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An analysis of the factors affecting the vocational competencies of electricians in industry with regard to refrigeration and air-conditioning technicians

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ABSTRACT: The purposes of this research are to analyse and describe the major factors that affect the vocational competencies of electricians in industry, particularly refrigeration and air-conditioning technicians. The total sample for the study was 1,745. The reliability of the instrument calculated by Cronbach's alpha coefficient was 0.98 and 0.99 respectively. The data was analysed using means, standard deviation and an analysis of factors by Principal Component Analysis (PCA), where PCA orthogonal rotation axis is calculated using the Varimax method. The results of the study found that an electrician's, as well as a refrigeration and air-conditioning technician's, knowledge, skills and working habits were affected by a number of factors. These included the principles and procedures of controlling electrical equipment and machinery, the installation of electrical systems in buildings, testing and maintenance, working principles and the installation of systems for refrigeration and air-conditioning, tools and equipment for the installation of refrigeration and air-conditioning, general skills and safety, personal characteristics and personality, human relationships and learning organisation, to name just a few.

INTRODUCTION

One of many issues concerning vocational education is that the teaching and learning of vocational areas are not related to the market and/or enterprise needs [1]. The reason for this is that the curriculum has been organised in a horizontal manner so that a student has to learn basic knowledge from every vocational area, which the future job may not necessarily require him/her to know. For example, in order for an electrician to function, he/she may only need knowledge in particular areas of the maintenance of electrical systems considered necessary for industry or manufacturing. This kind of occupation can be called *demand-driven* and/or *innovation-driven*. However, nowadays, the curriculum does not respond to key functions of job classification, already stated elsewhere [2].

Thus, educators have to construct the ability or competency or *Vocational Qualification (VQ)* of each occupational position so that employers can *put the right person in the right job*. This is why the Committee of Education Reform, with regard to vocational education in Thailand, has tried to formulate the Thai Vocational Qualification (TVQ), wherein vocational competencies are divided into five levels. The TVQ places emphasis on competencies, the accreditation of prior learning and experience, the promotion of public-private sector cooperation in providing additional skills training for workers in various enterprises so as to raise labour productivity to international levels, and enhancing the global competitiveness of Thailand.

What's more, the Office of Standard Accreditation and Quality Education Assessment in Thailand has identified that a graduate student must take a competency profile test [3]. The test items cover the competencies required by industry, manufacturers and/or enterprises. The Department of Vocational Education (DOVE) in Thailand has developed seven vocational education classifications, namely:

- General electric devices service.
- Electrical installation in buildings.
- Electrical installation outside buildings.
- Maintenance of electrical motors, electrical generators and electrical transformers.
- Refrigeration and air conditioning maintenance.
- Electricians in industry.
- Service of electrical devices controlled by electronics [4].

It is the researchers' intention to analyse two of these vocational education classifications, which industry electricians and refrigeration and air-conditioning technicians need so that their knowledge, skills and working habits will be identified as core competencies of their trade. These aforementioned knowledge, skills and working habits will be specified in the curriculum and/or as a *competency profile*.

OBJECTIVE

The objective of this research is to analyse the factors that affect the vocational competencies of electricians in industry, particularly refrigeration and air-conditioning technicians.

EXPECTED OUTCOMES OF THIS STUDY

The expected outcomes of this study are as follows:

- The Department of Vocational Education (DOVE) can adopt the results of this study as guidelines for the curriculum development of electricians in industry, especially refrigeration and air-conditioning technicians.
- Administrators and instructors will be able to improve teaching and learning activities that concentrate on

students' competencies, which are congruent with the industry needs.
- The Office of Standard Accreditation and Quality Education Assessment, with regard to vocational education, will take the results of the study into account as standard criteria, notably for electricians in industry and refrigeration and air-conditioning technicians.

RESEARCH METHODOLOGY: ELECTRICIANS' VOCATIONAL COMPETENCIES IN INDUSTRY

Sample

The sample chosen for this study included 650 electrical power instructors at Thai vocational technical colleges and 459 electricians in industry. The total study sample was 1,109.

Tools for Data Collection

The instrument used for data collection was a 7-rating scale. The reliability of the instrument was calculated using the Cronbach's alpha coefficient, which was 0.98.

Data Analysis

The data was analysed by using means ($\overline{X}$), standard deviation and an analysis of factors by Principal Component Analysis (PCA); orthogonal rotation axis was achieved by utilising the Varimax method [5].

Results of the Study

The results of the study showed that there were six major factors that affected electricians' knowledge in industry, as follows:

- Basic knowledge for electrical industries;
- Operational control circuit of electrical machinery;
- Electrical and industrial tools and equipment;
- The application of general knowledge for operational support;
- Principles and procedures of controlling electrical equipment and machinery;
- Principles and procedures of industrial safety.

These factors could be explained from 73.68% of the total variance. The correlation coefficient between 6 and 61 factors was 0.437-0.828, while the correlation coefficient between six factors that affect electricians' knowledge in industry was 0.521-0.881, which was in the high level. The correlation coefficient within the six internal factors was 0.015-0.081, which was in low level. This is shown in Table 1.

The regression or predicting equation that affected electricians' knowledge in industry was:

$$Y = 0.553(C_{ontrol}) + 0.806(C_{ircuit}) + 0.609(T_{ools}) + 0.521(S_{afety}) + 0.593(G_{eneral}) + 0.881(B_{asic})$$

The predicting equation has the power of prediction 57.143% and the error of prediction was 14.286%.

There were four major factors that affected electricians' skills in industry, as follows:

- The testing and maintenance of electrical equipment, electrical machinery and electrical systems;
- General skills and industrial safety;
- Installation of electrical systems in buildings;
- Control circuit connections in electrical machinery.

Table 1: Correlation coefficients between six factors that affect electricians' knowledge in industry.

Factors	Correlation Coefficient
Basic knowledge for electrical industry	0.881
Operational control circuit of electrical machinery	0.806
Electrical and industrial tools and equipment	0.609
The application of general knowledge for operational support	0.593
Principles and procedures of controlling electrical equipment and machinery	0.553
Principles and procedures of industrial safety	0.521

These factors could be explained from 75.614% of the total variance. The correlation coefficient between 4 and 53 factors was 0.453-0.790, while the correlation coefficient between four factors that affected electricians' skills in industry was 0.533-0.804, which was in high level. The correlation coefficient within the four internal factors was 0.034-0.113, which was in the low level. This is shown in Table 2.

Table 2: Correlation coefficients between four factors that affect electricians' skills in industries.

Factors	Correlation Coefficient
Testing and maintenance of electrical equipment, electrical machinery and electrical systems	0.804
General skills and industrial safety	0.621
Installation of electrical systems in buildings	0.589
Control circuit connections in electrical machinery	0.533

The regression or the predicting equation that affect electricians' skills in industries was:

$$Y = 0.533(C_{ontrol}) + 0.589(C_{ircuit}) + 0.804(M_{aintenance}) + 0.621(G_{eneral}/S_{afety})$$

The predicting equation has the power of prediction 50% and the error of prediction was 25%.

There were three major factors that influenced electricians' working habits in industry, namely:

- Learning organisation;
- Personal characteristics and personality;
- Personal mastery.

These factors could be explained from 72.551% of the total variance. The correlation coefficient between 3 and 31 factors was 0.576-0.819, while the correlation coefficient between these three factors that affected electricians' working habits in

industry was 0.700-1.000, which was in the high level. The correlation coefficient within the three internal factors was 0.096-0.108, which was in the low level. This is shown in Table 3.

Table 3: Correlation coefficients between three factors that affect electricians' working habits in industry.

Factors	Correlation Coefficient
Learning organisation	1.000
Personal characteristics and personality	0.715
Personal mastery	0.700

The regression or predicting equation that influenced electricians' working habits in industries was:

Y = 0.715(Characteristics) + 0.700(Mastery) + 1.000(Learning Organisation)

The predicting equation has the power of prediction 66.667% and the error of prediction was 33.333%.

RESEARCH METHODOLOGY: REFRIGERATION AND AIR-CONDITIONING TECHNICIANS' VOCATIONAL COMPETENCIES

Sample

The study sample included 452 electrical power instructors at vocational technical colleges and 184 refrigeration and air-conditioning technicians. The total sample for study was 636.

Tools for Data Collection

The instrument used for data collection was a 7-rating scale. The reliability of the instrument was determined by the Cronbach's alpha coefficient, which was 0.99.

Data Analysis

The data was analysed by using means $(\overline{X})$, standard deviation and an analysis of factors by Principal Component Analysis (PCA). Orthogonal rotation axis was done again by the Varimax method [5].

There were five major factors that affected the vocational competencies of refrigeration and air-conditioning technicians, namely:

- Components and working principles of refrigeration and air-conditioning;
- Basic knowledge for electrical industries;
- Symbols and types of electrical materials;
- Principles of installation and swaging copper tubes;
- Principles and procedures of industrial safety.

These factors could be explained from 73.460% of the total variance. The correlation coefficient between five factors that affected refrigeration and air-conditioning technicians' knowledge in industry was 0.502-0.704, which was in the high level. The correlation coefficient within the five internal factors was 0.013-0.061, which was in low level. This is shown in Table 4.

Table 4: Correlation coefficients between five factors that affect refrigeration and air-conditioning technicians' knowledge.

Factors	Correlation Coefficient
Components and working principles of refrigeration and air-conditioning	0.704
Basic knowledge for electrical materials	0.691
Symbols and types of electrical materials	0.624
Principles of installation and swaging copper tubes	0.596
Principles and procedures of industrial safety	0.502

The regression or predicting equation that influenced refrigeration and air-conditioning technicians' knowledge was:

$$Y = 0.596(C_{omponent}/P_{rinciples}) + 0.691(B_{asic}\ K_{nowledge}) + 0.502(S_{ymbols}/T_{ypes}) + 0.624(A_{pplication}/P_{rinciples}) + 0.704(S_{afety})$$

The predicting equation has the power of prediction 40% and the error of prediction was 20%.

There were three major factors that affected refrigeration and air-conditioning technicians' skills, as follows:

- Refrigeration and air-conditioning installation systems;
- Communication and computer applications;
- Tools and equipment for installation.

These factors could be explained from 74.647% of the total variance. The correlation coefficient between 3 and 38 factors was 0.517-0.820, while the correlation coefficient between three factors that influenced refrigeration and air-conditioning technicians' skills was 0.656-0.989, which was in the high level. The correlation coefficient within the three internal factors was 0.014-0.061, which was in the low level. This is shown in Table 5.

Table 5: Correlation coefficients between five factors that affect refrigeration and air-conditioning technicians' skills.

Factors	Correlation Coefficient
Refrigeration and air-conditioning installation systems	0.989
Communication and computer applications	0.755
Tools and equipment for installation	0.656

The regression or predicting equation that affected refrigeration and air-conditioning technicians' skills was:

$$Y = 0.989(System) + 0.755(C_{ommunication}) + 0.656(T_{ools})$$

The predicting equation has the power of prediction 66.667% and the error of prediction was 33.333%.

There were three major factors that affected refrigeration and air-conditioning technicians' working habits, primarily:

- Learning organisation;
- Human relationships;
- Personal characteristics and personality.

These factors could be explained from 77.192% of the total variance. The correlation coefficient between 3 and 31 factors was 0.541-0.814, while the correlation coefficient between three factors with that influenced refrigeration and air-conditioning technicians' working habits was 0.645-0.997, which was in the high level. The correlation coefficient within the three internal factors was 0.047-0.120, which was in the low level. This is shown in Table 6.

Table 6: Correlation coefficients between three factors that affect refrigeration and air-conditioning technicians' working habits.

Factors	Correlation Coefficient
Learning organisation	0.997
Human relationships	0.764
Personal characteristics and personality	0.645

The regression or predicting equation that affected refrigeration and air-conditioning technicians' working habits was:

$$Y = 0.645(P_{ersonality}) + 0.997(L_{earning}\ O_{rganisation}) + 0.764(H_{uman}\ R_{elationships})$$

The predicting equation has the power of prediction 66.667% and the error of prediction was 33.333%.

DISCUSSION

Electricians' Vocational Competencies in Industry

The basic knowledge of electricians working in industry includes the types and characteristics of materials in various industries, the particular specification of electrical materials and equipment, reading and writing for the drafting of electrical and electronics systems, as well as industrial and electrical mathematics. This kind of knowledge seems to be the most important to an electrician in industry because, for example, in a practical situation, when there is a trip in a circuit breaker because of a short circuit in an electrical system, an electrician has to check the loads in circuits and/or look into electrical drafting, as well as the characteristics of materials/equipment before replacing them. At this point, the electrician may need the calculation of ampere in order to select the accurate materials equipment [6]. In this way, the circuit in the electrical system can be tested.

The testing and maintenance of electrical equipment, electrical machinery and electrical systems are often required for an electrician in industry because, generally speaking with regard to product processing, the operation of machinery needs to be maintained so that nothing abrupt or unforeseen happens to a piece of machinery. Thus, it will help extend the life of the machine longer, and there will also be a lower cost, hence saving time and ensuring constant production.

Learning organisation is one of an electrician's most prominent working habits as it means that people at all levels, individually and collectively, are continually increasing their capacity to produce results that they really care about [7]. Furthermore, learning organisations can bring forth positive outcomes, such as respectful relationships between workers and shared visions/ideas, as well as sacrifice and commitment for the entire workforce.

Technicians' Vocational Competencies in Refrigeration and Air-conditioning

Refrigeration and air-conditioning technicians' knowledge deals with safety first, including the rules and regulations of safety in mechanical and electrical systems, exercising caution in the utilisation of mechanical and electrical systems, as well as recognising safety in industry and at manufacturers. This kind of knowledge is especially important to a refrigeration and air-conditioning technician because, when the temperature is rather high or there is a block in a liquid line, the pressure of a refrigerant increases and it may suddenly explode. Thus, a technician must be precautious at every step of a refrigeration and air-conditioning installation; otherwise, it may endanger his/her own life.

Technicians should be able to install refrigeration and air-conditioning systems. Furthermore, their function will include materials and equipment selection, removing and assembling, welding, circuit connections, vacuum and refrigerant charging, and testing of operations. These competencies of refrigeration and air-conditioning technicians require multi-skilling as a mechanical and electrical operation.

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