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Understanding Discrepancy: A Conceptual Persistent Healthcare Quality Improvement Process for Software Development Management

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1. Introduction

This chapter illustrates a sustained conceptual service quality improvement process for management of software development within a healthcare enterprise. Our proposed process is revised from Niland's Healthcare Quality Information System (HQIS) (Niland, 2006). This process includes functions to survey the satisfaction of our supported system functionalities, describes the information system operation bylaws on-line, and provides on-demand information system training. To achieve these goals, we integrate five information systems at the National Taiwan University Hospital (NTUH), including healthcare information system, health quality information system, requirement management system, executive information system, and digital learning system, to form a full Deming cycle (Deming, 1986). Essentially, the process can supply sufficient sources for user requirement management in a healthcare enterprise. Preliminary user satisfaction surveys have indicated that our information system development gradually promotes user satisfaction and has been accepted by the users since 2006. In conclusion, we can straightforwardly understand the discrepancy between the diverse user requirements and select the right system development methodology with our proposed process in a healthcare enterprise.

2. Background

The Healthcare Information System (HIS) in NTUH was built under an IBM/SNA (Systems Network Architecture) environment with a hierarchical Information Management System database (IMSDB) over twenty-five years ago. The HIS contains multiple components operating independently, e.g., Outpatient Information Systems (OIS), Inpatient Information System (IIS), and Emergency Treatment Information System (EIS). The client/server approach was designed and implemented in the system (Cheng, 2005; Hsieh, 2006).

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As time advancing, the above built-in technologies have turned out to be obsolete. As an integrated access among HIS components has become inevitable, NTUH Information Office started to carry out developing and deploying a new HIS at the beginning of year 2004. Currently, the entire HIS architecture is committed to the Microsoft technologies: .NET platform incorporated at the HIS core as well as its ancillary systems with the invocation (method calls) expressed in Health Level 7 (HL7) and embedded in XML/SOAP (Simple Object Access Protocol) formats. The newly developed OIS, IIS, and EIS have been implemented under such architecture and become fully operational since January 2006, January 2007, and August 2008 respectively. On average, the NTUH HIS serves approximately 8,000 outpatients, 300 emergency cases, and 2,500 beds for inpatients daily. Under these circumstances, it is essential to focus on the business requirements and enhance the information systems by inspecting feedbacks from end users. Therefore, a sustained conceptual service quality improvement process for the management of software development within a healthcare enterprise is critical.

3. Related work

Wang stated that "in order to increase productivity, organizations must manage information as they manage products," and proposed a Total Data Quality Management (TDQM) methodology for improving the data entry quality in information systems (Wang, 1998). Although the data quality can be improved by the TDQM methodology, chameleonic user requirements can make the information systems less satisfactory. Therefore, it is substantial for us to continuously refine the information systems to unite users' exact demands.

Niland proposed a robust Healthcare Quality Information System (HQIS) in 2006 which has the potential to address this deficiency through the capture, codification, and analysis of information about patient treatments and credibly concerned results (Niland, 2006). Niland proved that HQIS would be a feasible method for system implementations, maintenance in a healthcare enterprise environment. However, it is necessary for a healthcare organization to construct an environment for solving and processing requirements effectively.

From the perspective of software engineering, software development has a life cycle, and it is advised to follow a set of administrative steps such as system requirements, system analyses, system designs, system developments, system tests, and system maintenance (Sommerville, 2007). In particular, we aim at the software development that has to satisfy the requirements of healthcare professionals in a mission-critical healthcare enterprise. Ravichandran and Rai suggested that software quality goal is best attained when top management purposely appoints an administration infrastructure that promotes improvements in process design and rallies stakeholders to expand the structure of the development processes (Ravichandran and Rai, 2000). Furthermore, Higgs stated that a point to remember when implementing information management systems is that doctors and nurses must genuinely be involved in decision making and risks. The key phrase is `open and honest` (Higgs, 1997). In other words, problems and opportunities must be shared by all parties in an organization.

In 2002, Califf provided an alternative view by presenting a model that integrates quantitative measurements of quality and performance into the development cycle of managing and future therapeutics (Califf, 2002). He proved that the migration from quality management to HIS is feasible; however, it did not disclose the evaluations about system performance related evidences. Therefore, we proposed a conceptual persistent healthcare

quality improvement process for software development knowledge management which can be implemented in a healthcare enterprise.
The services for healthcare enterprise are diverse and difficult to restrict users to handle their routine processes within an information system under rough functionalities. Therefore, the healthcare environment that implicitly buries some requirements or problems should be concerned and solved. Based on the above illustrations, there are problems that ought to be resolved for the engineering requirements between developers and staffs in a healthcare enterprise. For example, user requirements need to be effectively collected, analyzed, and migrated with legacy information systems in order to implement an `open and honest` environment that assists to promote organization requirements, and to meliorate the software requirement engineering processes and outcomes.

4. Methods

We proposed a conceptual process for the circular healthcare quality promotion, which can be integrated with the healthcare enterprise software development and the Deming cycle (also known as PDCA cycle) (Deming, 1986). First, we simplified the informatics blueprint of HQIS (Niland, 2006); afterwards, we defined a circular process to upgrade the healthcare quality and system satisfaction. Finally, we collected some exploratory surveys as quantitative evaluation information from all users, including doctors, nurses, technicians, clerks, and engineers, and persistently fine-tuned our system functions based on the latest major user requirements.

4.1 Revising informatics blueprint

Our research revised Niland's HQIS into a circular process where the obtained outcome is in-turn automatically fed back to the process. Meanwhile, we simplified HQIS by ignoring the socio-technical part in order to rapidly collect the effective, on-line data. In other words, our HQIS solely emphasizes on service quality, organizational feedback, as well as knowledge management perspectives. Regardless, the knowledge management platform is not connected with our previous process yet, but the platform is under-production and will be incorporated in the near future (Cheng, 2008). We designed a circular process in our software development compliant with the Deming cycle of four traditional stages: Plan, Do, Check, and Act. Figure 1 illustrates the Deming cycle within four designated sectors which are enclosed by dash-lines from left to right and form a counter-clockwise cycle.
The right-most dash-line frame presents the 'Plan' stage in the Deming cycle. The Plan stage embraces at least two systems: the requirement management system and the executive information system. Both systems coupled together will expressly feed specific information with each other. The decision making will be postponed to the subsequent 'Do' stage after a thorough information analysis is conducted.
The left-most dash-line frame is a simple screen example which contains the 'Do' stage of the Deming cycle. In our HIS execution environment, users can recognize at least four types of icons to retrieve further information in a designated process. These icons can be hidden at first and can be visible later while the mouse navigating over the specified area. The purposes of these four-icon representations are: "q" to carry out an on-line function satisfaction survey, "%" to inspect the on-line survey statistics, "?" to activate the on-line function description helper, and "b" to redirect users to the related on-demand information system courses.

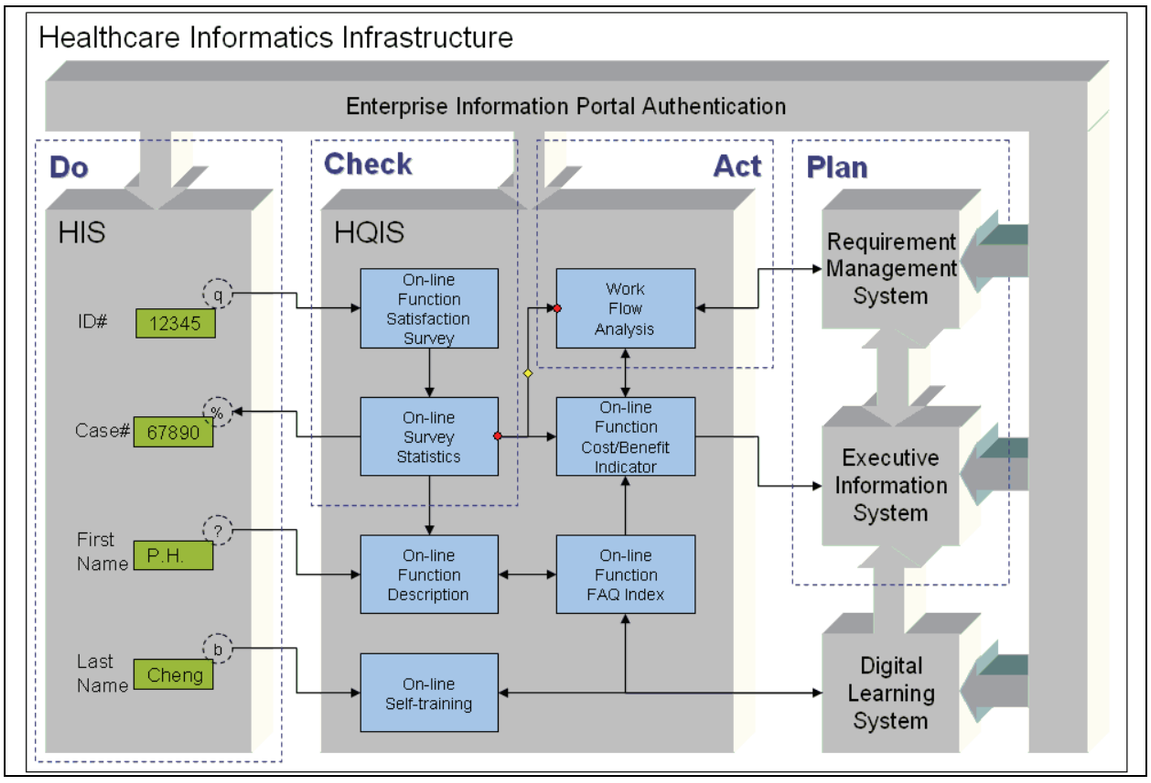


Fig. 1. Deming (PDCA) cycle managing the service quality of user requirements and software development

The above four icons are mapping to the corresponding modules such as, function satisfaction survey module, survey statistics module, function description module, and self-training module, in our HQIS. The former two modules execute the "check" operation of the Deming cycle and obtain on-line support survey results for the defined functionality. The third module receives the results of survey statistics module and is integrated with the functions of frequently asked question indexes (FAQI) module. The last module can be combined with FAQI module in HQIS and connected with an additional digital learning system within the healthcare enterprise environment.

Finally, the on-line survey statistics module forwards the results to both the work flow analysis module and the function cost/benefit indicator module. The work flow analysis module represents the "act" stage of the Deming cycle and will generate relevant information to the requirement management system for further decision making. We believe that our process can induce user requirements be effectively collected, analyzed, and legacy information systems be integrated.

4.2 Continued feedbacks for outcomes

In order to constantly retrieve the most immediate user requirements, we have implemented a survey information system to communicate with majority of the enterprise users. Every registered healthcare professional can enter the cross cultural survey system through the enterprise information portal. After the authentication process, users can decide whether to attend the on-line survey. Basically, each on-line survey can be attended only once, and the time log will be maintained automatically for further statistical usages. We believe that such

survey feedbacks can continuously improve the software requirement engineering processes and outcomes.

Generally speaking, most of the functionalities in HIS should follow the particular healthcare enterprise bylaws, insurance declaration rules, and/or committed work flows. Moreover, it is extremely difficult for every healthcare professional to clearly understand how computer functions ought to be performed. In consequence of their heavy duties and tight schedules, it is nearly impossible for them to participate in all of the system requirement discussion meetings. According to these reasons, we try to utilize an Asynchronous On-Line Survey (AOLS) system to identify whether the developed functions are favored or not. Meanwhile, our research anticipates that most of the surveys can statistically represent the preferences of major users in a healthcare enterprise environment, and the software engineers in the information technology department can approach and achieve the preferences.

Disciplinarily, people/users in an educational department or organization have to be well trained in every related system function before that function can be put into use. However, the system function training may imprudently ignore some ambiguous flows which can cause mistakes during the complicated healthcare enterprise work flow processing, where most of the work flows are hybrid flows that intermix computer flows with manual flows . If flow analysts do not predefine clearly, mistake may happen during the execution time.

5. Results

The more organized the system modules in a healthcare enterprise are, the higher is the resulting quality of care. In our revised version of HQIS, there are seven modules designed: function satisfaction survey, survey statistics, function description, self-training, FAQI, functional cost/benefit indicator, and work flow analysis. The former six modules are on-line services, and the last one is manually performed by system analysts in the information technology department.

5.1 Semi-anonymous survey system

The satisfaction survey module of our HQIS is an on-line semi-anonymous survey which can be executed by all enterprise staffs. Each survey result will be passed on to the on-line survey statistics module. This module will generate statistical information automatically, and the information can be readily extracted by the on-line users. Figure 2 shows the screen snapshot of one of the specific survey results in the on-line survey system. The survey data listed in the survey log can be accessed by authorized users. Note that some users will complete the survey with their comments which is indicated in the lower section of Figure 2. These useful comments will be collected, classified, and forwarded to related departments for further references; the process matches Higgs' "open and honest" key phrase (Higgs, 1997).

After a predefined survey period, HQIS can create useful statistical graphs to be shared with all users. The statistical graph creation is implemented through computer programming to provide quantitative measurements of quality in the development cycle (Wang, 1998), which can even be used to improve the quality of future therapeutics (Califf, 2002). However, the experiences of decision of statistical graph selection sometimes are subjective, and we believe that we will learn experiences from implementations.

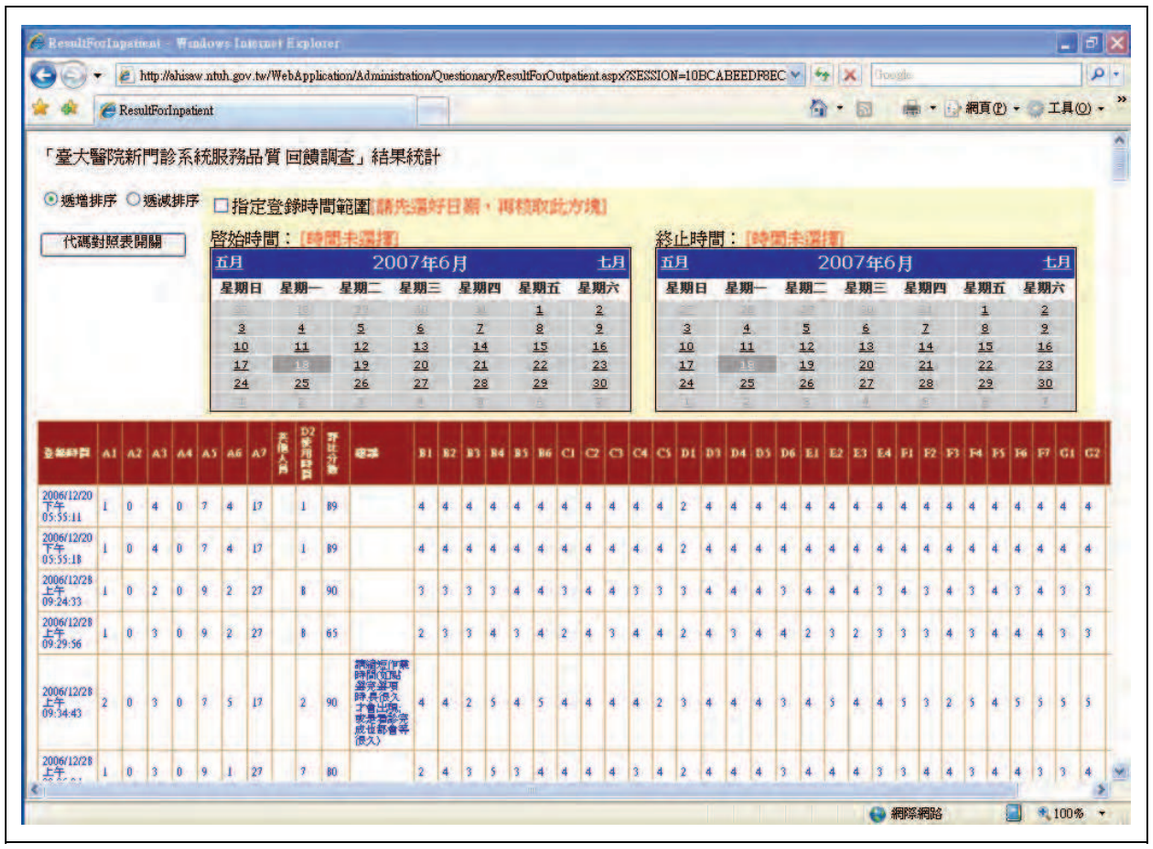
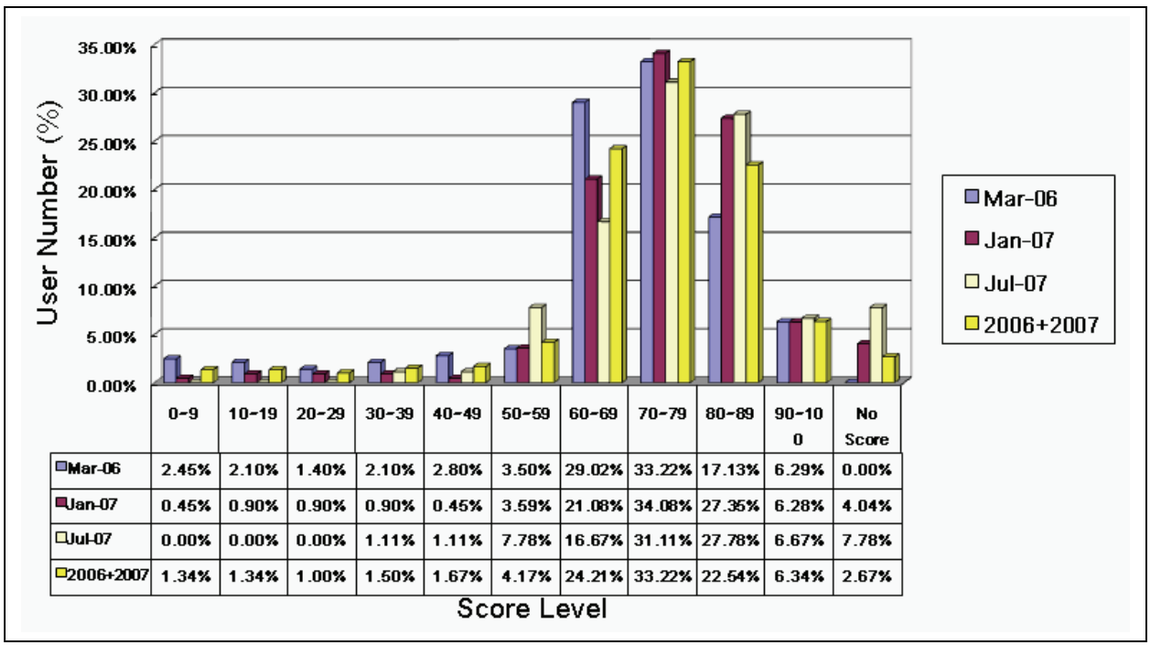


Fig. 2. A screen snapshot of the survey data in the on-line survey system

The information technology department conducts survey actions in NTUH. Figure 3 demonstrates a high-assurance service promotion phenomenon that our health information systems received average scores of 65.87, 71.31, and 71.98 in March 2006, January 2007, and July 2007, respectively. Note that the satisfaction scores of the information system service quality are slightly increased within six months from January 2007 to July 2007. The Cronbach's α is 0.897 and the effective samples are 286, 223, and 90 for these three surveys respectively. Actually, we acquired 36 questionnaires in each survey except the seven fundamental attribute questions. The following figure only provides total scores of individual surveys; the variances of the scores are 18.18, 14.10, and 12.07 for these three surveys respectively. Note that the first survey is accomplished manually, not by our survey system.

In our HQIS, the function description module can supply outline illustrations for a specific function. In other words, the system will explain which system analyst is responsible for a certain function, why the function has to be performed, which committee is decided to carry out the function, and when is appropriate to execute the function. All the explanations will be extracted later into an on-line PDF document file maintained in a well constructed folder.



	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-100	No Score
Mar-06	2.45%	2.10%	1.40%	2.10%	2.80%	3.50%	29.02%	33.22%	17.13%	6.29%	0.00%
Jan-07	0.45%	0.90%	0.90%	0.90%	0.45%	3.59%	21.08%	34.08%	27.35%	6.28%	4.04%
Jul-07	0.00%	0.00%	0.00%	1.11%	1.11%	7.78%	16.67%	31.11%	27.78%	6.67%	7.78%
2006+2007	1.34%	1.34%	1.00%	1.50%	1.67%	4.17%	24.21%	33.22%	22.54%	6.34%	2.67%

Fig. 3. Total scores of information systems from March 2006, January 2007, and July 2007

This module will possess an on-line FAQI module additionally to support the 24-hour on-line usage in our information technology department.

5.2 On-demand training

Generally, the attendance rates for medical associated education of healthcare professionals are quite high in NTUH. However, the attendance rates of HIS related education, correspondingly, sometimes are substantially low from our experiences, especially for surgical doctors. Their attendance rates approximately are 10%~20%, even for a recommended time period. Moreover, the healthcare professionals are frequently interrupted by emergency calls during the education courses.

We try to refine our education process and support extra on-demand information system education for healthcare professionals. Since the new communication links have established, the conflicts, misunderstanding among healthcare professionals and information department can be remarkably decreased. Thus, it indicates that the information technology department has successfully increased its customer satisfactions.

Some enthusiastic users offer their subjective opinions in order to improve the enterprise work flow. However, most of them do concern about their own work flow and do not outright familiarize the entire work flow in a healthcare enterprise. Therefore, the on-line self-training module of our HQIS provides all the current work flows for user browsing and learning. The more the users firmly understand the entire work flow, the more smooth coordination will persist.

Anyhow, user requirements can continuously enhance the software requirement engineering processes and outcomes. Usually and relatively, fewer user ideas are practical because most of their points of view are based on the perspective of their own department, and lacking the bigger, overall pictures. If we accept a destructive criticism and forcefully integrate it into the enterprise work flow, the bottleneck will emerge from the imbalanced work flow and will inevitably be requested to modify in the near future.

6. Discussion

The following arguments will focus on three significant concerns: management by objectives, anonymous vs. signed survey, and statistical major requirements.

6.1 Management by Objectives (MBO)

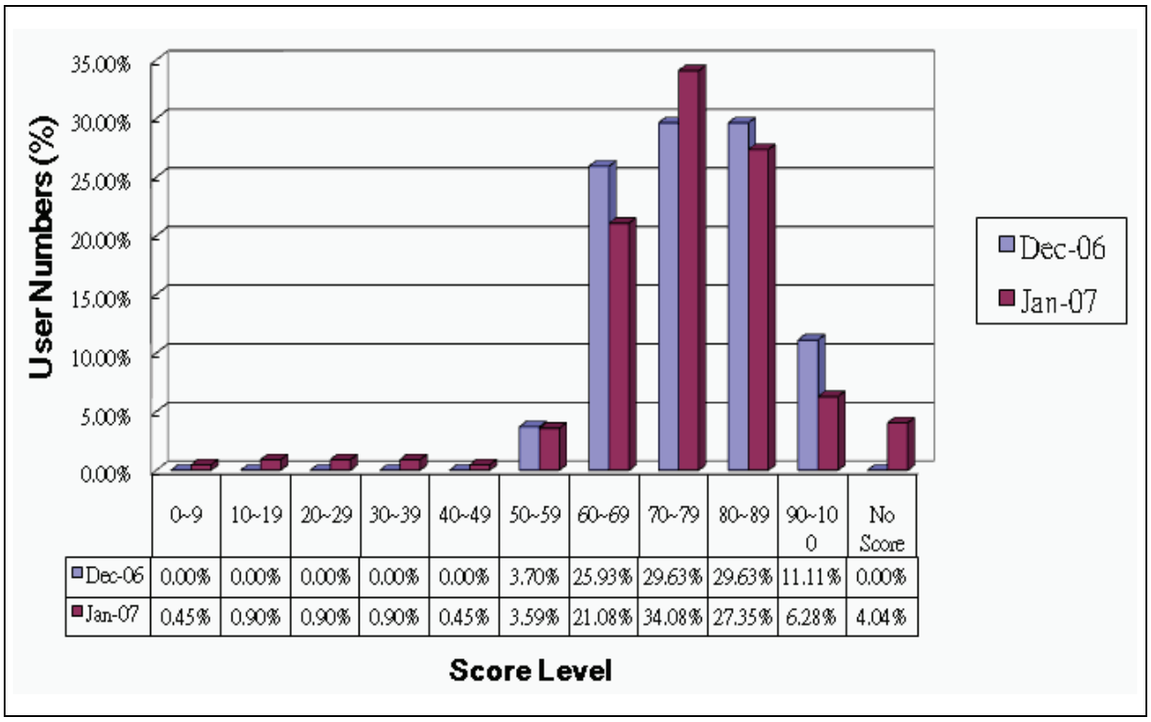
Because most healthcare services are mission-critical, the service quality promotion is the most important concern in healthcare management level. Managers emphasize on particular problems and figure out the real causes. Afterwards, they propose proper solutions to solve the problems. Obviously, they will define relevant indicators to monitor the execution outcomes.

Therefore, most of the managers will utilize the PDCA cycle to track required targets and attempt to promote their objective services within a circular execution process. However, the PDCA cycle is one of the methods for promoting service quality within a short cycle process and is not quite suitable for a long cycle process. Meanwhile, MBO (Dinesh, 1998) with balanced scorecard (Kaplan, 1996) is a minimum requirement for promoting service qualities; it will restrict the scope of target. Furthermore, some of the accredited processes are not the major target for healthcare enterprise; they simply support certain methods for organization to understand their weak points and allude them for further quality promotions.

6.2 Anonymous vs. signed survey

Broadly speaking, most of the potential users favour an anonymous survey. The survey will ultimately achieve better outcomes than a signed one. Similarly, such a situation exists in our healthcare enterprise. However, the NTUH remains using signed surveys to obtain system requirements from all users. These user-replied surveys might contain description on user's system requirements more clearly. Moreover, system analysts can understand the sources of their demands and subsequently make a better system implementation decision. It is a win-win solution, and no one loses under the situation.

From December 2006 to January 2007, our research activates signed survey and anonymous survey, respectively, as depicted in Figure 4. Due to the time periods of two surveys performed are concatenated and almost overlapped, we believe that these survey outcomes are valid. The variances of signed and anonymous surveys are 9.51 and 14.10, respectively. Apparently, we learned that most of colleagues fear to fill-in the signed survey, and its scores are thus concentrated in-between 60~89. However, as the 2007 anonymous survey scores are also concentrated at the same score level, but the distribution will be more reasonable than the 2006 one; most of the colleagues honestly provide their scores.



	0~9	10~19	20~29	30~39	40~49	50~59	60~69	70~79	80~89	90~100	No Score
Dec-06	0.00%	0.00%	0.00%	0.00%	0.00%	3.70%	25.93%	29.63%	29.63%	11.11%	0.00%
Jan-07	0.45%	0.90%	0.90%	0.90%	0.45%	3.59%	21.08%	34.08%	27.35%	6.28%	4.04%

Fig. 4. Anonymous vs. signed survey: total scores of information systems from December 2006 to January 2007

Strictly, our anonymous survey is actually a semi-anonymous mechanism. That is, database administrators can trace the log to identify specific survey data, if they intended to do so. However, the Ex-superintendent, Dr. F. Y. Lin, of NTUH emphasises on the 'open and honest' policy and put it as the first hospital discipline. Our organization trusts every colleague and welcomes any voices. Our process implements an 'open and honest' environment to assist and promote organization requirements. We believe that it will be the source of innovation power. On the other hand, if the accuracy of the signed surveys increases and the satisfactions of system functions grow with continual surveys, then such results would confirm that the signed surveys are feasible. Furthermore, the healthcare professionals understand that it is another workable and acceptable way to knowledgeably communicate with system analysts.

In general, there are popular methodologies to measure the quality of medical information system management. Our process will furnish objective statistical information to assess whether the specific system functions or flows are error sources or not. Since the survey is on-line and randomly collected in NTUH with 5,360 employees at least, the statistical information would be normally distributed. Therefore, the healthcare quality management center can use the information to determine whether the systems should adopt such changes and to enhance the healthcare quality.

6.3 Statistical major requirements

Since the signed survey is acquired on-line randomly, it is appropriate for system analysts to gather the user requirements from a simple contact window. That is, the demographic information describes the voices of majority and differentiates the non-major opinions. Moreover, the statistical information can then be proposed to high-level managers to noticeably strengthen the implementation proposals and to allocate constructive budgets promptly. We believe that this system function, which is implemented based on the statistical requirement information, will become popular in our healthcare enterprise.

Despite the major requirements can strongly influence the decision in an organization, some of the specifications which would go against the organizational rules of morality should be denied by high-level mangers that also face the dilemma to make necessary decisions. On the other hand, after the healthcare quality management center receives statistical data from this process, the data can be discussed, evaluated and justified whether to alter the healthcare processes. In the meantime, system analysts can utilize the discussion decision to direct their work flows and try to obtain an optimized flow to improve the quality of services continuously.

Our research elaborates enormous challenges for healthcare quality management centre and system analysts as follows. How does one implement an optimized work flow? How does one illustrate evidence that it can improve the quality of care? Which work flow is appropriate for our colleagues in the current enterprise environment? When should one begin or terminate the work flow? Could one evaluate the quality of the new work flow before executing it? Could one observe the new work flow process status on-line? As of now, there are no complete, comprehensive answers.

7. Conclusion

Based upon the design, implementation experiences comprehended during the NTUH healthcare information infrastructure developing and deployment, we gradually achieved that brand new projects can be accomplished and integrated into the infrastructure on schedule. It is a trivial and feasible approach to retrieve the latest and principal requirements which are randomly gathered by the on-line service-oriented information systems attached with accurate time logs. The healthcare quality management centre and system analysts can utilize the statistical survey results to promote and constitute the service quality. Our proposed process provides a high-assurance service-oriented requirement mechanism that can engage the information technology department to obtain sufficient and essential demands from all users.

We are confident that, from our own experiences, the process can compass, improve the software service quality of software development and maintenance, including sophisticated patient care and security, in a healthcare enterprise environment. Before our information technology department transubstantiates most of the hard-copy healthcare records into Electronic Health Records (EHR), we strongly believe our proposed process can introduce valuable insights into the HIS evolution. By emerging the process into the software development procedures, there will be significant advantages over traditional methodologies during EHR implementations.

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