Development Indicator Factors of Thai Engineering Graduates in Innovation: Testing Measurement Invariance by Low and High Level of Innovation Work Experience

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Abstract
The purpose of this research was 1) to develop competency factor indicators of Thai engineering graduates in innovation 2) to validate competency factor indicators model of Thai engineering graduates in innovation 3) to test the invariance of the model of competency factor indicators of Thai engineering graduates in innovation had invariance between groups of low and high level of innovation work experience. The participants of this research were 305 engineering graduates who works in variety occupations of companies. The research tool is the questionnaires surveyed via E-mail with the reliability of 0.934. Data were analysed using descriptive statistics, the Pearson's correlation Coefficient and testing hypotheses by using SEM analysis and multiple group structural equation model analysis by Mplus program. The research results found that 1. competency factor indicators of Thai engineering graduates in innovation consisted of two factors, namely general competency and specific competency to research. The general competency factor consisted of 11 indicators. The specific competency conducive to research factor consisted of 6 indicators. 2. The model of the competency factor indicators for Thai engineering graduates in innovation found that the model fit the empirical data. 3. The model of competency factor indicators for engineering graduates in innovation indicated invariance of model form had invariance between groups of low and high level of innovation work experience. The comparison of the chi-square value of a base line model with an observed model showed that the model had invariance between groups of low and high level of innovation work experience.
Keywords: Development Indicator Factors, Innovation, Competency, Engineering Graduates

Introduction

Currently, technical innovations in engineering have advanced considerably in response to the use of engineering graduates to work in innovative organizations during a rapidly changing global competitive environment. Therefore, the organization needs talented engineering graduates to join the innovation work to gain competitive advantage and create value proposition for the business. From the previous study of innovative competencies of engineering graduates who can work in accordance with the changing dynamic environment that employee performance is an important foundation of successful organization (Pearnpitak, 2018). Thus, human resources are the important factor that every organization should be concern to their competency (Chutchawanchanchanakij, 2017). Competency has many definitions and types. Therefore, competency can be defined as it's used for schools, institutions, fields, industries and organizations. Boyatzis (1982) defined the competency as the personality, motive, trait, skills, social role of person which can perform level of personal achievement. Ratanopas (2014) defined competency as the knowledge, skills and personal attributes of people that result in effective and superior performance in specific job roles. Therefore, competency meaning depends on types of generic and specific role. The meanings of competency indicate the culture of organization not only knowledge, skills, and attribute but also other factors which can be seen from work styles or specific role. After thoughtfulness, the researcher found that there is difference between general competency and specific competency according to the following table 1:

Table 1 Difference between general and specific competency

General competency	**Specific competency**
Core competency	Functional competency
Professional competency	Technical competency
Common competency	Position competency
Knowledge skills and attributes	Job competency
Critical and expected behaviors	Specific behaviors

Source: Boyatzis (1982); Ratanopas (2014)

Especially employee who must work in related of the innovation process which is different from general competency or performance (Trias de Bes & Kotler, 2011). Kimanivong (2015) define innovation as the application of new ideas to produce better outcomes. Moreover, the innovation is often difficult to get one single view of the competency of all teams and individuals across all the indicators of competency (Trias de Bes & Kotler, 2011). Schar, Gilmartin, Rieken, Brunhaver, Chen and Sheppard (2017) suggest that the relationship between factors of participation in learning experiences, innovation self-efficacy, and factors of engineering task self-efficacy can be associated with factors in innovation self-efficacy. Besides, the issue of competency of engineering graduates require the development of innovation self-efficacy, a broader range of experiences beyond engineering experiences might be important (Schar, et al., 2017). This is similar to the book of Trias de Bes and Kotler (2011) reveal that the work style of winning at innovation is divided into six types: 1) activators who initiate the project of innovation, 2) browsers who search information for innovation team, 3) creators who create ideation, 4) developers who invent new idea to be new things, 5) executors who implement new things to the market, and 6) facilitators who support instrument for team. To develop better understanding about competency of engineering in innovation, it is important to acknowledge the difference between general competency and specific competency of engineering graduates. Therefore, general competency of Thai engineering graduate is as 11 outcomes based of the Thailand Accreditation Board of Engineering Education also known as TABEE remain a

subcommittee within the Council of Engineers (Rules & Procedures for Accreditation of Engineering, 2016). TABEE factors are as follows: 1) new tool usage, 2) society environment sustainability and engineering profession, 3) individual and team work, 4) communication, 5) investigation, 6) technology design, 7) engineering problems analysis, 8) project management and finance, 9) lifelong Learning, 10) knowledge of mathematics science and engineering, and 11) ethics.

Moreover, Kraisuth and Panjakajornsak (2018) suggest that competency emphatically indicates organizational culture or type so that industrial companies in Thailand need to reduce the engineers' competency gap using collaborative management and teamwork for human resource development. According to the mentioned competency, the leader of organizations should select the right person who can work in innovation team, but the leader of organizations should know the indicators of factors affecting innovation team for human resource development. The literature evidence, that the innovative competency of engineering graduates who can work in accordance with the dynamic changing environment that the organization needs from employee's performance. As the factors affect the performance can link qualified engineer and indicate competency wells into fit model (Kraisuth & Panjakajornsak, 2018).

However, the researcher has not been found evidence of a report or thesis or dissertation showing research that the Mplus program has been used to analyse multiple group of multilevel structural equation models for finding indicators of competency of engineering graduates in innovation. Accordingly, this study purpose to use Mplus Program to come up with factor indicators on competency of Thai engineering graduates in innovation that might be strongly appropriate new research study (Muthén & Muthén, 2017).

Literature Review

For the study of competency which indicates the Thai engineering graduates in innovation, the researcher reviews related literatures consisting of:

Concept of competency

The theory of competency is considered the concept which is the work performance related to traits, motives and personality of the individuals that endorse the intensity and intrinsic strength linkage of cognitive processes and execution of behaviours and performance (Boyatzis, 1982). There are many indicator factors of competency that bring to a success for organizational sustainable, employee who is a main key towards supporting an organization to be productive in achieving goal (Sangperm, 2017). According to Schar, et al. (2017) studied competency concept of engineering student by using innovative behaviour with adapted innovator's DNA model and innovative behaviours scale which are conceptualize successful entrepreneurship. According to the study of the competency that impacts person, it is found that competency can be measured with the indicator of capabilities and performance skills in innovation of work which are defined into an individual person, an interpersonal team and a networking of working connection (Watts, Aznar-Mas, Penttilä, Kairisto-Mertanen, Stange, & Helker, 2013).

Importance of competency

Corresponding with the research of Arif and Sindhu (2017) studying the factors causing competencies affect creative decision making of the team leaders, through organizational learning process in new things for value creation. Importance of capability or competency factors can help to measure the value of persons, so manager can make right decisions related to organizational resources in order to increase productivity and relation of work culture (Kaneko & Yimruan, 2017). The most important issues for the selection and retention of professional employees who have been being the key personnel in driving to successful organizational management should have been identify with high consideration

(Chutchawanchanchanakij, 2017). Thus, the employees and the team have positive relationship the employees and the team can work together with belonging to the organization (Watthanabut & Sathaphorn Manasabutr, 2017).

Self-efficacy of competency

The research results of Dong and Soransataporn (2012) reveal that there are 4 areas to help students increase their self-efficacy; 1) successful experiences boost self-efficacy while failures deteriorate it, 2) experience in work which can strengthen someone belief in their own personal abilities, 3) persuasion and teaching can increase self-efficacy with trust in communication and feedback to guideless through the motive task with best effort inspiration, 4) positive of emotional can create high beliefs in self-efficacy while as anxiety can decrease it. This is similar to the study of Arif and Sindhu (2017) identified self-efficacy as the confidence on performance to obtain all advantage of the internal force driven including mental resources and behaviours within the suitable environment to achieve outcome base. Arif and Sindhu (2017) also mentioned that core competencies and creative decision have the relation of the team leader and members can work together in uncertain environments or situation or market for learning in organization as the members can create more innovation, technique and creative decision making for problem solution and value creation.

Competency indicator factors of engineer in innovation

Studying the indicators of the general competency of TABEE, and the specific competency of A-to-F model which refer to work style in innovation. As the TABEE factors have been used as a rules and procedures for Thai engineering graduates (Rules and Procedures for Accreditation of Engineering, 2016). The key indicators of TABEE relate to general competency of Thai engineering graduates, which are defined as ability, work activity, skills, and knowledge for choosing factors as our unit of analysis. The TABEE of general competency of engineering graduates has attach the importance to 11 factors consisting of (1) selecting and applying of appropriate modern tool usage, (2) responsible for society environment sustainability and engineering profession, (3) individual and team work, (4) communication, (5) engineering problems analysis, (6) technology design, (7) complex engineering problems, (8) investigation, (8) project management and finance, (9) active learning or lifelong learning, (10) knowledge of mathematics, science and engineering, and (11) ethics (Accreditation Board for Engineering and Technology, 2017). To address the key indicators, which are defined as the TABEE factors have been used as examination and measurement of engineering competencies. The researcher found the relationship between TABEE factors and work style in innovation of the O*NET data source which refers the way a company's employees behave in innovation (O*NET, 2018). This is similar to the study of A-to-F model that have shown the personality traits as well as personal innovation process performs. A-to-F model can represent the general competency which organizational requirement consist of the followings: (1) activators who can initiate new projects or new things or innovation in process of innovation work, (2) browsers who are specialist in the field of searching information usage for team, (3) creators who create new ideas, concepts, possibilities of whole design system or architecture in innovation process, (4) developers who transform ideation into products services by invention, (5) executors who can implement product or service innovation into the market or channel or customer adoption, and (6) facilitators who can support instrument or budget of tools, equipment and resource for team needs (Trias de Bes & Kotler, 2011). Both TABEE and A-to-F model conducted by the argues that factors affecting organizational human resource is an indicator of talent. This leads researcher to study that indicator factors of Thai engineering graduates in innovation provides testing measurement invariance by level or group of innovation work experience.

Research Objectives

The objectives of this study are (1) to develop competency factor indicators of Thai engineering graduates in innovation, (2) to validate competency factor indicators model of Thai engineering graduates in innovation, and (3) to test the invariance of the model of competency factor indicators of Thai engineering graduates in innovation had invariance between groups of low and high level of innovation work experience.

Conceptual Framework

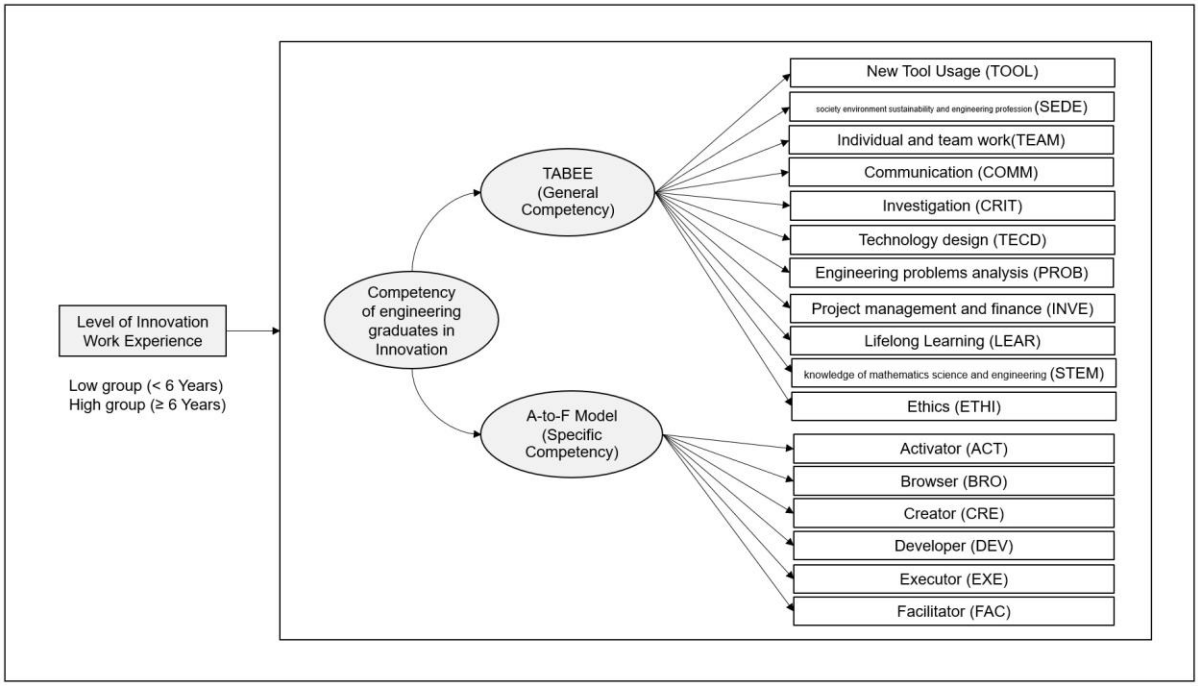

Figure 1. The factors of competency of engineering graduates in innovation

Research Methodology

Data used in the research are samples of Thai engineering graduates. The size of sample group using calculation of Soper (2018) was computed the minimum sample size required 150 for a study that uses a structural equation model (SEM), given the number of observed and latent variables in the model, the anticipated effect size, and the desired probability and statistical power levels. From the calculated sample group, using the statistic principle by using ratio of parameter values, the number of sample group for this research consists of 305 persons. The questionnaire was designed as the tool and tested for quality on the validity by 12 experts to examine the objective correspondence, content, and language used by measuring the IOC and then finding the confidence level with the Try-Out sample group of 30 persons using Cronbach's alpha coefficient the value is 0.934. Then, 305 samples of Thai engineering graduates that were selected by purposive sampling technique and snowball sampling techniques to answer the questionnaire involving the indicator factors and self-efficacy with 7 Likert scale.

Data analysis involves the quantitative research with the descriptive statistics namely frequency, percentage, mathematic means, and standard deviation with the multivariate analysis on the structural equation models. Statistical analysis was made on descriptive statistic, Pearson's product moment correlation using SPSS for windows. The confirmatory factor analysis and multilevel structural equation model analysis was performed using Mplus version 8.3. Data were then analyzed by SEM and Multiple Group Analysis.

Research Results

The Indicator Factors of Thai Engineering Graduates in Innovation

Most of the respondent, Thai engineering graduates are for 305 persons, 205 persons (82%) are male and 133 persons (43.61%) are in the age of 30-39 years. Most of the sample 284 persons (93%) have engineering degree. 77 persons (25%) have the experience of 11-15 years. 259 persons (85%) related to work engineering. 157 persons (51.48%) have less than 6 years' innovation work experience (Low group).

Overall, the indicator factors of Thai Engineering graduates in innovation of the level self-efficacy score towards the general competencies is quite high. The scores were sorted by averaging from highest to lowest, the indicates with the highest are lifelong learning ($\bar{x}$ = 5.145) followed by individual and team work ($\bar{x}$ = 4.985), then followed by communication ($\bar{x}$ = 4.886) and the lowest average indicator scores are design technology ($\bar{x}$ = 3.999). And it was found that the standard deviation of the overview of the self-efficacy score of the engineering graduates on the general competency in all 11 factors were slightly different (SD = 1.229). When considered in each indicator, it was found that every issue was slightly different. Thus, the samples have the same or similar direction of opinion.

In the issue that the specific competency affiliate work style in innovation, the indicator factors of Thai Engineering graduates in innovation of the level self-efficacy score towards the specific competencies is high. The scores were sorted by averaging from highest to lowest, the indicators with the highest are activator or imitation ($\bar{x}$ = 4.016) followed by creators or ideation ($\bar{x}$ = 4.985), and the lowest average indicator scores are facilitators or instrument ($\bar{x}$ = 3.777). And it was found that the standard deviation of the overview of the self-efficacy score of the engineering graduates on the specific competency in all 6 factors were slightly different (SD = 0.806). When considered in each indicator, it was found that every factor was slightly different. Thus, the samples have the same or similar direction of opinion. The results of this study were as follows: (1) Competency factor indicators of Thai engineering graduates in innovation consisted of two factors, namely general competency and specific competency to research. The general competency factor consisted of 11 indicators: modern tool usage society environment sustainability and engineering profession, individual and team work, communication, investigation, technology design, engineering problems analysis, project management and finance, lifelong learning, knowledge of mathematics science and engineering and ethics. The specific competency conducive to research factor consisted of 6 indicators: activator, browser, creator, developer, executor and facilitator, (2) The model of the competency factor indicators for Thai engineering graduates in innovation found that the model fit the empirical data ($\chi 2(246) = 470.740$, $\chi 2/df = 1.914$, CFI = 0.927, TLI = 0.920, RMSEA = 0.077, SRMR = 0.119), (3) The model of competency factor indicators for engineering graduates in innovation indicated invariance of model form had invariance between groups of low and high level of innovation work experience, but the model indicated variance of the factor loading of each indicators and factor loading of general competency and specific competency conducive to research factors. The tests of strong factorial invariance of the measurement models were statistically accepted at.01 on both the models with all parameters freely estimated in the low and high group that doesn't change when scales are multiplied by a common factor is scale invariant, a base line model, data ($\chi 2(246) = 470.740$, $\chi 2/df = 1.914$, CFI = 0.927, TLI = 0.920, RMSEA = 0.077, SRMR = 0.119) and the models with loadings only constrained to be equal across groups, an observed model. ($\chi 2(246) = 470.740$, $\chi 2/df = 1.914$, CFI = 0.927, TLI = 0.920, RMSEA = 0.077, SRMR = 0.119) as shown in Table 2 and Table 3.

The hypothesis test is on the model validation with empirical data. Then, the values are considered as shown in Figure 2.

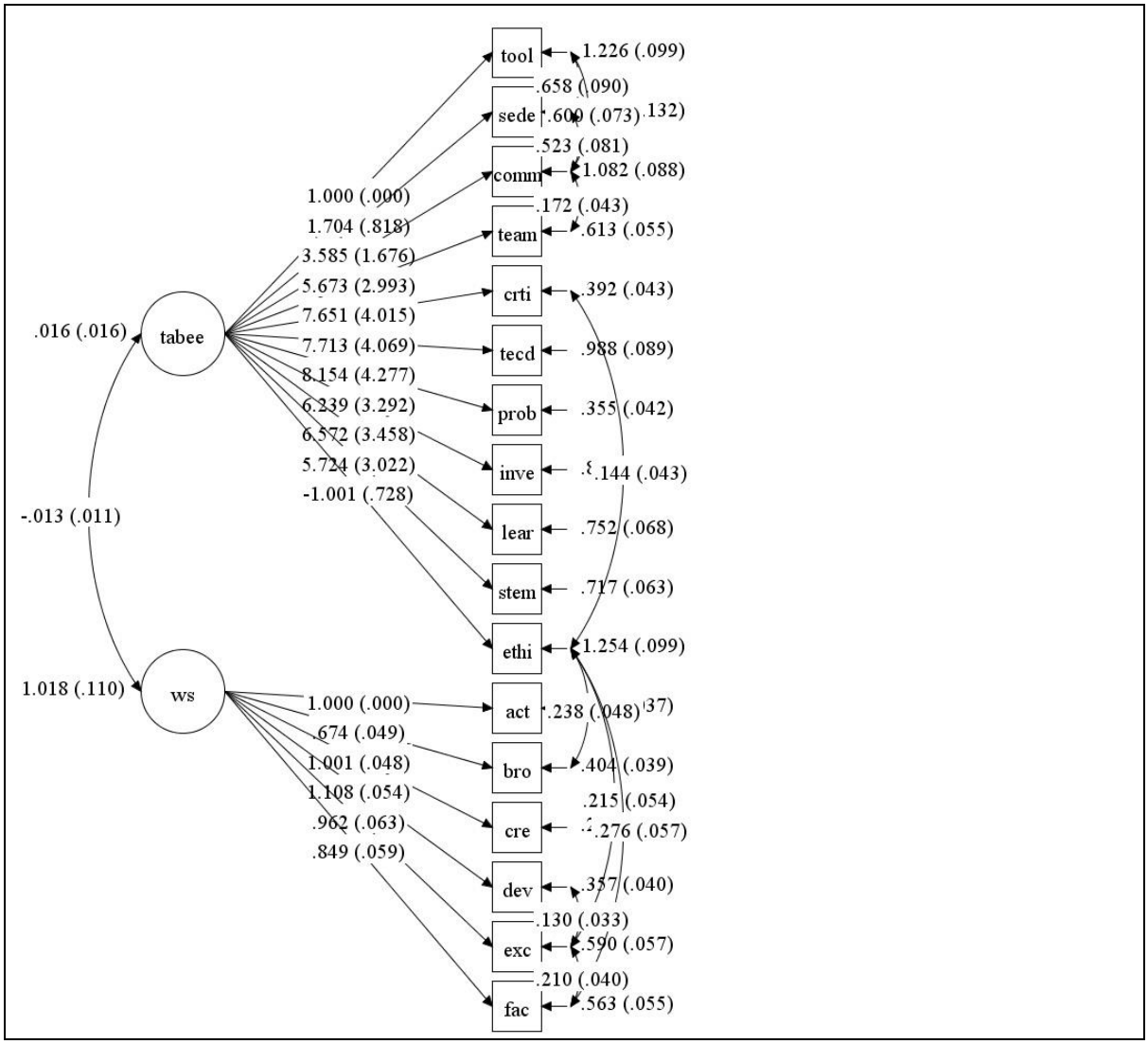

Figure 2. Structural equation models following the hypotheses representing the factors indicators for Thai engineering graduates in innovation

Testing Measurement Invariance by Low and High Level of Innovation Work Experience

According to Table 2, the correspondence between the structural equation models as (Modified Model) is correspondence with the empirical data more considered form the correspondence $\chi 2(246) = 470.740$, $\chi 2/df = 1.914$, CFI = 0.927, TLI = 0.920, RMSEA = 0.077, SRMR = 0.119 passing following the criteria in all values. P-value equals to 0.000 which is less than.01 representing the acceptance in the hypothesis because Hari, et al. (2010) recommend Goodness of Fit Test Guidelines for models with complexity has more than 30 parameters (NI = 38) $\chi 2$ = Sig.p, RMSEA <.08, TLI/CFI >.92

As shown in Table 3, the model of competency factor indicators for engineering graduates in innovation indicated invariance of model form had invariance between groups of low and high level of innovation work experience, but the model indicated variance of the factor loading of each indicators and factor loading of general competency and specific competency conducive to research factors. The comparison of the chi-square value of a base line model with an observed model showed that the model had invariance between groups of low and high level of innovation work experience (($\Delta \chi 2$ (470.740) = 470.740, p <.01)).

Table 2 Results of analysis on the data obtained from the indicators used in examining the correspondence and harmony of the variables and empirical data (after being adjusted)

Factor	Standardization Estimator		R^2		Goodness of Fit Index (Results of consideration) Passed
	Low	High	Low	High	
TOOL	0.105	0.109	0.011	0.012	Chi-Square (χ^2) = 470.740
SEDE	0.164	0.153	0.027	0.024	df = 246 df = 246
COMM	0.390	0.399	0.152	0.159	χ^2/df = 1.914
TEAM	0.662	0.671	0.438	0.451	RMSEA = 0.077
CRTI	0.856	0.786	0.732	0.618	SRMR = 0.119
TECD	0.708	0.651	0.501	0.424	TLI = 0.920
PROB	0.905	0.789	0.819	0.622	CFI = 0.927
INVE	0.660	0.637	0.435	0.405	LOW = 262.827
LEAR	0.687	0.673	0.473	0.453	High = 207.913
STEM	0.677	0.570	0.458	0.325	
EHTI	-0.117	-0.106	0.014	0.011	
ACT	0.838	0.901	0.702	0.812	
BRO	0.695	0.754	0.483	0.569	
CRE	0.888	0.905	0.789	0.819	
DEV	0.870	0.896	0.757	0.804	
EXE	0.774	0.796	0.599	0.634	
FAC	0.721	0.826	0.519	0.683	

Remark: p <.001

Table 3 Testing Moderation: Multiple Groups

Model	Value	df	Δ Value	Δ df
Low group	470.740	246	-	-
EXPORT	470.740	246	-	-

Remark: 2 levels of innovation work experience are low group (less than 6 years of innovation work experience) and high group (≥ 6 years of innovation wok experience)

Discussion and Conclusion

Overall, the general competency factors have negatively correlation with specific competency at-.013(.011). The hypothesis is accepted as Goodness of Fit Index tests that the results of consideration are passed, which indicate that variables are related and therefore suitable for structure detection. The results as standard factor score coefficient indicator positively affects competency of engineering graduate in innovation at 0.01 level. However, ethics indicator negatively affects correspondence even though this factor can indicate persons' identity (Pearnpitak, 2018). Finally, it is necessary to have 17 indicator factors of Thai engineering graduates in innovation which the results show significantly in statistics. 17 indicators are in accordance with criteria of Accreditation Board for Engineering and Technology (2017) attributes TABEE by general competency of outcome base for engineering graduates and A-to-F model of Trias de Bes and Kotler (2011) attributes work styles by specific competency of innovation process in organization. According to the study of Ratanopas (2014) on the competency that influences person, it is found that there are 2 types of competency that should be general and specific competency of engineering graduates in innovation, have been identified as the meaning that depends on types of generic and specific role. In conclusion, engineers have significantly high score on lifelong learning of general competency, on the other hand, the current finding of lowest scores on facilitators of specific competency so that

the results carry explained implications for engineers to distinguish between active learning in innovation and to recognize the leadership for support team with instrumentation's issues that are involved, in addition to future research in this area. Discussion in term of use a non-random sample, may not be appropriate the entire population of Thai engineering graduates. This study provides factors of the key indicators which offer validity and reliability of scale which guides to support future research. In recommendation, Mplus program can help to increase the develop indicator factors for developing country because it is strongly appropriate to use for starting new research technique of multi-level structural equation model (Muthén & Muthén, 2017).

However, the limited number of studies on Thai engineering graduate's information database reflects imprecise in engineering occupation and other occupations. The analysis of identifying the indicators for each occupation should be explored to identify the specific factors for each country. Further studies in competency of employees should be concern on different types of organization that might be required (Limphaibool, Limphaibool, & Davidson, 2017).

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