Laboratory activities on renewable energy are generally a part of K-12 curriculum. Most teachers lack a firm understanding of practices, uses, and concepts associated with this approach. For a teacher to feel comfortable integrating these methods into their class generally requires that they engage in professional development focusing on concepts and related pedagogical strategies [9].

A broader definition of competency includes attitudes, skills, and knowledge. Competency refers to the physical or intellectual ability to perform a task. Spencer and Spencer [10] described how competencies can be observable as well as non-observable. Competence refers to substantial knowledge and skills gained following professional education or training and professionals who undertake a specific paid job or self-employment duties [11]. Competencies are the core of education. The goal of professional competency is to apply the knowledge and skills learned in school to the tasks encountered while working in industry. The empha-

* Accepted 15 October 2016.

sis of energy technology education involves the enrichment of an individual's capabilities [12]. Competencies represent a collective of learning within an organization, and involve the coordination of a diversity of production skills as well as the integration of multiple streams of technologies. Competencies are identified behaviors, knowledge, skills, and abilities that affect the achievement of employees and success within a firm [13, 14].

This study developed competency indicators to facilitate the process of educating high school students in the area of energy technology. Following completion of a literature review and behavioral event interviews, we employed the Delphi technique to assess the appropriateness of the proposed indicators. After having experts in energy technology and education assess the fitness of the competency indicators, the structural features of the competencies were confirmed using empirical data [15]. Our ultimate goal was to facilitate the development of curriculum in energy technology and provide practical guidelines with which to elucidate the requirements of students engaged in this field of study.

2. Literature review

2.1 Conceptual framework

The conceptual framework connects the definition to knowledge, attitudes, and skills statements. Knowledge, attitudes, and skills statements were adopted because they are used to generate competencies for licensure and certification exams [16, 17]. McClelland [18] formally introduced the concept of competency. He proposed competency as the criteria for the evaluation of performance. Competency has been defined as "the external behavior expressed by a person based on his or her knowledge, skills and attitudes and, therefore, is generally reflected in his/her performance in values, attitudes, deduction and judgment" [19]. Competency comprises a variety of domains related to knowledge, skills and attitudes [20, 21]. Many competencies are considered innate, while others are acquired through learning. Competency is an indication that one possesses the skills and knowledge necessary to perform a particular function. In this study, knowledge, attitudes, and skills statement represent the various competencies of energy technology.

2.2 Competency analysis

An analysis of competency is meant to identify the factors required to perform job-related tasks, including motives, characteristics, skills, and knowledge. Specifically, competency refers to the actions required to play a given role or undertake a given task [22]. Competency is also a dynamic concept involving the practical implementation of theory. The analysis of competency evaluates the ability to achieve a desired outcome in a given situation [23]. Meeting the needs of industry requires that educators determine the indicators and standards necessary to measure competencies. Programs in energy technology should identify industry standards and competency analysis should determine whether students attain those standards [24, 25]. Competency has been used to assess training and recruitment techniques as well as the performance of management and employees [26]. Educational professionals use competency in staff development, recruitment, and the design of curriculum [27–29]. These efforts can be described as the requirements for a knowledge-based society [30]. Burgoyne [31] defined competency from the perspective of stakeholders. Le-Deist and Winterton [32] described competency as fuzzy, despite its usefulness in linking education with job requirements. Most researchers describe competencies as the activities expected of professionals. Competency model for effective teaching those judgments to a set of standards were defined [33, 34].

2.3 Energy technology

Energy can be classified as renewable and nonrenewable. Renewable energy sources can be replenished within a short period, while nonrenewable sources may require millions of years. A wide range of energy sources are in use today, including solar, petroleum, biomass, geothermal hydropower, wind, hydrogen-fuel, and nuclear. All of these energy sources entail environmental, economic, and social costs. The availability of energy and costs are factors determining economic growth. Energy technology is an engineering science that involves experts from a range of disciplines dealing with the extraction, transportation, conversion, storage, and application of energy with the aims of enhancing efficiency and minimizing negative effects on the environment [35].

The energy industry is facing a potential workforce crisis over the next five to ten years. The following job classifications will have large numbers of employees eligible to retire: (1) More than half of all non-nuclear power plant operators. (2) 52% of generation maintenance technicians. (3) 40% of all transmission and distribution workers. (4) 46% of engineers. The energy industry competency building block model is designed to provide a consistent definition of the competencies required to work in energy industry. The model builds from basic fundamentals to more industry and career specific competencies [36].

2.4 Competencies associated with energy technology

Working with technical experts and industry associations, the U.S. Employment and Training Administration (ETA) [37] developed a competency model for the field of renewable energy with the aim of developing a workforce capable of performing jobs specific to this sector. This model is intended to evolve with changing skill requirements. Shyr and Lo [38] proposed a set of working competency items as a proxy for the technological requirements of the energy industry. In both cases, the items represent the practical competencies required of students in a technology university.

3. Methods

3.1 Behavioral event interview

In accordance with the framework proposed by McClelland, we employed work roles in the definition of competencies in the field of energy technology to form the basis of education at an industrial vocational high school in Taiwan.

Numerous methods have been used for the definition and development of competencies, the most common of which is the behavioral event interview (BEI) [39]. Based on the critical-incident interview, BEI seeks to identify differences between typical and outstanding performers. Structured interviews are used to characterize the actions and opinions of a range of individuals involved in a specific field of endeavor. Content analysis is then used to compare their statements to identify competencies that could be considered essential. BEI is particularly effective in the collection of empirical data and the systematic analysis of content.

Gregory [40] conducted interviews with experts in communications to identify the competencies associated with public relations. Marrelli et al. [41] applied BEI to individuals deemed experts in their field in order to identify competencies specific to particular goals that are subject to evaluation.

3.2 Delphi technique

The Delphi technique is a collective approach to decision making [42]. Typically, ten or more experts are assembled in an isolated environment to share their opinions. The objective is to obtain a consensus with regard to the prediction of trends and events [43]. Delphi technique has been applied in education, engineering, and a wide range of other disciplines [44–46]. To prevent a small number of experts from dominating the proceedings, this study sent categories of competency indicators to a focus group for evaluation, the feedback from which was used for further revision.

Delphi technique is a group communication process aimed at achieving a convergence of opinion related to specific real-world issues. The Delphi process is meant to provide a range of alternatives and expose underlying assumptions, by administering a series of questionnaires in multiple iterations from a panel of selected participants. Researchers employing this approach must recruit a representative pool of expertise while avoiding an excessively large panel of experts, which might otherwise hinder the process. The literature provides no consensus regarding the optimal number of participants with which to pursue the Delphi technique; however, most researchers would agree that 10 to 15 participants is sufficient, as long as the background of the experts is reasonably homogeneous [47].

3.3 Questionnaire design

The questionnaire used in this study collected data in three domains: (1) knowledge, (2) attitudes, and (3) skills. Sixty indicators of working competency in the field of energy technology were derived. These indicators were assessed in regards to their importance to job performance according to the following 5-point scale: "5-very important", "4-more important", "3-somewhat important", "2-less important", and "1-least important."

Competencies were classified using cumulative percentages calculated from the importance ratings provided by respondents, as follows: (1) Essential (must have) with 90% of the responses indicating 4 or 5; (2) Important (should have) with at 90% of the responses indicating 3, 4, or 5; and (3) Unimportant, as indicated by a failure to meet the above criteria [48–50].

This study combined the findings from BEI with Delphi technique for the collection and analysis of data. BEI was employed to reach the definitions for the competencies pertaining to energy technology engineers working in the field. Delphi technique was employed by the field experts who examined the BEI findings for consistency and relevance [51].

3.4 Participants

Five field engineers in energy technology were recruited for BEI. Participants in the Delphi stage of the study included four industry experts and six researchers with an average of 8 years of experience in the field. Six of the ten professionals were PhDs in education, educational technology, or engineering. The participants in the survey were thirty students from industrial vocational high school in Taiwan.

Before conducting BEI, participants were sent emails to explain the purpose of the study, the nature of the interview process, and the questions to be asked. Interviews were conducted face-to-face over a period of approximately two hours. During the interviews, participants responded to questions and provided detailed accounts of how they would deal with the situations outlined in the questions. Interviews were audio-recorded with the permission of the participants.

Prior to Delphi analysis, emails were sent to explain the purpose of the of the Delphi technique. Three rounds of surveys were then conducted to identify indicators of working competency in the field of energy technology.

3.5 Instruments

Questions for BEI were developed and verified by four experts in energy technology for content validity. Delphi analysis involved the examination of sixty questions mainly regarding teaching and research. The survey used for validation included three items: personal information (gender and age) and an importance rating for each of the 60 competencies. A pilot version of the instrument was reviewed by four experts in energy technology and feedback led to revisions of the indicators that were considered confusing or ambiguous.

4. Results

4.1 Data analysis

Descriptive analysis was adopted for the mean, SD, and Z value of K-S test with regard to Delphi analysis. The Kolmogorov-Smirnov one sample goodness of fit test was used to confirm that participants were consistent in their opinions.

Table 1 to Table 3 presents the results of BEI and the Delphi technique questionnaires, including domains regarding knowledge, attitudes, and skills. The surveys reveal the views of experts with regard to the fitness level of each indicator associated with competency in the field of energy technology, as taught in an industrial vocational high school. In the K-S test, a score of 0.05 was deemed

Table 1. Knowledge domain indicators and statistics

Indicator label	Mean	SD	Z value	Mean of Domains	Rank of Domains
1-1 Demonstrate an understanding of the latest development in solar energy	4.60	0.516	1.897**	4.23	3
1-2 Demonstrate an understanding of the latest development in wind energy	4.60	0.516	1.897**		
1-3 Demonstrate an understanding of the latest development in biomass energy	4.30	0.483	2.214**		
1-4 Demonstrate an understanding of the latest development in hydropower energy	4.60	0.516	1.897**		
1-5 Demonstrate an understanding of the latest development in geothermal energy	4.40	0.516	1.897**		
1-6 Demonstrate an understanding of the latest development in hydrogen-fuel energy	4.30	0.483	2.214**		
1-7 Demonstrate an understanding of the latest development in petroleum energy	4.20	0.422	2.530**		
1-8 Demonstrate an understanding of the latest development in nuclear energy	4.20	0.422	2.530**		
1-9 Understand the solar energy conversion process	4.60	0.516	1.897**		
1-10 Understand the wind energy conversion process	4.70	0.483	2.214**		
1-11 Understand the biomass energy conversion process	4.40	0.516	1.897**		
1-12 Understand the hydropower energy c conversion process	4.50	0.527	1.581*		
1-13 Understand the geothermal energy conversion process	4.50	0.527	1.581**		
1-14 Understand the hydrogen-fuel energy conversion process	4.40	0.516	1.897**		
1-15 Understand the petroleum energy conversion process	4.20	0.422	2.530**		
1-16 Understand the nuclear energy conversion process	4.20	0.422	2.530**		
1-17 Can describe techniques applied in solar energy	4.60	0.516	1.897**		
1-18 Can describe techniques applied in wind energy	4.70	0.483	2.214**		
1-19 Can describe techniques applied in biomass energy	4.40	0.699	1.581*		
1-20 Can describe techniques applied in hydropower energy	4.40	0.699	1.581*		
1-21 Can describe techniques applied in geothermal energy	4.40	0.699	1.581*		
1-22 Can describe techniques applied in hydrogen-fuel energy	4.30	0.483	2.214**		
1-23 Can describe techniques applied in petroleum energy	4.20	0.422	2.530**		
1-24 Can describe techniques applied in nuclear energy	4.20	0.422	2.530**		

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

Table 2. Attitudes domain indicators and statistics

Indicator label	**Mean**	**SD**	**Z value**	**Mean of Domains**	**Rank of Domains**
2-1 Concern about energy development issues	4.50	0.527	1.581**	4.65	1
2-2 Concern about international energy message	4.70	0.483	2.214**		
2-3 Concern about the global environment and climate issues	4.80	0.422	2.530**		
2-4 Committed to energy conservation	4.70	0.483	2.214**		
2-5 Read manuals before operating brand new household appliances	4.50	0.527	1.581**		
2-6 Use natural power and reduce household appliance use	4.60	0.516	1.897**		
2-7 Support the development of efficiency products	4.50	0.527	1.581**		
2-8 Select products with energy conservation markers	4.70	0.483	2.214**		
2-9 Understand that energy savings and carbon reduction are important	4.90	0.316	2.846**		
2-10 Can determine the value of various energy technologies	4.70	0.483	2.214**		
2-11 Can analyze data related to energy equipment	4.50	0.527	1.581**		
2-12 Knowledgeable regarding techniques to extend energy savings and recycling	4.70	0.483	2.214**		

$^{**}p < 0.01$.

Table 3. Skills domain indicators and statistics

Indicator label	**Mean**	**SD**	**Z value**	**Mean of Domains**	**Rank of Domains**
3-1 Can operate solar energy-related equipment	4.70	0.483	2.214**	4.39	2
3-2 Can operate wind energy-related equipment	4.50	0.527	1.581**		
3-3 Can operate biomass energy-related equipment	4.40	0.516	1.897**		
3-4 Can operate hydropower energy-related equipment	4.40	0.516	1.897**		
3-5 Can operate geothermal energy-related equipment	4.30	0.483	2.214**		
3-6 Can operate hydrogen-fuel energy-related equipment	4.40	0.516	1.897**		
3-7 Can operate petroleum energy-related equipment	4.20	0.422	2.530**		
3-8 Can operate nuclear energy-related equipment	4.20	0.422	2.530**		
3-9 Can maintain solar energy-related equipment	4.60	0.516	1.897**		
3-10 Can maintain wind energy-related equipment	4.40	0.516	1.897**		
3-11 Can maintain biomass energy-related equipment	4.50	0.527	1.581**		
3-12 Can maintain hydropower energy-related equipment	4.50	0.527	1.581**		
3-13 Can maintain geothermal energy-related equipment	4.40	0.516	1.897**		
3-14 Can maintain hydrogen-fuel energy-related equipment	4.30	0.483	2.214**		
3-15 Can maintain petroleum energy-related equipment	4.20	0.422	2.530**		
3-16 Can maintain nuclear energy-related equipment	4.20	0.422	2.530**		
3-17 Can analyze and explain data related to solar energy equipment	4.50	0.527	1.581**		
3-18 Can analyze and explain data related to wind energy equipment	4.60	0.516	1.897**		
3-19 Can analyze and explain data related to biomass energy equipment	4.30	0.483	2.214**		
3-20 Can analyze and explain data related to hydropower energy equipment	4.50	0.527	1.581**		
3-21 Can analyze and explain data related to geothermal energy equipment	4.50	0.527	1.581**		
3-22 Can analyze and explain data related to hydrogen-fuel energy equipment	4.30	0.483	2.214**		
3-23 Can analyze and explain data related to petroleum energy equipment	4.20	0.422	2.530**		
3-24 Can analyze and explain data related to nuclear energy equipment	4.20	0.422	2.530**		

$^{**}p < 0.01$.

statistically significant, such that participants considered the indicator as important and consistent. The mean scores of the 60 competencies were above 4.2, indicating that the Delphi group considered the included competencies as "essential".

4.2 Knowledge domain

Knowledge statements pertain to an organized body of information, usually of a factual or procedural nature. In our three-step process (review of literature, behavioral event interview, and Delphi

Table 4. The Mann-Whitney U test of Knowledge domain

Indicator label	Groups	n	U-test
1-1 Demonstrate an understanding of the latest development in solar energy	Students Experts	30 10	–0.186
1-2 Demonstrate an understanding of the latest development in wind energy	Students Experts	30 10	–0.787
1-3 Demonstrate an understanding of the latest development in biomass energy	Students Experts	30 10	–1.812
1-4 Demonstrate an understanding of the latest development in hydropower energy	Students Experts	30 10	–0.378
1-5 Demonstrate an understanding of the latest development in geothermal energy	Students Experts	30 10	–1.276
1-6 Demonstrate an understanding of the latest development in hydrogen-fuel energy	Students Experts	30 10	–1.625
1-7 Demonstrate an understanding of the latest development in petroleum energy	Students Experts	30 10	–1.996*
1-8 Demonstrate an understanding of the latest development in nuclear energy	Students Experts	30 10	–1.302
1-9 Understand the solar energy conversion process	Students Experts	30 10	–0.362
1-10 Understand the wind energy conversion process	Students Experts	30 10	–0.305
1-11 Understand the biomass energy conversion process	Students Experts	30 10	–1.087
1-12 Understand the hydropower energy conversion process	Students Experts	30 10	–0.362
1-13 Understand the geothermal energy conversion process	Students Experts	30 10	–0.736
1-14 Understand the hydrogen-fuel energy conversion process	Students Experts	30 10	–1.676
1-15 Understand the petroleum energy conversion process	Students Experts	30 10	–1.986*
1-16 Understand the nuclear energy conversion process	Students Experts	30 10	–2.369*
1-17 Can describe techniques applied in solar energy	Students Experts	30 10	–0.186
1-18 Can describe techniques applied in wind energy	Students Experts	30 10	–0.192
1-19 Can describe techniques applied in biomass energy	Students Experts	30 10	–1.493
1-20 Can describe techniques applied in hydropower energy	Students Experts	30 10	–1.011
1-21 Can describe techniques applied in geothermal energy	Students Experts	30 10	–0.759
1-22 Can describe techniques applied in hydrogen-fuel energy	Students Experts	30 10	–1.625
1-23 Can describe techniques applied in petroleum energy	Students Experts	30 10	–2.537*
1-24 Can describe techniques applied in nuclear energy	Students Experts	30 10	–2.537*

*$p < 0.05$.

Table 5. The Mann-Whitney U test of Attitudes domain

Indicator label	Groups	n	U-test
2-1 Concern about energy development issues	Students Experts	30 10	–1.347
2-2 Concern about international energy message	Students Experts	30 10	–0.378
2-3 Concern about the global environment and climate issues	Students Experts	30 10	–0.787
2-4 Committed to energy conservation	Students Experts	30 10	–0.559
2-5 Read manuals before operating brand new household appliances	Students Experts	30 10	–0.736
2-6 Use natural power and reduce household appliance use	Students Experts	30 10	–0.145
2-7 Support the development of efficiency products	Students Experts	30 10	–0.181
2-8 Select products with energy conservation markers	Students Experts	30 10	–1.345
2-9 Understand that energy savings and carbon reduction are important	Students Experts	30 10	–1.079
2-10 Can determine the value of various energy technologies	Students Experts	30 10	–0.202
2-11 Can analyze data related to energy equipment	Students Experts	30 10	–0.547
2-12 Knowledgeable regarding techniques to extend energy savings and recycling	Students Experts	30 10	–0.958

technique), we derived 24 knowledge statements from the conceptual framework.

Table 1 lists the mean scores and standard deviation (SD) values of the BEI questionnaires and Delphi methodology. In addition, the means of this domain shows that student knowledge pertaining to energy technology was 4.23. This knowledge domain ranks third.

4.3 Attitudes domain

Attitudes statements pertain to the adept mental manipulation of things. We derived 12 attitudes statements from the conceptual framework and three-step survey.

Table 1 lists the mean scores and standard deviation (SD) values of the BEI questionnaires and Delphi methodology. The means of this domain shows that student attitudes pertaining to energy technology was 4.65. This attitudes domain ranks first.

4.4 Skills domain

A skills statement pertains to one's capacity in the performance of an observable activity. We derived 24 skills statements in this study.

Table 1 lists the mean scores and standard deviation (SD) values of the BEI questionnaires and Delphi methodology. The means of this domain shows that student skills pertaining to energy technology was 4.39. This skills domain ranks second.

4.5 Validation of competency indicators

As seen in Table 1 to Table 3, using analysis based on three domains of competency as proposed, the domain deemed to be of greatest importance was the domain of attitudes (M = 4.65), followed by that of skills (M = 4.39) and of knowledge (M = 4.23); however, little difference was observed between the three. The competency perceived to have the greatest importance was *2-9, "Understand that energy savings and carbon reduction are important"* (M = 4.90), within the domain of attitudes. 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 energy technology competency indicators in industrial vocational high school was the domain of attitudes.

In an effort to validate the above set of competencies resulting from the literature review and categorization process. Further analysis was conducted to confirm whether domain experts and students differed in the competencies. The nonparametric Mann-Whitney U test was used and the results are presented. With respect to knowledge domain, it includes the 24 items (Table 4). As for attitudes domain, it includes the 12 items (Table 5).

Table 6. The Mann-Whitney U test of Skills domain

Indicator label	Groups	n	U-test
3-1 Can operate solar energy-related equipment	Students Experts	30 10	–0.378
3-2 Can operate wind energy-related equipment	Students Experts	30 10	–0.735
3-3 Can operate biomass energy-related equipment	Students Experts	30 10	–1.087
3-4 Can operate hydropower energy-related equipment	Students Experts	30 10	–0.903
3-5 Can operate geothermal energy-related equipment	Students Experts	30 10	–1.812
3-6 Can operate hydrogen-fuel energy-related equipment	Students Experts	30 10	–1.676
3-7 Can operate petroleum energy-related equipment	Students Experts	30 10	–1.812
3-8 Can operate nuclear energy-related equipment	Students Experts	30 10	–1.369*
3-9 Can maintain solar energy-related equipment	Students Experts	30 10	–0.186
3-10 Can maintain wind energy-related equipment	Students Experts	30 10	–1.472
3-11 Can maintain biomass energy-related equipment	Students Experts	30 10	–1.347
3-12 Can maintain hydropower energy-related equipment	Students Experts	30 10	–1.347
3-13 Can maintain geothermal energy-related equipment	Students Experts	30 10	–1.351
3-14 Can maintain hydrogen-fuel energy-related equipment	Students Experts	30 10	–1.625
3-15 Can maintain petroleum energy-related equipment	Students Experts	30 10	–1.163*
3-16 Can maintain nuclear energy-related equipment	Students Experts	30 10	–1.537*
3-17 Can analyze and explain data related to solar energy equipment	Students Experts	30 10	–1.347
3-18 Can analyze and explain data related to wind energy equipment	Students Experts	30 10	–0.378
3-19 Can analyze and explain data related to biomass energy equipment	Students Experts	30 10	–1.812
3-20 Can analyze and explain data related to hydropower energy equipment	Students Experts	30 10	–0.547
3-21 Can analyze and explain data related to geothermal energy equipment	Students Experts	30 10	–0.452
3-22 Can analyze and explain data related to hydrogen-fuel energy equipment	Students Experts	30 10	–1.264
3-23 Can analyze and explain data related to petroleum energy equipment	Students Experts	30 10	–1.537*
3-24 Can analyze and explain data related to nuclear energy equipment	Students Experts	30 10	–1.302

*$p < 0.05$.

With respect to skills domain, it includes the 24 items (Table 6). The level of significance α was selected to be 0.05. The corresponding two-tail critical value was ± 1.96. Except for items #1-7, #1-15, #1-16, #1-23, #1-24, #3-8, #3-15, #3-16 and #3-23, the domain experts regarding the importance of the competencies did not significantly differ from the students.

5. Discussion

This study identified the industry-based competencies that are required by institutions to provide effective learning solutions. These competencies are propelled by both intrinsic and extrinsic motivation. As indicated by Simpson [52], ongoing learner support systems are required to further student progress in their studies. Various methods have been proposed to identify competencies required in various stages of development [41, 53]. In this study, the integration of BEI and the Delphi technique provided a systematic methodology with which to identify working competencies, followed by clarification, elaboration, validation, and classification by scholars and experts in the field.

5.1 Contributions

This study makes three important contributions. First, our results add to the literature by presenting a set of competency indicators based on empirical data. Second, the working competencies identified in this study contribute to the improvement of learner support programs in energy technology education for industrial vocational high school students in Taiwan. Third, we provide an effective methodology for the identification of competencies through behavioral event interviews and the Delphi technique.

5.2 Application of findings within educational setting

The findings of this study can be used to provide industrial vocational high school students with a variety of projects to broaden their knowledge of renewable energy and the scientific method. Projects could focus on any number of forms of renewable energy, including solar, wind, biomass, hydropower, geothermal, hydrogen-fuel, and petroleum.

The scientific method is a pattern of inquiry that can form a structure for advancing one's understanding of renewable energy. This method allows students to answer questions ranging from the simplest to the most complex by identifying a problem, forming a hypothesis, designing and conducting an experiment, obtaining data, and ana1yzing the results.

5.3 Limitations

This study was limited to a select group of Taiwanese participants who are well versed in energy technology and familiar with instructor-led classes. Thus, the generalizability of our findings may be somewhat limited. Our research samples were industrial vocational high school students, not included others departments, it didn't predict the same tests for different departments have significant level, it perhaps the limitations of the study.

6. Conclusions

This study identified 60 working indicators of competency in energy technology for incorporation within the curriculum of an industrial vocational high school in Taiwan. These competencies can be divided into the knowledge domain (24 indicators), skills domain (24 indicators), and attitudes domain (12 indicators).

The consensus-building achieved through interviews and the application of the Delphi technique proved effective in identifying and validating the technological competency indicators required in energy technology industries. Nonetheless, research using a larger sample is still required to validate and generalize the results. Further research with learners possessing other proficiencies and learning experiences will be required to verify these findings. Standardized methods for measuring the effectiveness of educational activities must also be developed.

Acknowledgments—This research was based on work supported by the Ministry of Science and Technology of Taiwan, Republic of China, under contract 101-3113-S-018-002.

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