Exploring Factors from Traffic Quality Indicators for the In-service Education Information Service in Taiwan

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Abstract: -The purpose of this study was to explore factors for the In-service Education Information Service in Taiwan. The system was first established by National Kaohsiung Normal University based the trust of Ministry of Education on the year of 2003. There are 192035 teachers using this service. An investigation research method was applied to examine the data of quality indicators. The specific goals of this study are to summarize patterns of correlations among thirty variables of quality indicators, and to reduce this large number of observed variables to a smaller number of factors, to provide an operational definition for an underlying process by using observed variables. A system monitoring tool called PRTG was used for collecting data. The sample collected period was from 2016/9/30 to 2017/9/30. There were overall 7749 records of each indicators. The sample size was 606 and confidence interval was 5 at confidence level of 99%. A factor analysis procedure was applied to reveal the quality factors from those thirty quality indicators. Based upon verified statistical analysis results, major conclusions were presented. There are five factors could be identified via factor analysis process. The overall connecting factor would explain near 30% of quality. The education networking factor explain 23% of quality. The south networking explain 12% of quality. The proximal in-service explain 10 % of quality. The proximal NHCH service explain the rest 6% of quality.

Key-Words: - System Quality Factors, In-Service Education Information Service

1 Introduction

The purpose of this study was to evaluate association level among system quality indicators of the In-service Education Information Service in Taiwan. The system was first established by National Kaohsiung Normal University based the trust of Ministry of Education on the year of 2003. Since then, the system has been maintained for near 200 thousands users to access in-service education information service.

1.1 In-service Education Information Service

This service provides end-users to access information about in-service education courses. Teachers could to register course through the system and check with their personal in-service education records[1]. Teachers also could search courses offered by nationally authorized institutions.

In-service course providing institutions create course record on this system. After proved by higher rank administrator, the course information could be circulated nationally on the system. Courses provided could be searched via course search interface by any user.

Course offered institutions would get registry information and know who would be in the class beforehand. The course providing institution would upload learning record of each course members

1.2 Users' Characteristics of Service

Users of our service are teachers around the whole nation. They may access the service from their institutions and their home also. There are 192035 teachers as mentioned in the 2015 yearbook of teacher Education Statistics Education [2]. The service users are not only teachers, but also supervisors and administrators of institutions which offer in-service education courses.

General users might request information about what courses they could take, when the course would be conducted, where the course would be taught, and even register a course.

For the course providers or institutions, they require the service of creating course, editing course, announce a course, and recording attendance of a course.

1.3 Quality of an Information System

The factors affecting the success and efficiency of information systems are always a core and critical issue for the structure, system proper operation and improvement of the productive services[3].

The system managers must keep the service running all year round, and 24 hours a day. They should monitor not only those servers, but also the connection. For the servers, they must explore inside out of hardware, from power to server, from cpu, memory, hard disk, to process time and try to find out problems beforehand.

For a long time, lots information collected from different quality indicators, there is a need to reduce variables and to identify quality factors of the system. Those latent factors might provide operational definition for an underlying process by using observed variables.

2 Methodology

The purpose of this study was to identify system quality factors of the In-service Education Information Service in Taiwan. An investigation research method was applied to examine the data of quality indicators.

In this section, research structure, research objects, research steps, research tools, data analysis, and statistical hypothesis would be reported.

2.1 Research Structure

The research structure in this study included dependent variables of thirty quality indicators.

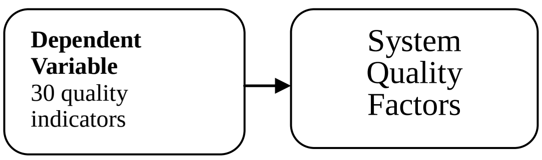

Fig. 1 Research Structure

There are 30 quality indicators in this study. Each indicator could provide certain information. The research question is whether there are latent factors underlying quality indicators.

Table 1 System quality indication at NCHC

Variable ID	Indicator Name
NCHC01	NCHC2Web1
NCHC02	NCHC2Web2
NCHC03	NCHC2Web4
NCHC04	NCHC2TecherJobWeb
NCHC05	NCHC2PreServiceTeacherReport
NCHC06	NCHC2FormalTransf
NCHC07	NCHC2TestTransf
NCHC08	NCHC2InserviceMobile
NCHC09	NCHC2GEMahara
NCHC10	NCHC2NKNUextended
NCHC11	NCHC2NKNU
NCHC12	NCHC2KUAS
NCHC13	NCHC2STU
NCHC14	NCHC2NSYSU
NCHC15	NCHC2NSYSUCenter
NCHC16	NCHC2LightProfDevelopmentWeb
NCHC17	NCHC2MOEelearn
NCHC18	NCHC2TeacherEdSearch
NCHC19	NCHC2MOEProfDevIntegrationWeb
NCHC20	NCHC2MOE
NCHC21	NCHC2Web3
NCHC22	NCHC2OpenID
NCHC23	NCHC2NCHCWeb
NCHC24	NCHC2SciTechVista
NCHC25	NCHC2Knowledge
NCHC26	NCHC2Hinet
NCHC27	NCHC2Yahoo Taiwan
NCHC28	NCHC2Google
NCHC29	NCHC2CNN
NCHC30	NCHC2YahooJP

In Table 1, eighteen connection quality indicators located at NCHC were listed. Those are indicators used to measure point to point connecting status including uptime/downtime, response time, and time stamp.

2.2 Research Objects

The purpose of this study was to evaluate system quality of the In-service Education Information Service in Taiwan. In this study, the research objects are quality indicators of the system. The research data had collected since 2016.

The data collected period was from 2016/9/30 to 2017/9/30. The population of monitored data was 7749. The relationship between two sets of quality indicators would be based upon a whole year random sampled 606 records.

According to the population and sample size, the confidence interval is 5 at 50 percentage and confidence level of 99%.

2.3 Research Steps

For reducing connection quality indicators into factors, several steps would be conducted to reach the goal. An investigating method was applied in this study. Major research steps were listed as followings.

1. Designing an investigation tool
2. Establishing service quality data collecting probes
3. Collecting system quality data
4. Conducting statistical data analysis
5. Naming & Operational Definitions
6. Conclusions

Based upon the definition of service quality indicators, an investigation tool was designed for collecting service quality data. Thirty probes were established for those quality indicators. After monitoring probes created, system quality raw data had been collected for further evaluation since last year.

2.4 Research Tools

In this section, research tools would be reported. For achieving research goal, there were two major research tools used in this study. The first one is the investigating tool and the second one is long term data collecting tool.

Both tools would be described in the following section. The first tool was designed by the research group. The second tool was installed and configured according to the research purpose.

2.4.1 Investigating tool design

For collecting content of each quality indicator, an investigating scale was designed. In the scale, there are four items. Those are list in followings.

1. ID
2. Location/Target
3. Time/Date
4. Character Value

ID is the indicator identification. Location is the place where the indicator is placed. Target is especially for the connection indicator to record its paired aim. Time/Date is for the time stamp so those indicators could be aligned. Character value is for recording indicator specified functional quantity.

2.4.2 Data collecting tool

A system monitoring tool called PRTG was used for collecting data. It could be used to monitor systems, devices, traffic and applications of IT infrastructure using techniques listed in followings.

- SNMP
- WMI
- SSH
- Flows and packet sniffing
- HTTP requests
- REST API returning XML or JSON
- Ping
- SQL

Indicators could be grouped for managing purpose as shown in Fig. 2. Text logs, map interface, and timeline graphics are provided by this tool.

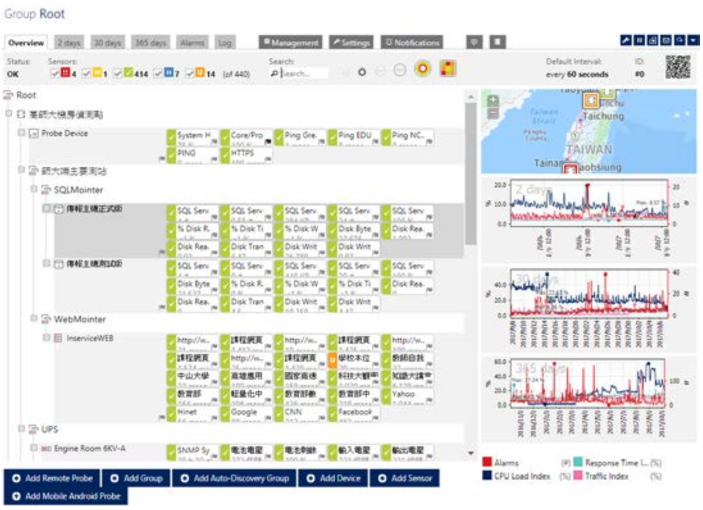

Fig. 2 Infroamtion views

2.5 Data analysis

The purpose of this study was to reduce quality indicator variables into to factors. The factor analysis method would be used in the data analysis procedure. Tabachnick and Fidell [4] pointed out that principal components analysis and factor analysis are statistical techniques applied to a single set of variables when the researchers is interested in discovering which variables in the set form coherent subsets that are relatively independent of one another. In this section, factor analysis technique would be reviewed according to its general form, limitations, and equations.

2.5.1 Factor Analysis in General

There were thirty quality indicator variables in this study. Variables that are correlated with one another but largely independent of other subsets of variables are combined into factors[5]. Factors are thought to reflect underlying processes that have created the correlations among variables[4].

The specific goals of factor analysis are to summarize patterns of correlations among observed variables, to reduce a large number of observed variables to a smaller number of factors, to provide an operational definition for an underlying process by using observed variables, or to test a theory about the nature of underlying processes[4].

Tabachnick and Fidell [4] further explained that factor analysis have considerable utility in reducing numerous variables down to a few factors. Mathematically, factor analysis produce several linear combinations of observed variables, where each linear combination is a factor. The factors summarize the patterns of correlations in the observed correlation matrix and can be used to reproduce the observed correlation matrix. Further, when scores on factors are estimated for each subject, they are often more reliable than scores on individual observed variables.

Steps in factor analysis or principal components analysis include selecting and measuring a set of variables, preparing the correlation matrix, extracting a set of factors from the correlation matrix, determining the number of factors, rotating the factors to increase interpretability, and interpreting the results.

2.5.2 Limitations of Factor Analysis

For theoretical issues, factor analysis are relaxed in favor of a frank exploration of the data, and decisions about number of factors and rotational scheme are based on pragmatic rather than theoretical criteria[4].

The first task of the researcher is to generate hypotheses about factors believed to underlie the domain of interest. Statistically, it is important to make the research inquiry broad enough to include five or six hypothesized factors so that the solution is stable. Logically, in order to reveal the processes underlying a research area, all relevant factors have to be included.

Next, one selects variables to observe. For each hypothesized factor, five or six variables, each thought to be a relatively pure measure of the factor, are included. Pure measures are called marker variables. Marker variables are highly correlated with one and only one factor and load on it regardless of extraction or rotation technique. The complexity of the variables is also considered. Complexity is indicated by the number of factors with which a variable correlates[4]. Tabachnick and Fidell [4] suggested that the sample chosen exhibits spread in scores with respect to the variables and the factors they measure is important.

They also pointed out practical issues of factor analysis such as sample size & missing data, normality, linearity, absence of outliers, absence of multicollinearity & singularity, and factorability of R.

Correlation coefficients tend to be less reliable when estimated from small samples. Therefore, it is important that sample size be large enough that correlations are reliably estimated. The required sample size also depends on magnitude of population correlations and number of factors: if there are strong correlations and a few, distinct factors, a smaller sample size is adequate[4].

Assumptions regarding the distributions of variables are not in force. If variables are normally distributed, the solution is enhanced. To the extent that normality fails, the solution is degraded but may still be worthwhile. Multivariate normality also implies that relationships among pairs of variables are linear. The analysis is degraded when linearity fails, because correlation measures linear relationship and does not reflect nonlinear relationship.

As in all multivariate techniques, cases may be outliers either on individual variables (univariate) or on combinations of variables (multivariate). Such cases have more influence on the factor solution than other cases.

In principal component analysis, multicollinearity is not a problem because there is no need to invert a matrix. For most forms of factor analysis and for estimation of factor scores in any form of factor analysis, singularity or extreme multicollinearity is a problem. If the determinant of R and eigenvalues associated with some factors approach 0, multicollinearity or singularity may be present.

A matrix that is factorable should include several sizable correlations. The expected size depends, to some extent, on N (larger sample sizes tend to produce smaller correlations), but if no correlation exceeds .30, use of factor analysis is questionable because there is probably nothing to factor analyze. Inspect R for correlations in excess of .30, and, if none is found, reconsider use of factor analysis.

3 Findings

In this section, research findings would be reported according to investigation results. First, descriptive results of investigation would be presented. Second, verified statistical analysis results would be reported.

Those thirty quality indicators were investigated mainly focused on the performance.

3.1 Issues

For considering the sample size and missing data, data are available initially from 606. With those cases deleted for partial missing and without outlying case, the factor analysis is conducted on 589 records.

For considering the normality, distributions of the 30 variables are examined for skewness. Many of the variables are skewed. Because the variables fail in normality, significance tests are inappropriate. And because the direction of skewness is different for different variables, we also anticipate a weakened analysis due to lowering of correlations in R.

For considering the linearity, the differences in skewness for variables suggest the possibility of curvilinearity for some pairs of variables. A spot check on a few plots is run through SPSS. Although the plot is far from pleasing and shows departure from linearity as well as the possibility of outliers, there is no evidence of true curvilinearity. Transformations are viewed with disfavor, considering the variable set and the goals of analysis.

Since all the value were actual monitored by probes, there are no outliers issue in all thirty variables. Non-rotated factor analysis reveals that the smallest eigenvalue is 0.005, not dangerously close to 0. The largest squared multiple correlation between variables where each, in turn, serves as dependent variable for the others is 0.95, not dangerously close to 1. Multicollinearity is not a threat in this data set.

For factorability of R, correlation matrix reveals numerous correlations among the 30 items, well in excess of 0.30; therefore, patterns in variables are anticipated. Most of the values in the negative anti-image correlation matrix are small, another requirement for good factor analysis. In Table 2, the sig. level is less than 0.05. The test result supported that the variable set is well to be conducted with factor analysis.

Table 2 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.914
Bartlett's Test of Sphericity	Approx. Chi-Square	32719.088
	df	435
	Sig.	.000

3.2 Descriptive Analysis

In the following, quality indicators would be reported based upon descriptive statistics.

3.2.1 Research Objects

The purpose of this study was to explore quality factors of the In-service Education Information Service in Taiwan. There were thirty network connection quality indicators as research objects this study. The data collection was from 2016/9/30 to 2017/9/30.

There were overall 7749 records of each indicators. Random sampling procedure was conducted through SPSS. The sample size was 606 and confidence interval was 5 at confidence level of 99%.

Table 3 N, Min., Max., Mean, Std. Deviation, , & Variance of Connection Quality Indicators

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
NCHC01	589	33.58	17450.75	153.39	863.3800	745425.127
NCHC02	589	29.16	6003.50	85.11	290.3837	84322.712
NCHCH3	589	31.00	19389.83	151.25	953.9513	910023.162
NCHC04	589	44.31	3281.93	77.11	216.3372	46801.808
NCHC05	589	38.33	10075.73	198.11	1071.6617	1148458.829
NCHC06	589	33.36	5771.06	66.37	294.8493	86936.113
NCHC07	589	32.88	3546.06	74.77	245.8936	60463.684
NCHC08	589	26.53	7273.22	78.46	449.6347	202171.365
NCHC09	589	85.50	9270.35	142.03	492.9272	242977.247
NCHC10	589	59.21	7351.35	138.20	393.4185	154778.171
NCHC11	589	125.63	9212.48	271.13	603.4137	364108.191
NCHC12	589	157.73	5291.15	340.65	285.4661	81490.913
NCHC13	589	81.35	11318.46	220.89	667.8705	446051.114
NCHC14	589	28.48	5205.11	73.43	280.7359	78812.666
NCHC15	589	30.36	10339.00	74.28	440.0874	193676.954
NCHC16	589	113.03	12047.36	262.23	814.2559	663012.779
NCHC17	589	31.05	31189.25	793.29	2100.2034	4410854.612
NCHC18	589	253.63	12616.22	449.56	702.2549	493162.010
NCHC19	589	117.00	12370.17	251.12	708.6833	502232.075
NCHC20	589	76.73	12807.67	259.27	781.6634	610997.690
NCHC21	589	29.61	17599.50	118.25	824.3798	679602.125
NCHC22	589	55.30	4305.40	100.44	275.7347	76029.672
NCHC23	589	44.83	2150.92	133.57	177.9792	31676.625
NCHC24	589	48.35	12997.00	871.64	767.0440	588356.507
NCHC25	589	2564.06	8785.36	4183.01	961.5195	924519.853
NCHC26	589	45.95	11822.91	182.22	717.3580	514602.626
NCHC27	589	393.08	11062.78	694.61	637.3086	406162.265

NCHC28	589	67.11	8277.92	165.39	494.5709	244600.385
NCHC29	589	149.66	4185.40	541.40	351.9495	123868.468
NCHC30	589	227.43	3731.04	627.36	270.3377	73082.510

3.2.2 Quality Indicators of Connection

There were thirty connection quality indicators for monitoring system quality in different ways.

In Table 3, their N, Minimum, Maximum, Mean, and Std. Deviation were listed under ID.

3.3 Verified Analysis

There are three verified analysis reported in this section. Those are

- Number of factors
- Nature of factors
- Importance of factors

3.3.1 Number of factors

For exploring factors, factor analysis procedure were conducted by using SPSS. A scree plot was presented in Fig. 3. According to the eigenvalue, there are five factors because of five components with value not less than one.

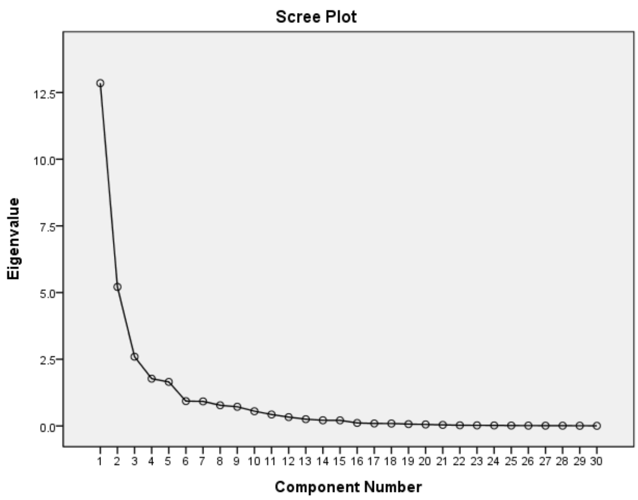

Fig. 3 Scree Plot

According to rotated component matrix in Table 4, the first facet contains variables of NCHC10, NCHC06, NCHC14, NCHC08, NCHC02, NCHC07, NCHC11, NCHC04, NCHC09, NCHC22, NCHC30, NCHC29, and NCHC23.

The second facet contains variables of NCHC19, NCHC18, NCHC13, NCHC26, NCHC20, NCHC16, and NCHC27.The third facet contains variables of NCHC15, and NCHC12.The forth facet contains variables of NCHC21, NCHC01, and NCHC03.The fifth facet contains variables of NCHC25, and NCHC24.

Table 4 Rotated Component Matrix

	Component				
	1	2	3	4	5
NCHC10	.961				
NCHC06	.942				
NCHC14	.932				
NCHC08	.911				
NCHC02	.859				
NCHC07	.840				
NCHC11	.835				
NCHC04	.823				
NCHC09	.728				
NCHC22	.708				
NCHC30	.599				.
NCHC29	.567				
NCHC23	.506				
NCHC19		.977			
NCHC18		.969			
NCHC13		.966			
NCHC26		.964			
NCHC20		.939			
NCHC16		.863			
NCHC27		.848			
NCHC17		.417			
NCHC15			.863		
NCHC12			.703		
NCHC28			.482		
NCHC05			.451		
NCHC21				.987	
NCHC01				.950	
NCHC03				.944	
NCHC25					.873
NCHC24					.740

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 7 iterations.

3.3.2 Importance of factors

Scores on factors can be predicted for each case once the loading matrix is available. The importance of a factor is evaluated by the proportion of varIn Table 5, proportion of variance and cumulative percent were listed. The proportion of covariance accounted for by a factor indicates the relative importance of the factor to the total covariance accounted for by all factor.

Table 5 Factor Importance

	Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %
1	8.961	29.871	29.871
2	6.812	22.707	52.578
3	3.517	11.724	64.303
4	2.911	9.702	74.005
5	1.880	6.268	80.273

In Table 6, factor scores of each components were listed under factor 1 to 5 accordingly. The importance of each component for certain factor could be easily identified by the coefficient score.

Table 6 Factor Scores

Component Score Coefficient Matrix					
	Component				
	1	2	3	4	5
NCHC2Web1	-.066	-.007	.047	.349	.019
NCHC2Web2	.165	.019	-.183	-.020	.021
NCHC2Web4	.005	-.015	-.063	.341	.002
NCHC2TecherJobWeb	.073	-.016	.073	-.010	-.036
NCHC2PreServiceTeacherReport	-.084	-.028	.218	-.003	.084
NCHC2FormalTransf	.163	-.008	-.120	-.011	-.053
NCHC2TestTransf	.089	-.021	.043	-.010	-.047
NCHC2InserviceMobile	.116	-.022	-.001	-.017	-.043
NCHC2GEMahara	.030	-.034	.168	-.021	-.030
NCHC2NKNUextended	.186	-.003	-.179	-.014	-.036
NCHC2NKNU	.073	-.029	.077	-.018	.007
NCHC2KUAS	-.046	-.025	.255	-.009	.054
NCHC2STU	-.002	.160	-.059	-.007	-.022
NCHC2NSYSU	.160	.004	-.124	-.012	-.045
NCHC2NSYSUCenter	-.084	-.037	.356	-.014	-.028
NCHC2LightProfDevelopmentWeb	-.068	.121	.135	-.008	-.016
NCHC2MOEelearn	.018	.070	-.073	-.017	.057
NCHC2TeacherEdSearch	-.033	.156	.009	-.011	-.031
NCHC2MOEProfDevIntegrationWeb	-.003	.163	-.067	-.008	-.022
NCHC2MOE	-.032	.150	.004	-.001	-.013
NCHC2Web3	-.033	-.017	-.031	.367	.007
NCHC2OpenID	.036	-.027	.145	-.008	-.064
NCHC2NCHCWeb	.044	.042	.011	.010	-.048
NCHC2SciTechVista	-.037	-.026	.038	.014	.410
NCHC2Knowledge	-.073	.008	.021	.004	.494
NCHC2Hinet	.018	.161	-.096	-.012	-.017
NCHC2Yahoo Taiwan	-.046	.129	.039	.000	.040
NCHC2Google	-.057	.014	.197	-.009	-.048
NCHC2CNN	.093	-.018	-.094	-.026	.157
NCHC2YahooJP	.076	-.007	-.090	-.017	.298

4 Conclusion

The purpose of this study was to explore quality factors of the In-service Education Information from those thirty quality indicators of measuring traffic flow volume. The In-service education information system is hosted by National Kaohsiung Normal University under the Ministry of Education supports. Those thirty indicators are located in National Center for High-performance Computing.

According to the research findings, there are three major conclusions.

4.1 Quality Factors of the System

This study found that there are five latent factors on the quality of the In-service Education Information Service. Respectively, the overall connection, education networking, south networking, proximal In-service, proximal NCHC service.

That is, these five latent variables mentioned above affect the quality of the In-service Education Information Service. On the other hand, it is concluded that those thirty quality indicators could be grouped into five categories.

Table 7 Summary of Factors

Target Server	Variable ID	Factor number	Operating definition	Factor Name
NKNU Extend Ed. College	NCHC10	1	Inservice traffic core connection: NCHC local traffic, TANET distributed centers, NKNU center, NKNU Inservice Center, and International Connection	Overall Connecting
NKNU Formal Transfer	NCHC06	1		
NSYSU	NCHC14	1		
InserviceMobileService	NCHC08	1		
Inservice WWW2	NCHC02	1		
NKNU Test Transfer	NCHC07	1		
NKNU Web	NCHC11	1		
MOE Teacher Job Web	NCHC04	1		
Inservice GEMahara	NCHC09	1		
Inservice OpenID Service	NCHC22	1		
Yahoo JP	NCHC30	1		
CNN	NCHC29	1		
NCHC	NCHC23	1		
MOE Prof. Dev. Integration Web	NCHC19	2	Traffic toward MOE machine farm, and non-TANET Major Sides	Education Networking
MOE Teacher Ed. Search	NCHC18	2		
STU	NCHC13	2		
Hinet	NCHC26	2		
MOE	NCHC20	2		
MOE Light Prof.Dev.	NCHC16	2		
Yahoo Taiwan	NCHC27	2		
MOE e-learn	NCHC17	2		
NSYSU Center	NCHC15	3	Traffic toward TANET Southern outlet	South Networking
KUAS	NCHC12	3		
Google	NCHC28	3		
Pre-service Teacher Report	NCHC05	3		
In-service WWW3	NCHC21	4	Traffic toward local In-service servers	Proximal In-service
In-service WWW1	NCHC01	4		
In-service WWW4	NCHC03	4		
NCHC Sci-Tech Vista	NCHC25	5	Traffic toward	Proximal

NCHC Knowledge	NCHC24	5	local NCHC servers	NCHC Service

In Table 7, summary of factors are presented by target server, variable ID, factor number, operating definition, and factor name.

4.2 Nature of Quality Factors

Based upon the one-way ANOVA of the system health by weekdays, it was concluded that the system health mean values among weekdays are with significant difference.

The so-called overall connecting refers to the service core connection: NCHC local traffic, TANET distributed centers, NKNU center, NKNU Inservice Center, and International Connection.

The education networking, refers to the Traffic toward MOE machine farm, and non-TANET Major Sides.

The South Networking is the traffic toward TANET southern outlet.

The proximal in-service refers traffic toward local in-service servers.

The proximal NCHC service refers to the traffic toward local NCHC servers for both sci-tech Vista, and knowledge service.

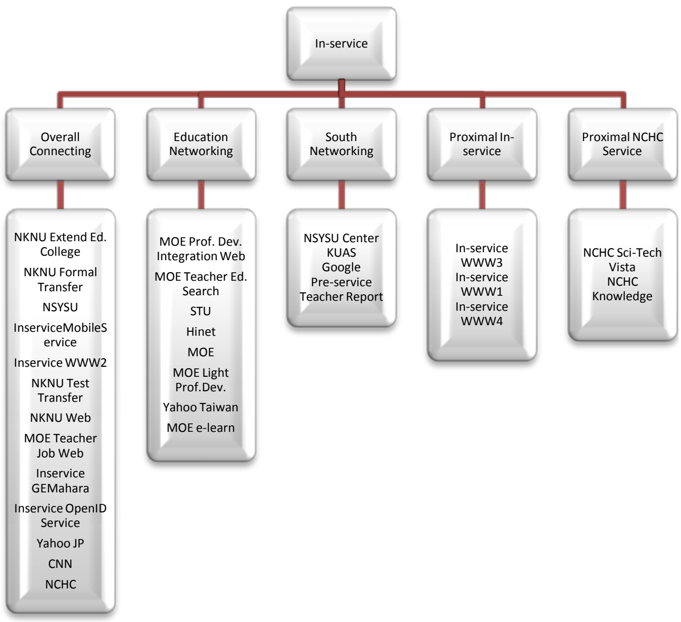

Fig. 4 Factor organization based on quality indicators

4.3 Implications

Logically, there are five sub-groups of those thirty connecting quality indicators. This reduction technique helps engineer to identify quality by factors, not individual indicator separately.

The overall connecting factor would explain near 30% of quality. The education networking factor explain 23% of quality. The south networking explain 12% of quality. The proximal in-service explain 10 % of quality. The proximal NHCH service explain the rest 6% of quality.

The system service maintenance could be more organized based upon the structure of factors. The monitoring might not be become light, but the interpretation work load would be much more less, from thirty separately to five groups. At the same time, the integrating meaning could be identified directly as a whole.

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