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Design of a Measurement System of End-User Information Competency with a Case Study

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1. Introduction

The need for the effective operation of enterprise resources has risen with the intensive competition facing among enterprises. For this reason, enterprises have implemented information systems to improve their competitiveness and performance, and to increase their productivity and business efficiency by using advanced IT (Information Technology). It is important for human resources working on an enterprise information system to have the capability to effectively executing the given tasks by applying their information systems to their business (Marthis and Jackson, 2000; O'Leary, Lindholm, Whitford, and Freeman, 2002). An end-user who directly works his or her business needs the ability to efficiently perform end-user tasks by applying IT and information systems to his or her business. And this directly influences the end-user task performance and the competition edge of the organization.

Therefore, this study presents a measurement system for the end-user information competency, which focuses on the end-user's total capability that an end-user can efficiently use information knowledge, solutions, and information systems for his or her tasks on enterprise information systems.

2. Previous Research

In this study, an end-user is defined as a person who directly interacts with his or her information systems based on previous studies (Rockart and Flannery, 1983; Martin, 1982; Yoon, 2008). Information can explain as an organizational set of data that can be efficiently used for a specific objective (Machlup, 1980; Plotkin, 1994; Freeman, 2001; Yoon, 2008). And, competency is a total set of knowledge, skills, and attitudes as the action characteristics of an organizational member that can do his or her tasks outstandingly and efficiently in an organizational environment (Mirable, 1997; Arthey and Orth, 1999; Rodriguez, Patel, Bright, Gregory, and Gowing, 2002; Yoon, 2008).

By analysis of the major components of competency obtained from the literature, we can extract five major components: Motives, Traits, Self-concepts, Knowledge, and Cognitive and Behavioural Skills (Spencer and Spencer, 1993; Mirable, 1997; Arthey and Orth, 1999;

Rodriguez, Patel, Bright, Gregory, and Gowing, 2002; Yoon, 2008): (1) Motives is a cause of activity leading an end-user to do what he wants to do and what he consistently had in mind to do, and an action which selects and instructs a trigger for a specific activity or an objective. (2) Traits mean a consistent response to physical characteristics and situation or information, and an emotional self-control and careful attitude is 'a consistent response' of a more complicated form. (3) Self-concepts mean attitude, a sense of value, and self-portrait, and a sense of value is an element which reflects on responsible activities in a given situation for a short-period. (4) Knowledge is information that knows for specific department, and only indicates that what a person can do, but does not predict what a person will actually do. (5) Cognitive and Behavioural Skills are the ability to perform specific mental or physical tasks, and mental or cognitive skills include analytical or cognitive thought. In general competency, individual characteristics such as motives, traits, self-concepts and knowledge lead to skills, and the action of a person with skills has an effect on the performance of his or her business in an organizational environment (Spencer and Spencer, 1993). In an information competency, individual characteristics such as motives, traits, self-concepts and knowledge lead to skills, and the action of a person with skills has an effect on the performance of his or her business in an information environment. In other words, information competency can be defined by transforming a general competency into a type of competency based on an information perspective.

Hence, the end-user information competency (EUIC) can be defined as a total set of knowledge, technology, skills and attitudes which function as action characteristics of an organizational member who can do his or her tasks outstandingly and efficiently on an enterprise information system. In other words, EUIC is defined as the total capability that an end-user directly interacts with the information systems to efficiently execute his or her business tasks through using an organizational data for them on information systems. EUIC is the total capability that an end-user can effectively do his or her tasks on information systems.

With these researches, we generated the 24 measurement items that can gauge an end-user information capability in terms of an information competency based on the major components of a general competency such as motives, traits, self-concepts, knowledge, and cognitive and behavioural skills.

3. Methods

3.1 Research Method

In previous literature, the construct validity of the measurement items was studied by many researchers. Kerlinger (1978) presented two methods of model construct validation: (1) correlations between total scores and item scores, and (2) factor analysis. Etezadi-Amoli & Farhoodmand (1996) used factor analysis to verify the validity of the measurement tool construct. Torkzadeh & Doll (1999) and Torkzadeh & Lee (2003) used correlation analysis to verify the validity of the measurement tool construct. This study is likely to verify the validity of the measurement tool construct and the extraction of adequate items by factor analysis and reliability analysis. The ratio of sample size to number of measurement items (11:1) was above the minimum (10:1) ratio suggested for factor analysis by previous literature (Kerlinger, 1978; Rodriguez, Patel, Bright, Gregory, and Gowing, 2002). The items indicating above a criterion value by a factor analysis were selected because they were

closely related to each other, and all the items were thought to be the measures of the same construct. A measurement of criterion-related validity was also examined to identify the items that may not be closely related to the EUIC. Items should present a proper or incongruent element toward the object in question. If the item is ambiguous or indicates a neutral attitude, it should be deleted. A measurement of criterion-related validity was executed to identify items that did not indicate favourable or unfavourable attitudes.
The measurement questionnaire used a five-point Likert-type scale; where, 1: not at all; 2: a little; 3: moderate; 4: good; 5: very good. The questionnaire explains its objectives and contents, and respondents give answers on characteristics such as degree, age, gender, major department, industry and business department, business position level and years of job experience. The survey was gathered data from a variety of industries, business departments, experience, and major educations.

3.2 Sample Characteristics

In this pilot test, a sample of 258 usable responses was obtained from a variety of industries and business departments, and from management levels. All respondents had college or university degrees in: humanities and societies (16.3%), management and economics (20.2%), engineering (51.8%), and science (11.7%). The respondents in terms of business departments were identified as strategy planning (21.1%), development and maintenance (26.8%), business application (38.4%), and administration support (13.7%). The respondents identified themselves as top manager (3.7%), middle manager (44.7%), and worker (51.6%). The respondent had on average of 8.9 years of experience (S.D. =1.118) in their field, their average age was 32.9 years old (S.D. =6.473), and their sex, male (79.8%) and female (20.2%).

3.3 Analysis and Discussion

The analysis of the collected questionnaires was conducted by using SPSS ver.12 software. Items were excluded when their correlation with the collected item-total was < 0.5 or when their correlation with the criterion scales was < 0.6. The correlations with the corrected item-total and the criterion item were significant at $p \leq 0.01$ and similar to those used by others in previous researches (Rifkin, Fineman, and Ruhnke, 1999; McCoy, 2001; Torkzadeh and Lee, 2003; Yoon, 2008). After these analyses, the first 24 measurement items were reduced to 14 items, with 10 items were deleted. The elimination was considered sufficient to ensure that the retained items were adequate measures of EUIC. The validity and reliability of the developed tool were verified through factor analysis and reliability analysis. They were used to identify the underlying factors or components that comprise the EUIC construct. These deletions resulted in a 14-item scale for measuring EUIC. Each of the 14 items had a factor loading > 0.635. The reliability coefficients (Cronbach's alpha) of four potential factors had values > 0.792, above the threshold recommended for exploratory research (Rodriguez, Patel, Bright, Gregory, and Gowing, 2002; Yoon, 2008). The descriptions and loadings for the 14 items are presented (see Table 1 and Table 2).

Variable	Factor Loadings			
	Factor 1	Factor 2	Factor 3	Factor 4
V01	0.754			
V03	0.713			
V06	0.642			
V08		0.839		
V10		0.787		
V11		0.713		
V12		0.702		
V14			0.894	
V16			0.781	
V17			0.719	
V18			0.723	
V21				0.786
V23				0.727
V24				0.635

* Significant at $P \leq 0.01$

Table 1. Factor loadings obtained from factor analysis

In order to research the reliability and validity of the measures, we calculated the corrected item-total correlations between each variable and its corresponding factor. These correlations along with alpha coefficients of each factor are presented (shown in Table 2).

Variable	Corrected item-total correlation	Alpha if item deleted
V01	0.728	0.812
V03	0.689	0.724
V06	0.678	0.627
Coefficient alpha for the above 3 items as a composite measure of Factor =0.792		
V08	0.781	0.847
V10	0.714	0.848
V11	0.817	0.821
V12	0.629	0.723
Coefficient alpha for the above 4 items as a composite measure of Factor =0.884		
V14	0.743	0.852
V16	0.826	0.778
V17	0.634	0.836
V18	0.738	0.798
Coefficient alpha for the above 4 items as a composite measure of Factor =0.901		
V21	0.692	0.724
V23	0.712	0.738
V24	0.624	0.593
Coefficient alpha for the above 3 items as a composite measure of Factor =0.798		

* Significant at $P \leq 0.01$

Table 2. Corrected item-total correlations and coefficient alpha for each factor

This also shows the alpha coefficients for the measurement of factors if a measure was deleted from the scale. These coefficients indicate the relative contribution of a measure to the construction of a scale for measuring a particular factor. They are all in the acceptable range. Most corrected item-total correlations were greater than 0.600, showing that the end-user measures are good indicators of their corresponding factors.
They were grouped by their high factor loading. Each of the 14 items had a corrected item-total correlation > 0.624. The correlation for each of the 14 items was positive and significant ($p = 0.01$ or below). Hence, the measurement items, with a validity and reliability were extracted by carrying two analyses (see Table 1 and Table 2). However, efforts to provide additional evidence of this tool's validity, internal consistency, and stability are encouraged.

4. Measurement Tool

4.1 Structure of Measurement Tool

By factor analysis on the first measurement items, we extracted 14 items to measure EUIC, and the extracted items were classified as 4 factor groups. The 4 factor groups indicate the potential factors that can measure the EUIC and they include 14 measurement items. With investigating the measurement items of each factor, we generated the 4 potential factors as follows: factor 1: information understanding; factor 2: information knowledge; factor 3: information application; and factor 4: information potential. The information understanding means concepts, sense of value, attitude and adaptability related to information, and the information knowledge indicates the knowledge of information solutions and systems. The information application is the skills of information application to efficiently execute his or her tasks on the information systems, and the information potential refers the potential ability to improve information competency in terms of breadth and depth. The 4 potential factors are considered as the major measurement factors of the tool construct. Fig. 1 shows the structure of the measurement tool based on the 4 potential factors and 14 measurement items. Each factor has three or four measurement items, and each item is composed of two or three measurement problems from the measurement problem database.

4.2 Measurement Factor and Item

The information understanding (see Fig.1) is the realm where measures concepts, attitude, and adaptability on information. It includes the measurement items that can identify end-user's concepts on the Internet and information society, understanding of IT progress trend of IT leading countries, and etiquette in using information on enterprise information systems.
The information knowledge (see Fig.1) indicates the knowledge that an end-user has to know to efficiently apply information solutions and systems to his or her works. It comprises the measurement items that can gauge the information knowledge such as knowledge related to hardware, software, networks, and database for operating information systems, solution knowledge related to ERP (Enterprise Resources Planning), SCM (Supply Chain Management), and CRM (Customer Relationship Management), knowledge related to e-Business (B2E, B2C, and B2B), and knowledge related to security measures on enterprise information systems.

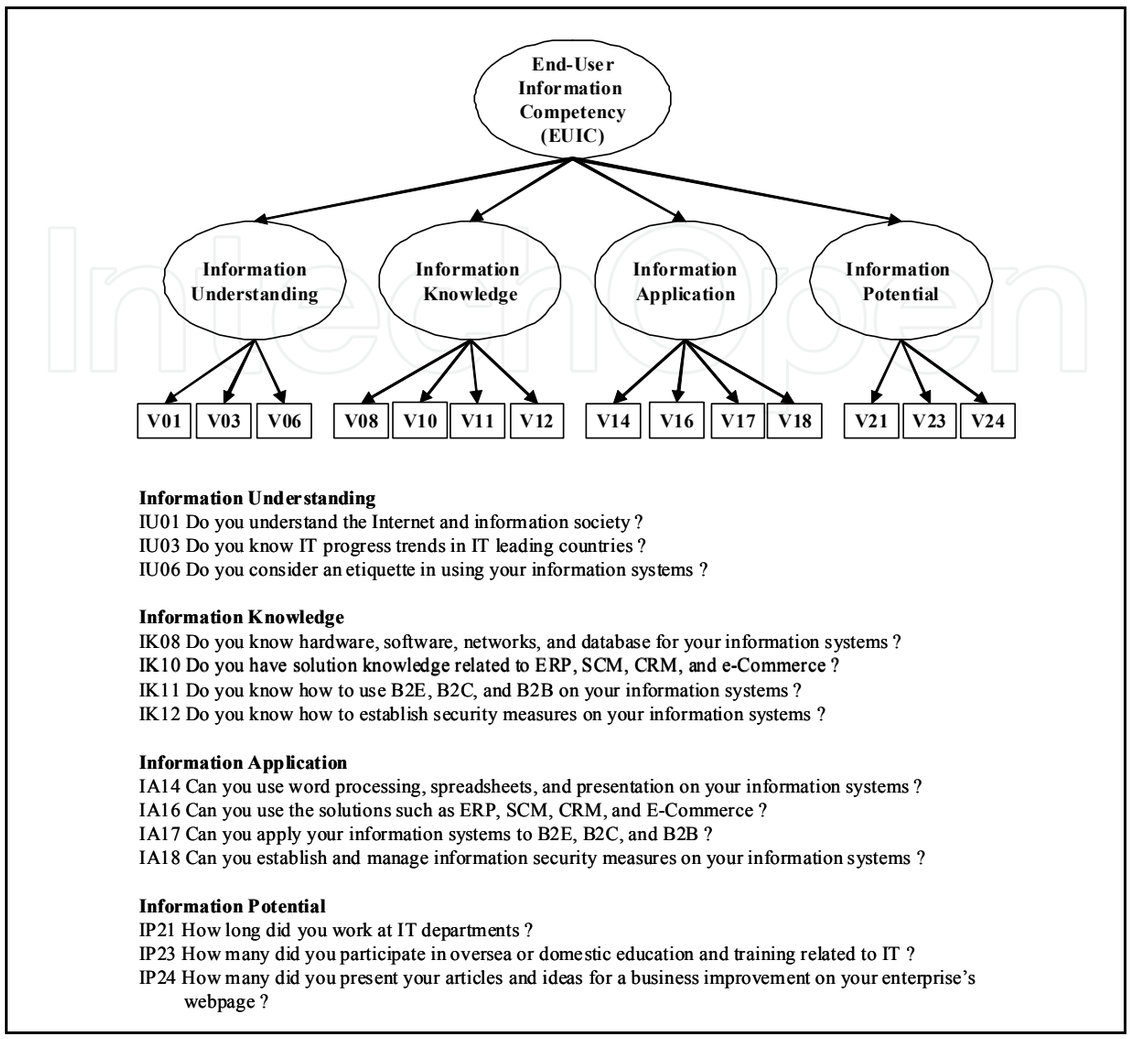

Fig. 1. Structure of the developed measurement tool

The information application (see Fig.1) means the ability that an end-user can effectively apply information knowledge, solutions, and systems to his or her business tasks. It includes OA (Office Automation) ability such as spreadsheet, presentation and word processing, the ability to use business solutions such as ERP, SCM, and CRM, the ability to apply the information systems to an end-user's work such as e-business of the form B to E (Business to Employee), B to C (Business to Customer), and B to B (Business to Business), and the skills related to establish and manage the security system. This factor is a very important department that can mostly influence the performance of an end-user's tasks through applying his or her all abilities of understanding, knowledge, and skills to his or her tasks on an enterprise information system.

The information potential (see Fig.1) refers the potential development probability of the EUIC by job experience, participation of domestic and overseas education and training, and presentation of articles and ideas for a task improvement on the enterprise website.

This is the important factor for the development of information knowledge and ability, and the extension of information competency in terms of the breadth and depth of EUIC.
The tool that has 4 measurement factors and 14 items is an important theoretical construct to measure an end-user's total information ability that can efficiently do his or her tasks on an enterprise information system (see Fig.1).

5. Measurement System

5.1 Framework of Measurement System

The measurement system has a measurement tool and an interpretation tool (shown in Fig. 2). The measurement process of this system is identified as two stages of the measurement process by the measurement tool and the interpretation process by the interpretation tool.

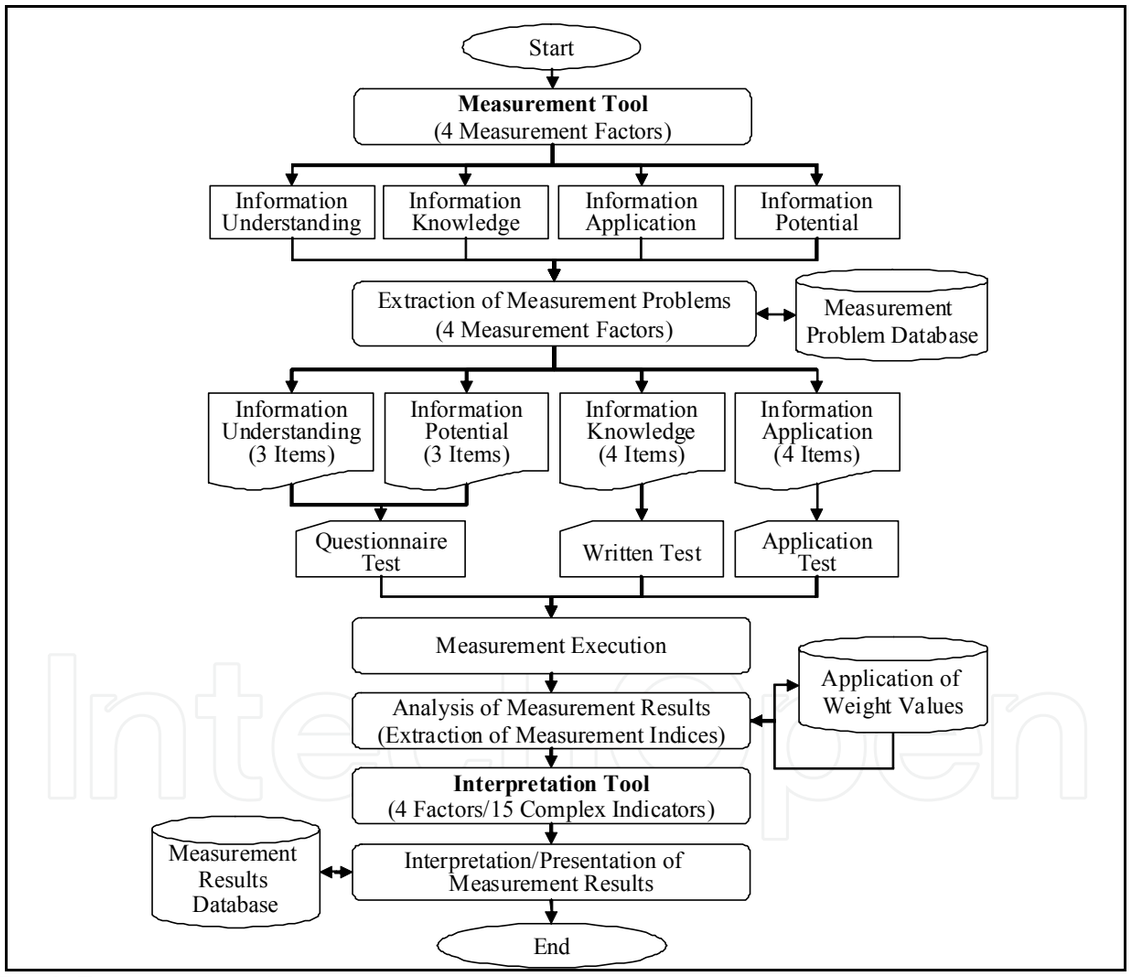

Fig. 2. Framework of the measurement system

The measurement stage is the extraction process of the measurement indices through measuring the EUIC by the measurement tool, and the interpretation stage is the process to explain the measurement results by the interpretation tool. It explains the meanings of the

measurement indices extracted from each measurement factor and the fifteen complex indicators. For measuring a EUIC, the system extracts the measurement problems from the measurement problem database. The form of the measurement problem is different from each measurement factor. The measurement factors such as the information understanding and the information potential are examined by a questionnaire form, and the information knowledge and the information application are examined by a written and application form.
The information understanding and the information potential are tested by a questionnaire form, and the information knowledge and the information application are examined by a written form and an application form.
The measurement index (MI) is calculated by applying each weight value to each measurement value extracted from each measurement factor. The MI is the total value extracted by applying the weight value to the measurement result that the end-user is examined by the measurement items in each measurement factor of the measurement tool. The extracted measurement index is reflected to the interpretation tool.
Finally, the system presents the interpretations of the measurement results of the EUIC based on the measurement factors and the complex indicators. And, the results are stored in the measurement results database and are utilized for presenting the measurement results when an end-user requests them. The total measurement and interpretation results are presented by the measurement report of the EUIC.

5.2 Measurement Method

In this study, we used the weight values for each measurement factor in order to develop an efficient tool considered the relative importance of each factor in measuring the EUIC. The weight values (shown in Table 3) were extracted from the analysis results of the questionnaire survey (AHP) for about 30 experts working in information departments.

Measurement Factor	Weight Value
Information Understanding	0.22
Information Knowledge	0.25
Information Application	0.33
Information Potential	0.20

Table 3. Weight value of each measurement factor

The measurement method first calculates the measurement values of each factor through the analysis of the measurement results that the end-user is tested by the extracted problems based on the measurement items of each factor. It figures out the measurement indices of each factor by multiplying each weight value by the measurement value of each factor. The measurement index (MI) means the value extracted by multiplying the weight value by the measurement value. And, the sum of the measurement indices of each factor becomes the total MI of the end-user. In this way, this tool presents the measurement results of the EUIC based on the total measurement index and the indices of each factor.

Hence, the total MI can be defined as Equation (1):

$$\text{Total MI} = \sum_{i=1}^{4} MV_{MFi} \times WV_{MFi} \quad (1)$$

Where, Total MI: total measurement index (MI) of an end-user

MV_{MFi} : Measurement Value (EV) of the i th Measurement Factor
WV_{MFi} : Weight Value (WV) of the i th Measurement Factor

Here, the sum of the weight values of each factor is 1.00 and i = 1, 2, 3 and 4 indicate the four measurement factors. By equation (1), we calculate the total measurement index of an end-user. In this way, this tool presents and interprets the measurement results of the EUIC based on total measurement index and the measurement indices of each factor.

5.3. Interpretation Tool

The interpretation tool has two kinds of interpretation methods (see Fig. 3). One is to explain the measurement results in each measurement factor, and the other is to present its results on the complex indicators. The interpretation by the measurement factors explains the meanings of the measurement results on four measurement factors.
The interpretation by the complex indicators presents core and general complex indicators based on the measurement results extracted by measurement items of each complex indicator. The complex indicator shows the implicative meanings and states of the EUIC as presenting the significant indicators of his or her measurement results.

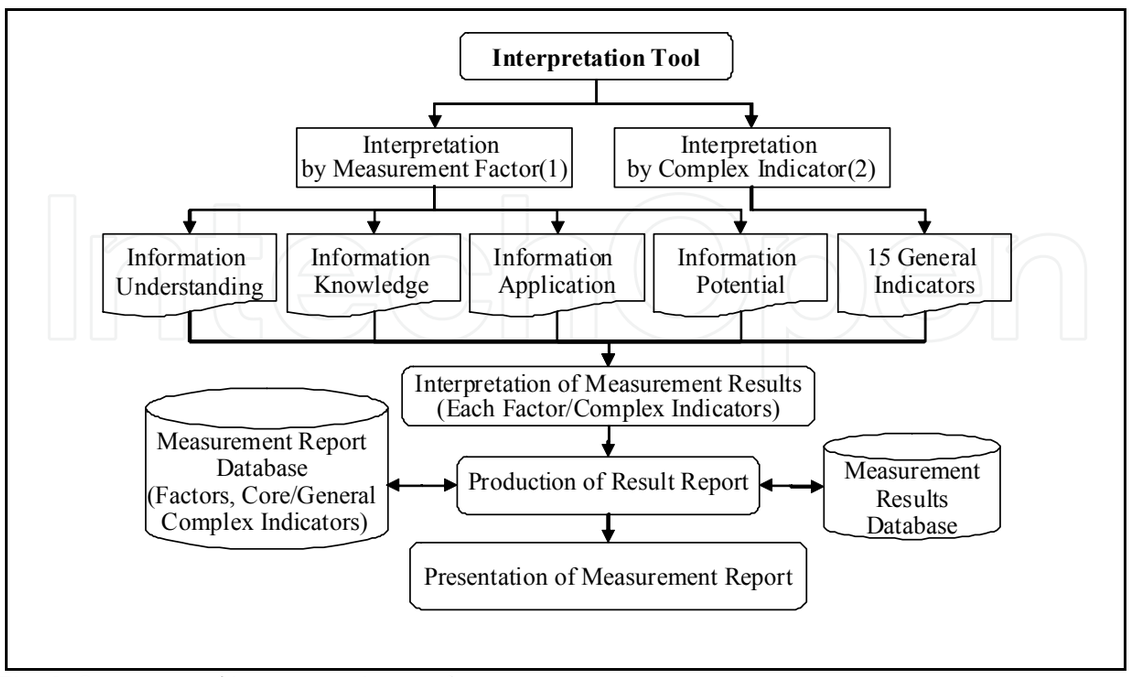

Fig. 3. Structure of interpretation tool

Therefore, the case study presents the measurement results by two methods with the measurement factors and the complex indicators. The final measurement report of the end-user is given by integrating the measurement results and its interpretations.
The complex indicators that present the implicative meanings of the measurement results were identified as 15 general complex indicators. The complex indicators were developed by about 50 experts in IT departments. The core complex indicators are 5 complex indicators (the serial number of 1, 4, 10, 14, and 15 indicator) of general complex indicators. The core complex indicators extracted from the general complex indicators present their meanings more implicative and significant than those of the general complex indicators. If we look at the complex indicators, we can generally know the present state or level of the EUIC. Each complex indicator for the measurement results is yielded by the result values based on the measurement item of it. Table 4 shows the complex indicators and the measurement items belonging to each complex indicator to generate the value of each complex indicator of the EUIC.

General Complex Indicators	Measurement Items
1. Information Understanding Indicator	-Understanding of information plan & implementation and application of business
2. Sense of Value Indicator	-Attitude, acknowledge, etiquette and law & regulation related to information
3. Information Base Knowledge Indicator	-Knowledge of basic information technology
4. Information Knowledge Indicator	-Knowledge of H/W, S/W, N/W, and DB related to information
5. e-Business Knowledge Indicator	-Knowledge of e-Business, e-Commerce and m-Business
6. Information System Knowledge Indicator	-Knowledge of H/W, S/W, N/W, and DB related to operating system
7. Information Security Indicator	-Knowledge of information security, security system, and institution and regulation of information security
8. OA Application Ability Indicator	-Ability using Word processing, Spread sheet, Presentation
9. Internet/Homepage Application Indicator	-Ability related to application of Internet and Intranet
10. Solution Application Indicator	-Ability using ERP,SCM,CRM,KMS, and HRM solutions etc.
11. Information System Application Indicator	-Ability applying information systems to B2E, B2B, B2C etc.
12. Information Management Ability Indicator	-Ability related to utility, security establishment and information management
13. Information Base Ability Indicator	-Degrees, certificates and job experience related to information
14. Information Education & Training Indicator	-Participation of oversea & domestic education and training related to information
15. Information Knowledge Production Indicator	-Presentation in national or international journals, publication of information books, and lectures & education related to information

Table 4. Complex indicators and measurement items

6. Case Study and Discussion

6.1 Sample Characteristics

This case study applied the developed tool to 163 workers working at "B" enterprise in South Korea. The business departments of respondents were identified as follows: strategy plan department (management strategy, plan management, and management plan etc.): 23.1%; development and maintenance department (development, management, and maintenance support etc.): 21.3%; business application department (sale, marketing, customer management, and service etc.): 37.4% and administration support department (personnel, finance, and welfare etc.): 18.2%. The business positions of respondents were classified as follows; top managers (CEO, director etc.): 2.8%; middle managers (chief of department, team manager etc.): 28.4% and workers (working-level person): 68.8%. The respondents had on average 7.7 years of experience (SD = 0.598), and most respondents (69.3%) had college or university degrees.

6.2 Analysis and Discussion based on Measurement Factor

First, application and analysis of each business department: As the analysis of an organizational level, we present the measurement results of each business department of the overall organization. The total measurement index of the overall organization was 61.58, and it was quite high. The strategy plan department and the business application department were 62.12 and 65.78 (shown in Fig. 4).

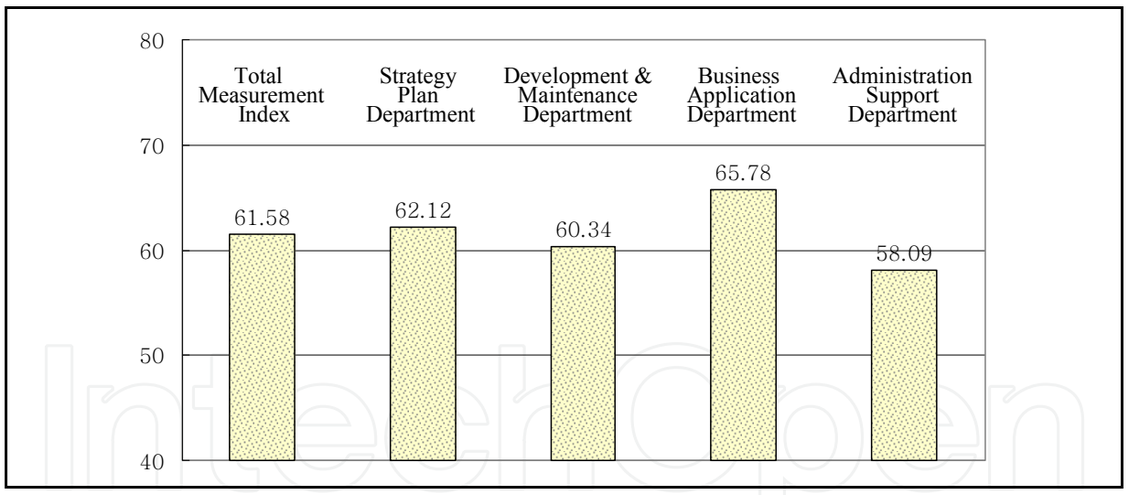

Fig. 4. Measurement indices of each business department

The measurement results of each business department shows that the measurement index of the business application department were higher than those of the other departments. This is due to the ability to effectively accomplish their tasks by frequently applying computing knowledge and computing system to e-Business of the form B to C, B to B and B to E, and the knowledge and abilities to utilize the various solutions such as ERP, SCM, and CRM in order to do their business tasks on an enterprise information system. Especially, the end-users in the administration support department have to make an effort to raise their information competency in general.

Second, application and analysis of a business department: The total measurement index of the strategy plan department (SPD) was 62.12, and it indicates quite high. The measurement indices of the SPD were quite high in the measurement factors of the information understanding, the information knowledge, and the information application, except for the information potential (shown in Fig. 5). But the measurement index of the information potential was 58.96 and it was the lowest level among the measurement factors. Therefore, the end-users of the SPD should make an effort to improve and develop the information departments such as the experience working in information departments, the information education and training, and the presentation of articles and ideas for a task improvement on the organizational website.

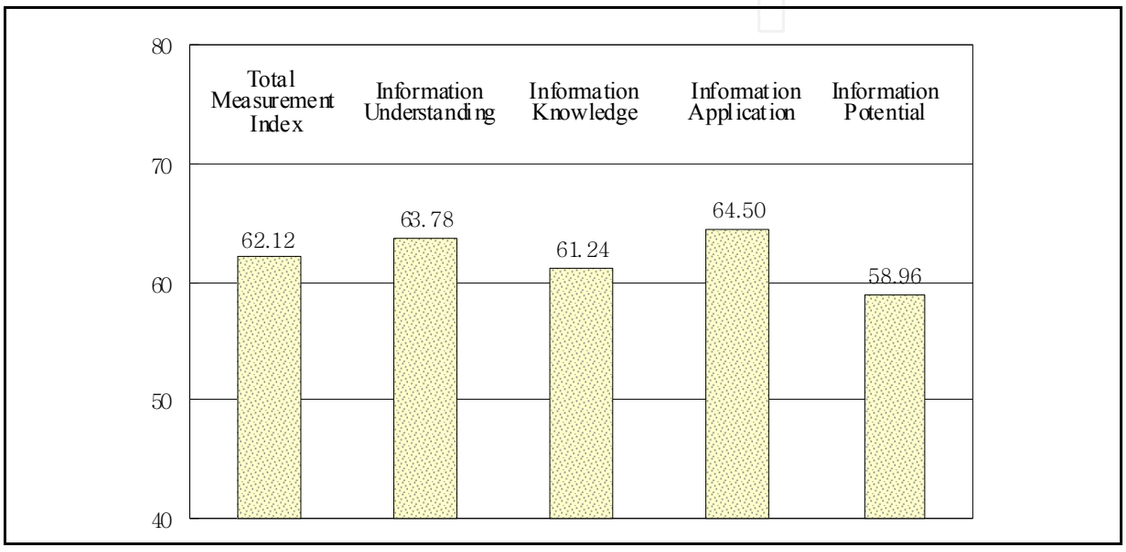

Fig. 5. Measurement indices for each factor of the SPD

Third, application and analysis of an end-user: The measurement results of an end-user working in the administration support department (ASD) were taken as an example. The measurement index of each measurement factor was generated by multiplying each weight value by the measurement value of each factor. The total measurement index is the sum of the measurement indices of each factor (see Table 5).

Division	Information Understanding	Information Knowledge	Information Application	Information Potential	Total Measurement Index
Measurement Indices of Each Factor	61.48	60.12	64.37	56.46	-
Weight Values of Each Factor	0.22	0.25	0.33	0.20	1.00
Calculation of Total Measurement Index	15.53	15.03	21.24	11.29	**63.09**

Table 5. Extraction process of the total measurement index for an end-user

The total measurement index of the end-user computing competency was 63.09 (see Fig. 6), and it was a little high. Especially, the measurement index of the information application was very high. This means the outstanding application ability for applying the information knowledge, solutions, and systems to his or her tasks on an enterprise information system. The measurement indices of the computing understanding, the information knowledge, and the information application were also quite high, except for the information potential.

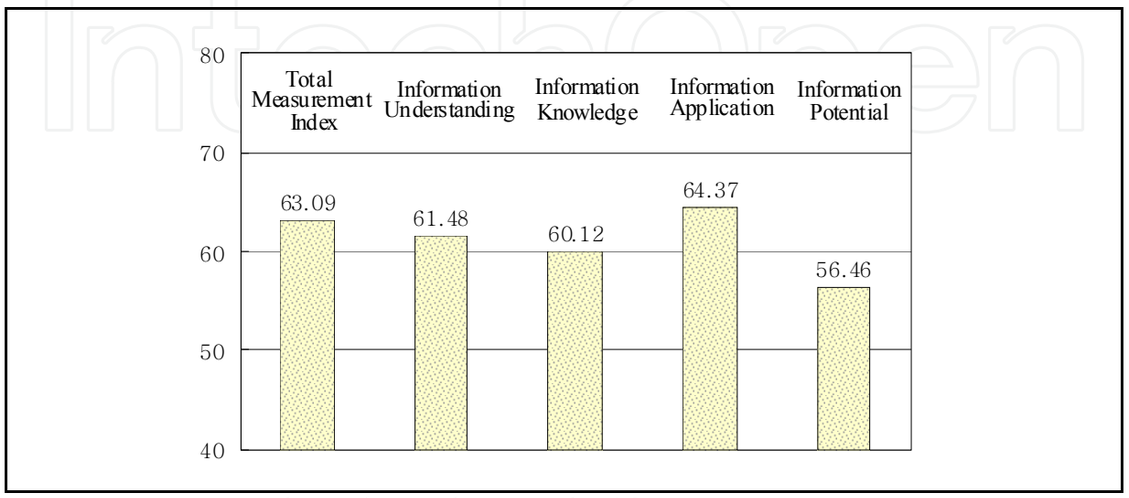

Fig. 6. Measurement indices of an end-user in the ASD

Therefore, this end-user should make an effort to complete information education and training, obtain job experience, and present articles and ideas for a business improvement on the organizational website in order to effectively raise his or her total information competency.

6.3 Analysis and Discussion based on Complex Indicator

The case study based on the interpretation of complex indicators considers an end-user in ASD as a sample. The measurement results were presented based on five core and fifteen general complex indicators (see Fig. 7). In general, the fifteen general indices of the core indicators are low levels, and the indicator of the solution application ability (ERP, SCM, CRM, KMS, and HRM etc.) was a little higher than those of the other core indicators.

The measurement results extracted on fifteen general complex indicators of an end-user working in ASD were also low levels in general (shown in Fig. 7). The complex indicators such as a sense of value, the information system knowledge, information security knowledge, OA application ability, the information system application, and the information base ability were quite a high but the others were low levels. Especially, the measurement results show that five core indicators were lower than the other indicators. Therefore, the end-user has to make a sufficient effort for raising the core indicators to efficiently improve his or her information competency.

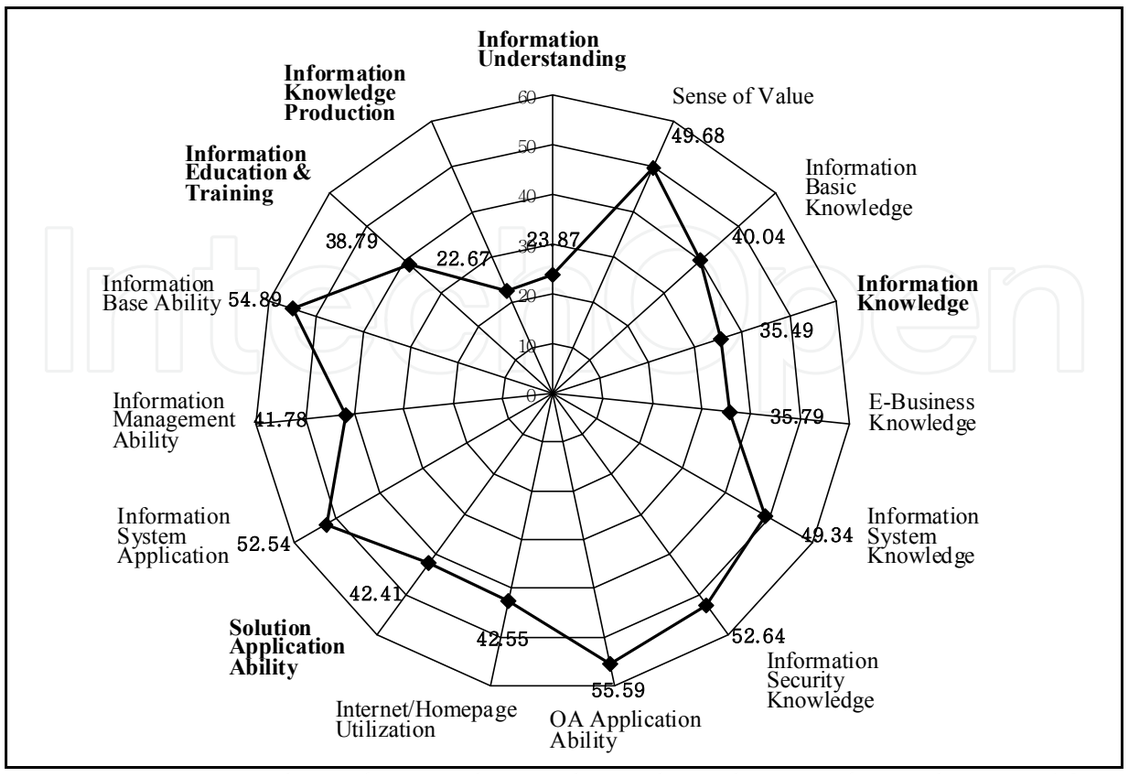

Fig. 7. Measurement indices of core and general complex indicators of an end-user in ASD

7. Conclusion

This study presented a measurement system that can efficiently gauge and interpret an EUIC working on an enterprise information system. The validity and reliability of the developed tool was verified by factor analysis and reliability analysis of the measurement items, and the proper measurement items of each factor were extracted by it. This is an instrument that can measure and interpret an end-user's total information capability based on an information competency. The interpretation tool provides the interpretation indicators that efficiently explain the measurement results of EUIC such as five core and fifteen general complex indicators. The application and utilization of this system was confirmed through a case study.

Therefore, this developed system opens up a new direction and method to develop a measurement system for EUIC since it functions as a measurement system that can entirely gauge and interpret EUIC in respect to the required information ability to efficiently execute an end-user's given tasks on an enterprise information system.

8. Acknowledgements

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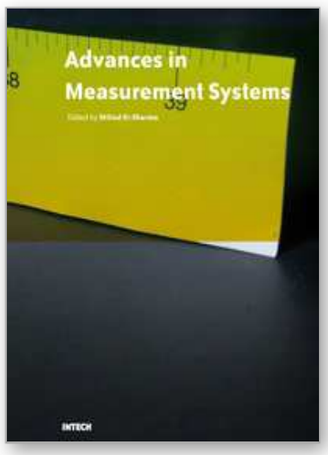

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