



## Medical Employees' Core Competency: Application of Two-Stage Clustering

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In 2005, the Taiwanese government has drawn up The Talent Quality-management System (TTQS) for businesses and medical units to carry out internal human training by offering a sound education and training evaluating system. Hospital executives are more aware of the need to improve the competitiveness of clinical staff and realize that a patient-centered healthcare model requires continuous innovation and quality improvement to enhance the competitiveness of hospitals. Using two-stage clustering (Self-Organization Maps and K-means), this research identified different types of departments—including physicians, medical staff, and administrators and discussed the respective core competency of the different groups. The study result showed the importance of conveying the core competency to the various departments and units in hospitals. Based on analyses we found that hospital staff's core competency identification is essential to help construct a human resources system, serving as a reference for hospitals and corporations in the selection, education, utilization, and retention of talents, as well as a practical benchmark for core competency applicable in the human resource management of hospitals and corporations.

*Keywords:* Core competency, K-means, self-organization maps (SOM), Two-stage clustering, The Talent Quality-management System (TTQS)

*JEL:* I11, L15

In the last two decades, the global competition has been fierce in medical industry. Among other factors, the core competency of enterprises also lies in the quality of qualified personnel, which shows the strategic importance of human resource (Zhang, 2003). Facing the economic recession, enterprises should think optimistically on how to cope with the global competition and to be more competitive to intelligently respond to the economic fluctuations which could reduce many labor-related expenses and enterprise costs. It is a crucial issue for enterprises to find out how to make human resource grow and to create an emerging future. Human capital is one of the most important factors of production and the key to win the competition. Enterprises need to invest in the human resource, plan and train their employees, and establish a sound

education and training system to foster the organization' s required manpower. The Taiwanese government has, based on the concept of the UK' s Investors in People (IIP), and the Swiss ISO10015, introduced The Talent Quality-management System (TTQS) which is a training process including Plan, Design, Do, Review, and Outcome. TTQS provides the training institution and enterprise with the system to evaluate the staff performance and process education and training that carry out from the internal training (Lin, *et al.*, 2010). In the process of Design, core competency is used as the assessment index. By extracting information from databases, this study identified the following core competencies: communication and coordination, innovation and development, problem-solving, learning and development, and accepting responsibility.

The purpose of this study is as follows:

1. The results of the two-stage clustering analysis on how to effectively introduce TTQS is provided. By this research to enable those institutions that have implemented or are going to introduce the TTQS to effectively make their own plans and assessment indicators, thereby enhancing the overall human resource.
2. Evaluate the relationship between TTQS and core competency. By reviewing the implementation of the assessment mechanism, it shows that whether all the assessed hospitals have met the standards of each index. Within the further understanding on the TTQS assessment indicators in identification, the assessed institutions are able to observe the degree of correctness of using the core competency.
3. This study aims to bring the positive impact on Taiwan's medical centers, by improving employees' core competency. Core competency is a general term for behavior, motivation, and knowledge related to work success (Byham and Moyer, 1996). Healthcare behavior involves high complexity and uncertainty. When medical employees perform healthcare behavior-based work, they must possess highly professional medical knowledge and skills to ensure the provision of safe patient care services. The importance of employees' core competency allows the country to compete with the international community and continuously provide the research results for future implementation.

## LITERATURE REVIEW

### Talent Quality-Management System (TTQS)

The Talent Quality-Management System for Talent Development was specially introduced by the International Organization for Standardization (ISO) in “ISO10015 Quality Management - Training Guide” and the British Investors in People (IIP) promulgated in December 1999. Workforce Development Agency (WDA), Ministry of Labor, Taiwan planned to develop the Talent Quality-Human Resource Management System based on the five major facets i.e. Plan, Design, Do, Review and Outcome (PDDRO) to ensure the reliability and correctness of the training process and construct good systematic training environment for human capital investments (Lin *et al.*, 2010).

Started in 2005, the TTQS specifications began to take shape with the efforts of many experts, aiming at the training of reviewers, developing grading criteria with TTQS score cards and completing the pretest of ten organizations. Through constant modifications, the government aims to make TTQS to ensure the effects of Taiwanese enterprises’ investment in human resource in a more complete manner. The systematic development of this system can enhance its application value and implementation quality to continuously review and amend the standards for training quality assessment.

With the introduction of the TTQS system and following the PDDRO standard (see Figure 1), it evaluates the results of employees’ and enterprise’s performance after the training program and integrate the results into the systematic plan that makes the education and training be more aligned with the business demands (Lin *et al.*, 2011). In addition, core competency is a crucial category of TTQS index.



Source: Corporation Training Network, Taiwan

Figure 1. TTQS Cycle

### **Core Competency**

Spencer and Spencer (1993) contended that competency represents the underlying characteristics of a person, which not only relate to the person's work position, but also facilitate understanding the person's expected or real reactions and expressions influencing behavior and performance. The core competency varies according to the organizational strategy and culture and the circumstances, such as customer orientation, innovation, integrity, and so on. Vazirani (2010) refers it as capability to compete with the market for unique intellectual processes or product capabilities that refer to the collective learning or performance ability of the entire organization. Chen *et al.* (2012) further point out that enterprises should give priority to their core competency (such as traits and motivations of employees) based on the selection of appropriate candidates for their functions because the core competency is not easy to modify and develop.

### **Two-Stage Clustering**

Cluster analysis is the procedure of objective classification based on the similarity and difference. The purpose of the classification is to facilitate the identification of the similarity between certain research subjects and group them in the same cluster on the basis of similar features. Subjects stay in the same cluster shows the high level of homogeneity.

Sharma (1996) recommends the categorization method like stratification and non-stratification. In the first stage of stratification, self-organization Map (SOM) method was implemented for clustering to decide the number of clusters. Then, those clusters were substituted in K-means in the stage two. The main reason of adopting the two-stage clustering is the drawback that once two subjects are clustered together in the 1st stage, they will always stay in the same cluster. K-means offset the drawback and reach the best number of clusters being homogenous in the clusters and heterogeneous clusters. While using the K-means, users have to keep trying locating the most appropriate number of clusters. As a result, using two-stage clustering reduces the cost of calculation and saves the time.

#### ***-Self-Organizing Map (SOM)***

SOM is a type of unsupervised learning network proposed by Kohonen (1990). It adopts the idea that brains have the feature of *birds of a feather flock together*. While, network learning is completed, adjacent output

processing units have similar functions for clustering. As SOM makes clustering in the concept of nearest neighbor, the resultant clusters are seen with overlapping partitions. The resultant clusters of non-level-type clustering can produce non-overlapping partitions. Vesanto and Alhoniemi (2000) identify self-organizing map patterns by matching the vector values of the pattern elements and classifying the patterns.

#### ***-K-Means***

K-means cluster algorithm was proposed by J. B. MacQueen in 1967, which is used to deal with the problem of data clustering. The relatively simple algorithm is widely used in the scientific field research and industrial applications. K-means method is frequently used in non-stratified cluster analysis (Buttrey and Karo, 2002). It requires predetermined number of clusters. Inappropriate number of clustering will lead to vague difference among clusters. In selecting clusters, it is recommended selecting different number of clusters for more algorithms to have reasonable explanation.

Both Abidi and Ong (2000) and, Vesanto and Alhoniemi (2000) proposed the technique of two-stage clustering as the clustering strategy for conducting data mining. This study adopts a two-stage clustering method (SOM and K-means) to carry out scientific and confirmatory comparison among groups of physicians, nurses and general administrative staff.

## **METHODOLOGY**

This study focused on the relevance and correctness of one Taiwan's case hospital in promoting core competency through the TTQS-accredited medical institutes. This research urges other medical research institutes to import TTQS research index and advises the medical centers to create a database which can be used for academic research purposes. It is hoped that the database of the medical hospital can be helpful to get the optimal results, generate feedback and reference.

In this study, the status of training and operation of human resource in medical institutions was mainly learned from the database of medical institutions. The research was divided into two parts. First, a discriminant analysis was conducted for each cluster. The medical center introduced core competency to physicians, nurses and general administrations in order to explore the various groups of surgical, medical and administrative support during the review in the hope of finding out the core competency that were most

distinguishable among different levels of groups. By using SOM and K-means separately identifies the doctors, nurses and general administrative units of each department in the medical institution's database. In this study, we hope to see whether the core competency of the TTQS have been effectively internalized and implemented from the perspective of the department that has been imported into TTQS, so as to translate the content of the database into information with reference value.

### Two-Stage Clustering Algorithm

The algorithm of two-stage clustering is as follows:

1. SOM: Kohonen used self-organization to conduct graphic recognition, where vector values in consistence with the graphic elements are used to classify the graphs.
2. K-means: In terms of economy, simplicity and effectiveness, K-means is a method worth applying. It is a non-layer type clustering, not subject to the effects of outliers, errors in distance measurement and selection of method of distance calculation. The results of cluster are better if the initial point of the cluster is known.

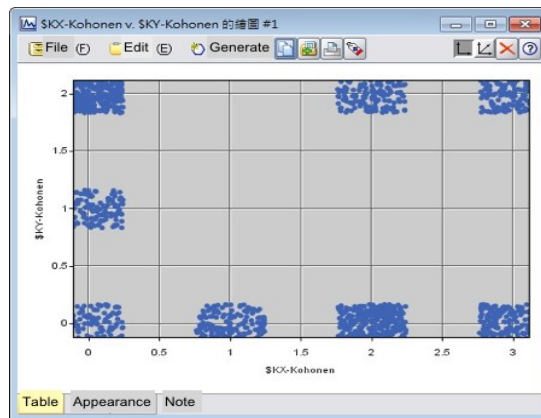
The K-means algorithm criterion function adopts square error criterion be defined as Equation 1:

$$E = \sum_{i=1}^k \sum_{p \in C_i} (p - m_i)^2 \quad (1)$$

Where,  $E$  is total square error of all the objects in the data cluster,  $p$  bellows to data object set,  $m_i$  is mean value of cluster  $C_i$ .

### Comparison of Two Groups by Grouping Method

This study used two-stage clustering to conduct a confirmatory comparison. In order to determine the target of this study to explore the "promotion of the core competency of the medical center" and to understand the distribution of the medical library, this study explored and analyzed the existing field data to divide the functional units into several clusters, obtained similarities from the same cluster, and through the results of the analysis, via the unsupervised self-organizing map (SOM) network. In the drawing for the distribution of SOM clusters, being the numbers of initial clusters in the first stage, the numbers were eight, as shown in Figure 2, which shows the distributions of group numbers of SOM grouping. Using the two-stage clustering analysis results of K-means, the study obtained the distribution of each cluster composition, as shown in Figure 3.



Source: This study

**Figure 2. SOM Grouping Scatter Diagram**



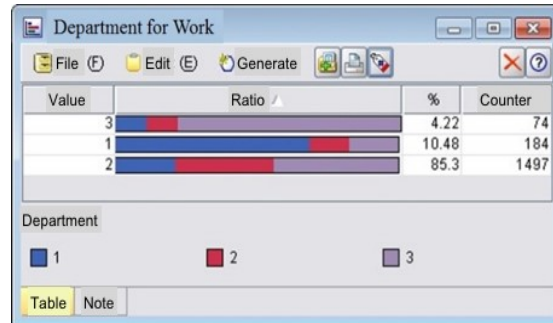
Source: This study

**Figure 3. K-Means Cluster Composition Distribution**

From “K-Means Distribution” in Figure 3, the blue portion of bar represents the Department of Surgery (D1), the red portion of bar represents the Department of Internal Medicine (D2), and the purple portion of bar represents the general administration (D3). The size of the cluster became more relevant to each other. In Figure 4, the size of the cluster became more explicit as it relates to each analysis. The distribution is as follows:

Each cluster shows the distribution proportion and it can be clearly observed. In Cluster-1, it includes the “doctors”, “nurses” and “administration staff” in medical department of hospital, which accounts for 10.48 percent. In Cluster-2, it involves “doctors”, “nurses” and “administration staff” in surgical

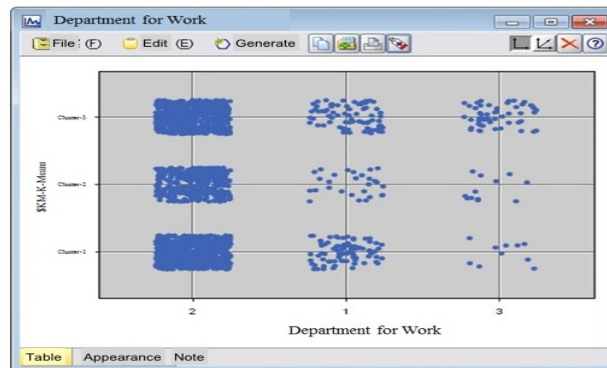
department of hospital, which makes up 85.3 percent. In Cluster-3, it includes “ doctors” , “ nurses” and “ administration staff ” in general Administration, which occupies 4.22 percent.



Source: This study

**Figure 4. K-Means Cluster Composition Distribution**

Then, the initial population of SOM was substituted into K-means. The K-means was used for the second-stage grouping of nodes on the map and is plotted (see Figure 5) as a two-stage clustering model of SOM-K-means cluster scatter.



Source: This study

**Figure 5. Distribution of SOM-K-Means Clusters**

As can be seen from Figure 5, the distribution of SOM-K-means scatter plots showed that the degree of consistency and the extent to which core competency is promoted. The analysis results are as follows:



1. When SOM is clustered into “ D2” , K-means cluster “ Cluster-1, Cluster-2, Cluster-3” falls within the range of this block. Since the entire core competency of the K-means also indicates that when a departmental unit falls into this block, awareness of its core competency is more strongly enforced to result in a higher level of implementation than that of the departmental units that carry out their core competency as a whole.
2. When the SOM is grouped into “ D1” , the K-Means cluster “ Cluster-1, Cluster-3” falls within the range of this block. Since the composition of this cluster has more core competency in implementing the core functional indicators (implementation and integrity) of operational performance, it can be seen that although their performance level is not as good as that of the department of surgery, they are relatively evenly distributed to the departmental units that carry out their core competency as a whole.
3. When the SOM is grouped into “ D3” and the K-means cluster “ Cluster-3” falls within the scope of this block; the core competency of this cluster is weak, which also indicates that the clustering promotes the core competency of very low level of consistency. Moreover, the departmental unit that falls on this block lies in the implementation of its core competency.
4. By adopting the SOM and K-means to analyze the competency gap between the employees, it helped the medical center to plan the suitable core competency for future human resource evaluation and management.

## **CONCLUSION**

This study used Talent Quality-Management System (TTQS) database maintained by one case hospital in Taiwan for empirical analysis. First, the study conducted a discriminant analysis for hospital staff credentials stored on database and conducted a differential analysis of each cluster to determine the most distinguished core competency among doctors, nurses and general administrative groups. Second, the study learned about the importance of each of its departmental units on its core competency and proposed specific solutions to improve its operations to provide a reference base for future implementation of the core competency on the departmental units of medical institutions. Research results are described below:

1. Two-stage clustering method provided an informative breakdown of the classification of each group or

department. Using the two-stage clustering method (SOM and K-means) in our institute, we have observed a higher proportion of "Cluster 3" and observed it from the perspective of its core competency. We can further examine and compare the classification results of previous literature. The high level of analytical consistency of cluster analysis also demonstrates the effectiveness of the implementation of core competency, which has obvious benefits for the imported departmental units.

2. After analysis, doctors, nurses and general administration from the department of medicine showed a more consistent degree of the proportion. In the case of administrative support, the consistency of core competence among doctors, nurses and general administration is less adequate. The reason may be that departmental units at these two levels are unable to grasp the approach because of the way of introducing the core competency to the medical center. Therefore, the integrity and the implementation of the core competency are inadequate and lead to low-level evaluation of the impact of various departments and units.

3. This study concludes that the Talent Quality-management System (TTQS) and its implementation, so far, have a positive and immediate impact on the medical institutions in Taiwan. The system helped enhance human resources and build the core competency. It brings the state as a whole to attach importance in the core competency of human resource allowing the country to have the strength of the people to compete with the international community and to continuously provide the research results for future implementation.

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