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Factor analysis for creating and developing the competency evaluation model

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Abstract

The research aims to study and apply a proper statistical method for creating and developing the evaluation model of pre-service teachers' competency in the 21st century. Data collection process includes an interview, focus group, questionnaire and evaluation. Descriptive statistics, Exploratory Factor Analysis and First and Second - Order Confirmatory Factor Analysis are the techniques used for data analysis. The samples of 1284 instructors and teachers in training unit are collected for the Factor analysis. The study presents 10 factors of the pre-service teacher competency in the 21st Century: (1) the proficiency of professional teachers' basic subjects, (2) the proficiency to promote learning efficiency, (3) the proficiency of the social context, (4) the learning management skills, (5) the media technology skills, (6) the communication skills, (7) the social skills, (8) the conscious and awareness, (9) the self-practice, and (10) the moral and ethics. The result shows that KMO =0.979 and the Bartlett's Test shows all indicators are correlated at α= 0.05. The total variance of the components is 79.782%. The fit indexes indicate the consistency of the structure evaluation model with empirical data includes Chi square/df. =1.96, RMSEA = 0.027, CFI =1.00 and GFI=0.93. The validity is measured by $t>|1.96|$ at α=0.05 and the reliability of indicator using R2 are between 0.62 to 0.83 for all 60 indicators. The construct reliability of this model are between 0.91 - 0.96 indicating a good reliability and the construct validity is consistent with standard criterion. The model includes 5 evaluation factors: focus group, scope, procedure, judgment, and report.

Keywords: applied statistics, evaluation model, pre-service teachers, competency, 21st century

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1. Introduction

Human resources are very important to country development and they are the value properties that show country wealth. Nowadays, the world is changing vary fast, human needs to adjust and develop his capabilities. [1] Organizations use competency ideas in human resources development to increase human capabilities. Competency is ability that shows experiences, skills and appropriate properties in working. [2] Public and private organizations give importance to human competency development; for example, [3] competency is a part of position specification and work evaluation, and [4] development of chef's competencies model and instrument for competency measurement. According to [5] the Secretary-General of the United Nations, education can change and develop human's life and society. It is international and base of human rights. Teachers and educational personnel are the most important factors for educational plan and development; however [6], the pre-service teacher production needs to be improved.

Competency development in each profession needs statistics to collect and analyze data and to create and develop the competency evaluation model. The word "Statistic" was introduced by Sir Ronald Fisher in 1922. [7] It comes from "Statistik" in German and "Status" in Latin means state [8]. Its meaning shows that statistics is related to state or country development. The meaning was given by statistics vocabulary [9].

The researcher has studied on the topic of "Evaluation Model of Pre-Service Teachers Competency in the 21st Century". This article is a part of this research that aims to study a proper statistical application for creating and developing competency evaluation model, and to use factor analysis for creating evaluation model of pre-service teacher competency in the 21st century.

2. Materials and methods

This study is comprised of materials and methods as the followings.

2.1 Design

The research and development (R&D) Phase I: Synthesis and quality check of factors and indicators include focus group, evaluation, and questionnaire survey. Phase II: Model creation and evaluation include model test and evaluation.

2.2 Samples and instrument

- 38 samples of educational professionals using purposive sampling for synthesis and quality check of competency indicators. Three rounds of synthesis and

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quality checking using the index of congruence (IOC) were conducted. The criterions are IOC > 0.7 for more than 5 experts and IOC > 0.5 for more than 3 experts. In this study the questionnaire for evaluate competency indicators is consistent with the criterions.

▪ The try-out group is 3 0 lecturers of Chiang Mai Rajabhat University and teachers from schools in Chiang Mai aria. The reliability of questionnaire is checked by internal consistency methods with Cronbach' s Alpha Coefficient(α) = 0.982 which is greater that Fraenkel and Wallen's [10] criterion stating that α at least 0.70 suggests good reliability.

▪ 1,284 samples of teachers in educational and teacher training institutions using questionnaire. Ratio of samples: indicators = 20:1 [11] and divided in to 2 groups as follows

❖ The teacher's producer includes all higher educational institute across the country. The sample of 90 institutes were collected using the simple random sampling from 131 institutes. The total of 643 questionnaires were completed and used for analyzing the factor analysis.

❖ Teacher in training unit school. The schools are all government schools with more than 50 students. The sample of 51 out of 262 schools were collected using stratified sampling which categorized by the type of schools, the number of teachers. For the high school, the teachers then were categorized by field of teaching while the elementary school were grouped by grade 1-6. The total of 641 questionnaires were completed and used for analyzing the factor analysis.

❖ General information of the sample is the following

The average age of the university Instructors is 41.82 years-old with the average of 12. 69 years' experience with pre-service teachers while the average age of teacher in training unit school is 44.73 years-old with the average of 20.42 years' experience with pre-service teachers. The demographic data is shown in Table 1 – Table 2

Table 1 Number of response (%) categorized by gender and level of education

	University Instructors	Teachers in Training Unit School	Total
Gender			
Male	307 (23.91)	156 (12.15)	463 (36.06)
Female	328 (25.55)	480 (37.38)	808 (62.93)
Not specified	8(0.62)	5(0.39)	13(1.01)
Level of Education			
Bachelor	25 (1.95)	378 (29.44)	403 (31.39)
Master	370 (28.82)	256 (19.94)	626 (48.75)
Ph.D.	242 (18.85)	3 (0.23)	245 (19.08)
Etc.	1 (0.08)	1 (0.08)	2 (0.16)
Not specified	5(0.39)	3(0.23)	8(0.62)
Total	643 (50.08)	641(49.92)	1284(100.00)

Table 2 Number of response (%) categorized by position

University Instructors	Number of response (%)	Teachers in Training Unit School	Number of response (%)
Lecturer	465 (72.32)	Primary Level	36 (5.62)
Assistant Professor	120 (18.66)	Practitioner Level	96 (14.98)
Associate Professor	29 (4 .51)	Professional Level	143 (22.31)
Professor	3 (0.47)	Senior Professional Level	310 (48.36)
Etc.	17 (2.64)	Expert Level	5 (0.78)
Not specified	9 (1.40)	Etc.	47 (7.33)
		Not specified	4 (0.62)
Total	643 (100.0)	Total	641(100.0)

Table 1 shows that 62.93 %of the sample are female which is 26.87% more than male. For educational level, 48.75% which is the majority of the sample have master degree.

Table 2 shows that 72.32% of University instructors are lecturer whereas 48.36% of teachers in training unit school are senior professional level.

▪ 20 samples of educational professionals, university supervisors, mentor teachers, and senior pre-service teachers for evaluation. 50 samples of senior pre-service teachers for model test and publication.

3. Results and discussion

3.1 The result of using applied statistics for creating and developing competency evaluation model

The procedure of creating and developing competency evaluation model and statistics are shown in Figure 1

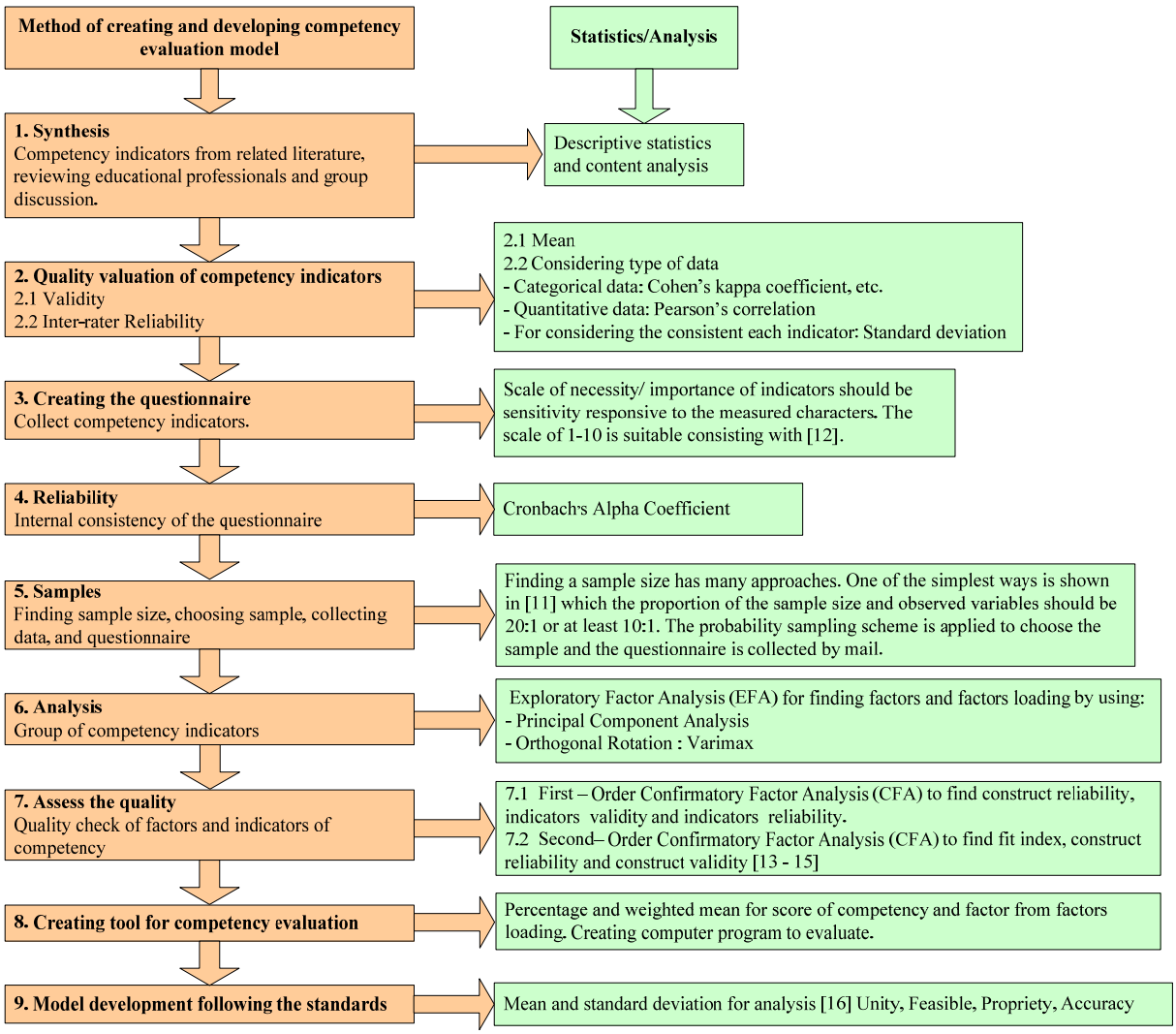


Figure 1 Procedure of creating and developing competency evaluation model and statistics

Statistical words using for factor analysis

1) Exploratory Factor Analysis

1.1) Validity check of exploratory factor analysis

(1) Kaiser –Meyer-Olkin (KMO) is a measure of how suited of the data for applying the Factor Analysis. The following values are for reference [17]

KMO Statistic	**Interpretation**
> 0.90	Marvelous
0.80 – 0.89	Meritorious
0.70 - 0.79	Middling
0.60 – 0.69	Mediocre
0.50 – 0.59	Miserable
< 0.50	Unacceptable

(2) Bartlett's Test of Sphericity [18]

The Bartlett's test has an approximate Chi-square distributed statistic. It provide the statistical significance, the observe variables (X_1, X_2,…,X_p) are correlated indicating a factor analysis may be applicable.

1.2) Appropriate factors

(1) Eigen value > 1.00

(2) Low error and RMSR (Root mean Square Residual)

(3) Percentage of variance > 60 [19]

(4) Consider scree plot – when the graph is parallel with a horizontal axis indicating that the number of factors may reach its maximum.

(5) Factor loading - factor > 0.60 or 0.40 [11] and [19]

Factor loading between ±0.030 to± 0.40 - the lowest value for factor analysis

Factor loading > ±0.50 - statistical significance for factor analysis

Factor loading >±0.80 - meritorious

2) Confirmatory factor analysis - Model fit

Prior to performing the Confirmatory factor analysis, the assumptions were tested includes (1) indicator variables are normally distributed using the Shapiro-Wilk test or Skewness ≤ |3|, Kurtosis ≤|10| (2) the linear correlation between the two indicator variables using t –test for testing correlation coefficient (3) Multicollinearity by considering correlation between the two indicators variable ≤ 0.85. In this research, the indicator variables are all passed the assumptions and choose the Maximum Likelihood Estimates (MLE) for estimating parameters

2.1) Fit Index - considering that model harmonizes with empirical data [20 - 25]. The results are presented in Table 3.

2.2) Validity of indicators - weight of factor should be high and at 0.05 statistical significance level, t > |1.96| [24]. In this case the t- test is testing whether the factor loading = 0 or not. If the indicator variable ≠ 0, it has an effect on the factor variable. All indicators can be tested using this test in the first-order confirmatory factor Analysis. However, for the second-order confirmatory factor analysis, some indicators are fixed; therefore, no SE which leads to the t-test is unable to calculated. The results are presented in Table 4.

2.3) Reliability of indicators - considering on multiple correlation (R^2) [24]

2. 4) Construct Reliability (CR) - Must be established before construct validity can be assessed. It is computed from the squared sum of standardized factor loading for each construct and the sum of the error variance terms for a construct. The rule of thumb for either reliability estimate is 0.70 or higher suggests good reliability. [11]

2.5) Construct Validity – Extent to which indicators of specific construct converge. The results are presented in Table 4.

3.2 Result of using factor analysis for creating and developing evaluation model of pre-service teacher competency in the 21st century

The research analyzes 60 indicators that were evaluated by content validity.

1) The result of exploratory factor analysis by using Kaiser –Meyer-Olkin Measure of Sampling Adequacy (KMO) shows as 0. 979 which means it' s marvelous [19]. As 0.05 statistical significance level of independent test, it performs that variables are uncorrelated and all 60 variables can use factor analysis.

2) Eigen values of 10 factors are >1. 00. The values are between 1.267-29.147. Variances are 2.111-48. 578% . Variances are used to explain indicators as 79.782%.

3) The fitted model from the second– order confirmatory factor analysis.

Table 3 The fit indexes of the evaluation of pre-service teacher's competency in the 21st century and the empirical data by the second– order confirmatory factor analysis.

Fit Index	Acceptable Threshold Levels	Produced Statistics
Chi square(P-value)	>0.05	0.00
Chi square/df. (NC)	<2	1.96
RMSEA (Root Mean Square Error of Approximation)	< 0.05	0.027
ECVI (Expected Cross-Validation Index)	< ECVI for Saturated Model(2.85)	2.81
Model AIC (Akaike's Information Criterion)	< Saturated AIC (3,660.00)	3,601.03
Model CAIC (Consistent Version of AIC)	< Saturated CAIC(14,928.66)	5,177.41
NFI (Normed Fit Index)	>0.90	0.99
NNF I(Non-Normed Fit Index)	>0.90	1.00
PNFI (Parsimony Normed Fit Index)	>0.50	0.88
CFI (Comparative Fit Index)	>0.90	1.00
IFI (Incremental Fit Index)	>0.90	1.00
RFI (Relative Fit Index)	>0.90	0.99
RMR (Root Mean Square Residual)	<0.05	0.038
SRMR (Standardized Root Mean Square Residual)	<0.05	0.024
GFI (Goodness of Fit Index)	>0.90	0.93
AGFI (Adjusted Goodness of Fit Index)	>0.90	0.91
PGFI (Parsimony Goodness of Fit Index)	>0.50	0.80
CN (Critical N)	>200	719.38

Note : Using Chi square depends on the sample size. If sample size is large, the Chi square will be high and the result will not be correct. [20] and [24] suggest that use Chi square/df. (NC).

Table 3 shows the results of second –order confirmatory factor analysis, evaluation of pre-service teacher's competency in the 21st century matches the empirical data by considering the goodness of fit indexes. The result shows that all indexes follow the criterion, except the Chi-square which gives p-value = $0.000 < 0.05$ of the significance level. However, considering the Chi-square/df.(NC)$=1.96$ is less than 2.0, one can conclude that this index also follow the criterion [24]. Moreover, the values of RMSEA, ECVI, Model AIC, Model CAIC, NFI, NNFI, PNFI, CFI, IFI, RFI, RMR, SRMR, GFI, AGFI, PGFI, CN pass all criterions. The construct model and the weight of factors are shown in Figure 2

Table 4 The statistics of second –order confirmatory factor analysis of evaluation of pre-service teacher's competency in the 21st century

Factor	Indicator	Standardized Factor Loading	Factor Loading	SE	t	R^2	CR	AVE
The proficiency of professional teachers' basic subjects(KB)	KB1	0.86	1.10	-	-	0.74	0.91	0.71
	KB2	0.86	1.08	0.03	33.10	0.73		
	KB3	0.84	1.06	0.02	52.74	0.70		
	KB4	0.81	1.09	0.04	30.89	0.66		
The proficiency to promote learning efficiency (KL)	KL1	0.85	1.10	-	-	0.73	0.94	0.71
	KL2	0.85	1.10	0.03	41.10	0.72		
	KL3	0.84	1.09	0.03	42.15	0.70		
	KL4	0.83	1.09	0.03	37.62	0.69		
	KL5	0.84	1.07	0.03	36.91	0.70		
	KL6	0.83	1.07	0.03	36.49	0.69		
	KL7	0.85	1.07	0.03	37.72	0.71		
The proficiency of the social context (KS)	KS1	0.83	1.21	-	-	0.69	0.93	0.71
	KS2	0.83	1.21	0.03	38.67	0.70		
	KS3	0.84	1.21	0.03	36.57	0.71		
	KS4	0.85	1.22	0.03	37.05	0.73		
	KS5	0.86	1.18	0.03	37.43	0.74		
The learning management skills (SM)	SM1	0.85	1.03	-	-	0.73	0.96	0.75
	SM2	0.85	1.04	0.02	57.17	0.72		
	SM3	0.87	1.08	0.02	50.36	0.76		
	SM4	0.88	1.12	0.03	40.80	0.77		
	SM5	0.88	1.13	0.03	42.44	0.78		
	SM6	0.86	1.13	0.03	39.97	0.73		
	SM7	0.85	1.11	0.03	38.73	0.71		
	SM8	0.88	1.17	0.03	41.91	0.77		
	SM9	0.87	1.09	0.03	41.18	0.76		
The media technology skills (ST)	ST1	0.87	1.12	-	-	0.75	0.96	0.79
	ST2	0.91	1.19	0.03	46.54	0.82		
	ST3	0.90	1.14	0.02	46.76	0.82		
	ST4	0.91	1.21	0.03	47.01	0.82		
	ST5	0.85	1.17	0.03	40.56	0.72		
	ST6	0.88	1.16	0.03	44.14	0.78		
The communication skills (SC)	SC1	0.86	1.11	-	-	0.74	0.93	0.74
	SC2	0.88	1.12	0.03	40.23	0.77		
	SC3	0.88	1.14	0.03	39.25	0.77		
	SC4	0.82	1.09	0.03	35.95	0.67		
	SC5	0.86	1.10	0.03	36.10	0.74		
The social skills (SL)	SL1	0.91	1.19	-	-	0.83	0.94	0.75
	SL2	0.91	1.13	0.02	46.05	0.82		
	SL3	0.87	1.16	0.03	38.80	0.75		
	SL4	0.82	1.15	0.03	35.29	0.67		

Factor	Indicator	Standardized Factor Loading	Factor Loading	SE	t	R^2	CR	AVE
	SL5	0.80	1.04	0.03	34.90	0.65		
The conscious and awareness (AW)	AW1	0.88	1.09	-	-	0.77	0.94	0.72
	AW2	0.90	1.05	0.03	41.45	0.81		
	AW3	0.87	1.04	0.02	42.38	0.75		
	AW4	0.82	0.91	0.03	30.03	0.67		
	AW5	0.82	0.92	0.03	30.16	0.68		
	AW6	0.80	0.95	0.03	34.02	0.64		
The self-practice (AS)	AS1	0.79	0.95	-	-	0.62	0.95	0.73
	AS2	0.85	0.97	0.02	43.23	0.73		
	AS3	0.88	1.06	0.03	34.17	0.77		
	AS4	0.90	1.01	0.03	34.88	0.82		
	AS5	0.83	0.99	0.03	39.12	0.69		
	AS6	0.85	0.99	0.03	37.12	0.72		
	AS7	0.80	0.94	0.03	35.68	0.64		
The moral and ethics (AM)	AM1	0.88	0.94	-	-	0.78	0.96	0.79
	AM2	0.91	0.94	0.02	48.18	0.82		
	AM3	0.90	0.94	0.02	45.16	0.80		
	AM4	0.88	0.96	0.02	44.17	0.77		
	AM5	0.89	0.97	0.02	45.52	0.79		
	AM6	0.86	0.92	0.02	56.40	0.75		
Main Factor	**Factor**							
Competency	KB	0.77	0.77	0.05	16.45	0.59	0.93	0.58
	KL	0.78	0.77	0.03	24.06	0.61		
	KS	0.76	0.76	0.04	17.26	0.58		
	SM	0.87	0.87	0.05	18.77	0.76		
	ST	0.76	0.77	0.05	16.62	0.58		
	SC	0.74	0.75	0.04	19.49	0.54		
	SL	0.76	0.76	0.03	24.48	0.57		
	AW	0.73	0.75	0.04	18.17	0.53		
	AS	0.71	0.71	0.03	21.14	0.50		
	AM	0.74	0.75	0.03	21.97	0.55		

Note : SE and t are not reported because of a fixed parameter.

As shown in Table 4;
The Construct Reliability (CR) lies between 0.91 - 0.96 which > 0.70 indicating a good reliability as stated by [11].

The Construct Validity is also follow the Hair's criterions [11] which consider the followings.

(1) Standardized Factor Loadings, all of which are > 0.70

(2) The Convergent Validity, which the Average Variance Extracted (AVE) is > 0.50.

(3) The Discriminant Validity is appropriate since the AVE is greater that Correlation Matrix or Covariance Matrix between different Factor Variables

(4) The Construct Reliability (CR), all of which are > 0.70

Considering the correlation between the indicators and the factors by using the Multiple Correlation (R^2), the R^2 are between 0.62 – 0.83 which are acceptable showing that the indicators are reliable or suggesting the correlation between the indicators and the factors. Validity shows that indicators are high and as 0.05 statistical significance level, t > |1.96| for indicators. [25] The results of this research show that some factors and some indicators of pre-service teachers' competency in the 21st century are consistent with the study of [26 - 28]. The Factor Loading are shown in Figure 2.

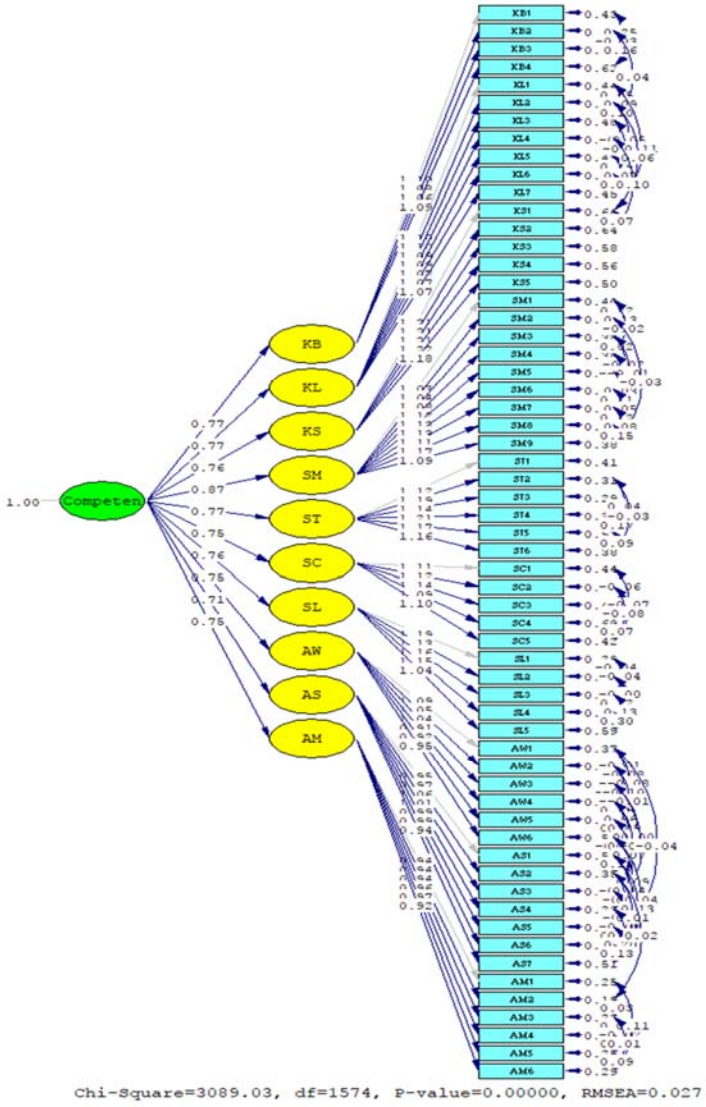


Figure 2 Structures and indicators of pre-service teacher competencies in the 21st century from the 2nd confirmatory factor analysis

4) Evaluation model contains 5 factors: focus group, scope, procedure, judgment, and report [29]. The researcher used evaluation tool to find percentage of factors loading from the second confirmatory factor. Then, finding weighted mean of each competency indicator and factor in 4 levels of competency of knowledge and understanding in teaching, focusing on score and percentage.

Competency of knowledge and understanding in basic subjects for the professional teachers	**Score**	**Percentage**
Knowledge and understanding in student development related to student characters	1.10	25.40
Knowledge and understanding in subjects	1.08	24.94
Knowledge and understanding in student evaluation	1.06	24.48
Knowledge and understanding in creating teaching plans that suit students	1.09	25.17
Total		100

Examples in Figure 3 and 4 present computer programs created for competency evaluation

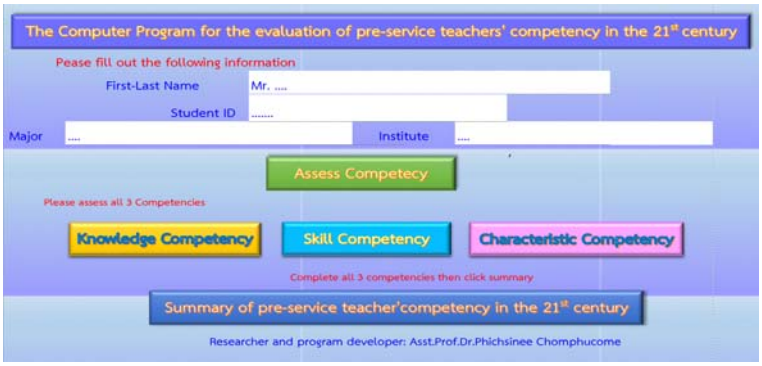
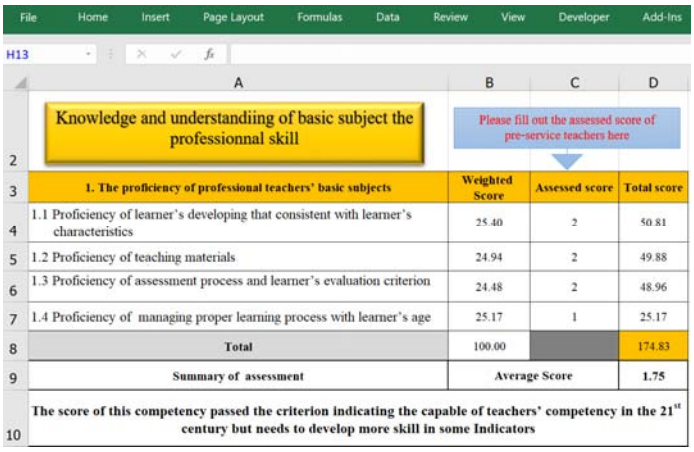


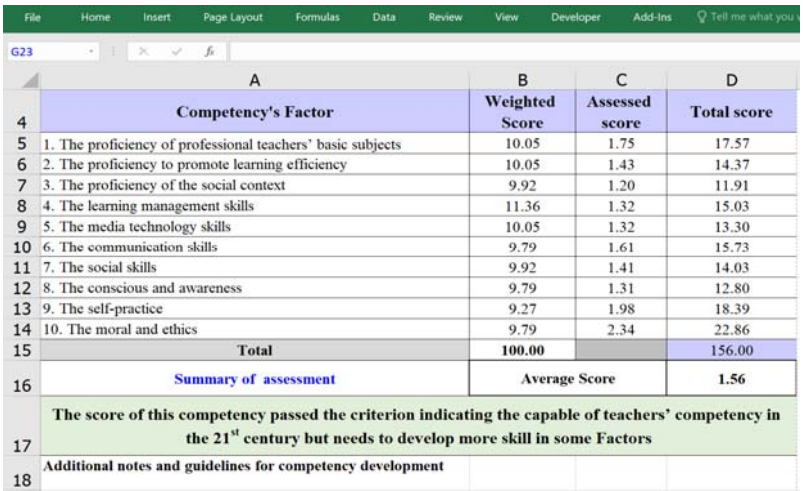
Figure 3 Evaluation processing main program



	1. The proficiency of professional teachers' basic subjects	Weighted Score	Assessed score	Total score
4	1.1 Proficiency of learner's developing that consistent with learner's characteristics	25.40	2	50.81
5	1.2 Proficiency of teaching materials	24.94	2	49.88
6	1.3 Proficiency of assessment process and learner's evaluation criterion	24.48	2	48.96
7	1.4 Proficiency of managing proper learning process with learner's age	25.17	1	25.17
8	**Total**	100.00		174.83
9	**Summary of assessment**	**Average Score**		**1.75**
10	**The score of this competency passed the criterion indicating the capable of teachers' competency in the 21st century but needs to develop more skill in some Indicators**			

Figure 4 Competency indicator evaluation processing program

Figure 5 shows weighted means of all competencies



	Competency's Factor	Weighted Score	Assessed score	Total score
5	1. The proficiency of professional teachers' basic subjects	10.05	1.75	17.57
6	2. The proficiency to promote learning efficiency	10.05	1.43	14.37
7	3. The proficiency of the social context	9.92	1.20	11.91
8	4. The learning management skills	11.36	1.32	15.03
9	5. The media technology skills	10.05	1.32	13.30
10	6. The communication skills	9.79	1.61	15.73
11	7. The social skills	9.92	1.41	14.03
12	8. The conscious and awareness	9.79	1.31	12.80
13	9. The self-practice	9.27	1.98	18.39
14	10. The moral and ethics	9.79	2.34	22.86
15	**Total**	**100.00**		156.00
16	**Summary of assessment**	**Average Score**		**1.56**
17	**The score of this competency passed the criterion indicating the capable of teachers' competency in the 21st century but needs to develop more skill in some Factors**			
18	**Additional notes and guidelines for competency development**			

Figure 5 Competency evaluation processing program

4. Conclusions

In creating and developing the competency evaluation model, the researcher used 9 steps of descriptive and inferential statistics. Factor analysis that used to find validity and reliability is fit index in acceptable threshold levels. Moreover, the research has to have enough samples. The data analysis using applied statistics and creating and developing of evaluation model of pre-service teacher competency in the 21st century contain 10 factors and 60 indicators. Additionally, the researcher created computer program using Microsoft Excel to evaluate pre-service teacher competencies conveniently and accurately.

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