Knowledge Audit with Intellectual Capital in the Quality Management Process: An Empirical Study in an Electronics Company

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Abstract: Most of the intellectual capital (IC) assessment tools are based on a “top-down” approach which does not explore deeply into the particular business process and the specific knowledge needs. Those IC assessment tools generally measure the intellectual capital of an organization as the return on intangible assets covering Human Capital (HC) such as staff skills, innovativeness and work experience, Structural Capital (SC) such as IT systems, documents and patents, and Relational Capital (RC) such as relationship with customers and suppliers. Traditional IC assessment tools with “IC reporting” deliverables aim at identifying useful knowledge that can create wealth for the organization in assessing the performance and value creation process. In contrary, a systematic “knowledge audit” is a process-oriented and stock-taking approach for evaluating the “knowledge healthiness” of an organization from the “bottom-up”. There is potential to merge two methodologies into one integrated assessment tool to present a comprehensive IC reporting in an organization. Knowledge assets underpin the capabilities and core competencies of any organization. The importance of a knowledge audit is the first step in determining how knowledge is handled in mission critical business processes in an organization. Quality management processes are the main subsets inside an organization’s critical business processes. A knowledge audit provides an evidence based assessment of the knowledge assets within an organization, however, there is a lack of a systematic approach in the way knowledge audits are conducted. In addition, there is no standard way of measuring Intellectual Capital (IC) through a better understanding of knowledge assets that are captured from a knowledge audit. The two different streams of KM and IC are complementary and provide the cornerstones for the definition of a managerial framework to identify, assess, exploit and manage organizational knowledge. In view of the importance of the knowledge audit and the deficiencies in the standard ways of IC measurement, a structured knowledge audit approach has been applied. This paper presents an integration of knowledge audit and IC reporting approach which has been applied in a Quality Assurance (QA) Department of an electronics company, for knowledge assets stock-taking in six specified Value Added Quality Management Processes (VAQMP). More than 74 staff, over 4 corporate functions and 5 departments in two manufacturing plants, from different work levels involving 6 quality management processes from each plant, participated in the research. 52 Participants were provided with various knowledge audit forms to complete in order to provide information about the IT tools/platforms, documents, implicit knowledge, as well as the critical industrial technologies in each VAQMP process. Quantitative and qualitative analysis was then undertaken, including stakeholder analysis and the identification of critical knowledge workers, industrial technologies, crucial documents, implicit knowledge, as well as the knowledge fountain and knowledge discovery points of the process. The outcomes and effectiveness of the knowledge audit were evaluated in both KM and IC aspects. In most Intellectual Capital assessment tools, the workflow of the business process and the specific knowledge needs are not taken into account. On the other hand, this structured knowledge audit helps to identify critical organizational knowledge that needs to be captured and transferred for the healthy operation and sustainability of the quality management processes, in order to prevent quality crises. Finally, after the consolidation of the explicit and implicit knowledge inventories, as well as constructing an IC value tree, an intellectual capital statement for the Group Quality Assurance (GQA) Department was produced.

Keywords: group quality assurance, intellectual capital, intellectual capital statement, IC value tree, taxonomy, value added quality management processes

1. Introduction

In the knowledge economy, for a company to maintain a competitive position for a long period of time, regardless of its strength, is not possible with the short life cycles of knowledge and ignorance of intellectual capital. Academics and practitioners have proposed a number of definitions of intellectual capital (IC). Their common characteristic is that they all agree that IC consists of specific and organized information which can be used by a firm for a productive purpose (Edvinsson and Sullivan, 1996). Among all the definitions (Edvinsson and Sullivan, 1996; Brooking, 1996; Stewart, 1997, Roos et al., 1997; Bontis, 1998), the commonly agreed definitions of intellectual capital(IC) is the importance of knowledge to the firm’s value creating process. Though optimization, as a process, is equally important in the knowledge economy, it alone cannot create or maximize value. The only way to create value in the knowledge economy is by adopting intellectual capital management (ICM) as the core business process. An organization’s ability to create value depends on its value added

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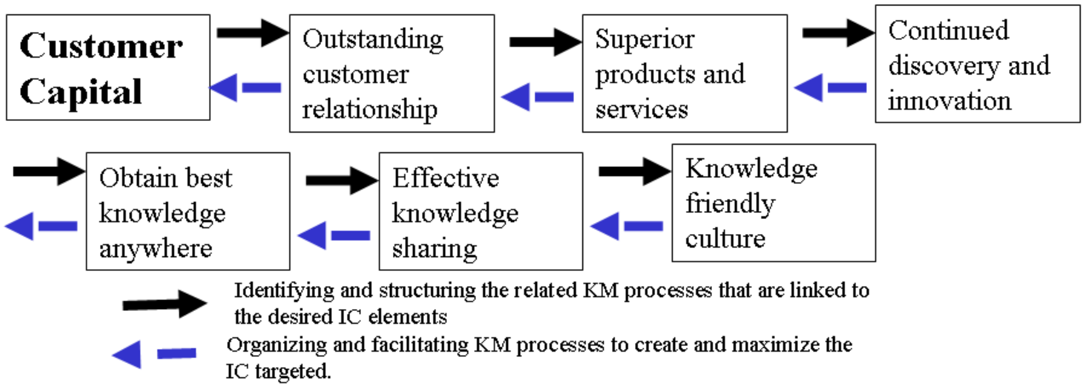
process, its intellectual resources, and the creativity of its workforce – its intellectual assets (Al-Ali N. A., 2003). Nevertheless, most of the intellectual capital assessment tools are based on a top-down approach which does not explore deeply into the particular business process and the specific knowledge needs. They measure the intellectual capital of an organization as the return on intangible assets covering Human Capital (HC) such as staff skills, innovativeness and work experience, Structural Capital (SC) such as IT systems, documents and patents, and Relationship Capital (RC) such as relationship with customers and suppliers. They aim at identifying useful knowledge that can create wealth for the organization and in assessing the performance and value creation process.

On the contrary, STOCKS (Strategic Tools to Capture Critical Knowledge and Skills) is a process-oriented and stock-taking knowledge audit approach that can be utilized for evaluating the knowledge healthiness of an organization. It focuses mainly on the identification and assessment of the knowledge inside the processes which is concentrated in the explicit knowledge items (e.g. part of SC) and part of the tacit knowledge items (e.g. part of HC), and gives a more credible overview of the knowledge inventory, including identification of knowledge workers, the level of codification and relative importance and the level of diffusion within the organization. Such detailed information is usually not available in the intellectual capital assessment approach. The STOCKS knowledge audit approach and the intellectual capital assessment methodologies serve different purposes but their functions can be complementary. Although STOCKS can only evaluate part of HC, SC and RC, the bottom-up approach of STOCKS supplements the top-down approach of intellectual capital assessment methodologies. Therefore, there is a potential to merge the two methodologies into one integrated assessment tool to present a comprehensive picture of knowledge management and intellectual capital management in an organization. In this study, the knowledge audit results were positive in obtaining a pool of useful data; the deliverables being the knowledge inventory, stakeholders' analysis, distribution of explicit knowledge, knowledge workers and knowledge in the tasks as well as the knowledge map. Intellectual Capital (IC) indicators were identified by the utilization of the knowledge audit results from the knowledge inventories. These IC indicators from the knowledge flow data can be used to reflect the "healthiness" of the studied KM processes. Such a "bottom–up" approach in building an IC value tree and then IC reporting for the Group Quality Assurance (GQA) Department is a first, in both academic and industrial worlds, and is the main or most significant contribution in this paper.

2. Relationship between knowledge management and intellectual capital

Knowledge management should be the first competency that an organization develops for intellectual capital management. Meanwhile, intellectual capital management and knowledge management differ from each other, but also complement each other. Due to the similarities and complementary aspects, Zou and Fink (2003) claimed that intellectual capital management and knowledge management should be linked to achieve added value, and must be integrated by combining knowledge management activities with intellectual capital elements to maximize the effectiveness. Wiig (1997) proposed that intellectual capital management should be considered at the strategic and top management levels, and Edvinsson (1997) and Wiig (1997) also mentioned the focus on value creation and extraction. However, knowledge management focuses on tactical and operational implementation of knowledge related activities. In general, knowledge management is concerned with knowledge creation, capture, transformation and use with an ultimate goal of developing an intelligent organization by creating and maximizing intellectual capital. Zhou and Fink (2003) provided an example which explains the relationship between knowledge management and intellectual capital, as shown in **Figure 1**. In order to maximize the relational capital, an organization might decide to develop an outstanding relationship with its customers, which is achieved by superior products and services. Therefore, the organization needs to keep ahead in the market by maintaining a program of continued discovery and innovation. Hence, the organization might focus on developing a knowledge friendly culture to enable effective knowledge sharing, as well as developing the best knowledge. By developing the appropriate linkages, knowledge management can be applied to contribute to the intellectual capital of an organization. By linking with knowledge management, the objective of maximizing intellectual capital can be achieved if knowledge activities are managed systematically and intensely. Roos et al. (1997) mentioned that the systematic approach requires management and measurement, so that organizations should measure what they want to manage as a part of the management agenda. Hence, Iazzolino G. and Pietrantonio R. (2005) recommended knowledge audits which can effectively support organizations in managing their own knowledge, achieving targeted objectives, as well as favoring the creation of intellectual capital valuing. The knowledge audit should focus on both the stock nature of knowledge, as it constitutes the intellectual capital of organizations, and the flow nature of knowledge, as it relates to the knowledge management activities within the business processes.



Aligning KM with IC: An example, Source: Adapted from Wiig (1997a). For a full diagram of the integration of selected characteristics between IC and KM, see Wiig (1997a, Figure 3, P. 404)

Figure 1: Relationship between KM and IC -an example (source: Zhou and Fink (2003))

3. Framework of research instrument design

An intellectual capital reporting method with a business process-oriented “bottom-up” approach is designed through a structured knowledge audit instrument, named STOCKS (Strategic Tools to Capture Critical Knowledge and Skills), and developed to overcome the shortcomings of traditional approaches in “top down” IC reporting models. The framework of process-oriented IC reporting is developed based on four considerations or perspectives, which are the Business and Quality Perspective, the Technological Perspective, the Knowledge Assets Conceptualization and the Cognitive and Behavioral Perspective, as shown in **Figure 2**.

Firstly, from the business and quality perspective, intellectual capital and knowledge management in a company should be linked to its strategic objective or business goal (Carlucci and Schiuma, 2006). To define the scope of a knowledge audit, the critical business process in supporting the business goal of the company should be first identified. The scope of the audit then needs to be aligned with the business goal, and as a result, the structured knowledge audit approach is designed to be a process-oriented tool.

Secondly, the knowledge models proposed by three different researchers, (1) Level of codification against Level of diffusion (Boisot, 1987), (2) Explicit against Tacit or Implicit knowledge (Polyani, 1966; Nonaka, 1994; Liebowitz and Beckman, 1998), and (3) Stakeholder resources against Structural resources (Schiuma and Marr, 2001), answer important questions such as how corporate knowledge is defined and classified. This then contributes to the knowledge assets conceptualization on the design of the structured knowledge audit questionnaires. The first model is the categorization of knowledge as explicit, tacit or implicit, which is still the most commonly used approach in knowledge management, as discussed by Polyani (1966), Nonaka, (1994), Liebowitz and Beckman (1998). The second one is defined by Schiuma and Marr (2001), which divides knowledge assets into stakeholder resources and structural resources. Boisot (1987) also proposed another level of codification and diffusion. One of the structured knowledge audit outputs makes good use of this matrix in order to reflect the nature of knowledge embedded in each task in a business process.

The third perspective of the framework is the technological dimension which deals with the data and information processing during the analysis stage of a structured knowledge audit. A large amount of data is collected from the audit process and subsequently analyzed so as to make appropriate recommendations to the company on the state of health of the knowledge management process.

Last but not least, the cognitive and behavioral perspective forms the basis of the major components of the interactive individual interview in the structured knowledge audit methodology. In this perspective, taxonomy building and social interaction are essential for employees to communicate, discuss and agree on the terminology, usage and importance of various knowledge items that support the business processes.

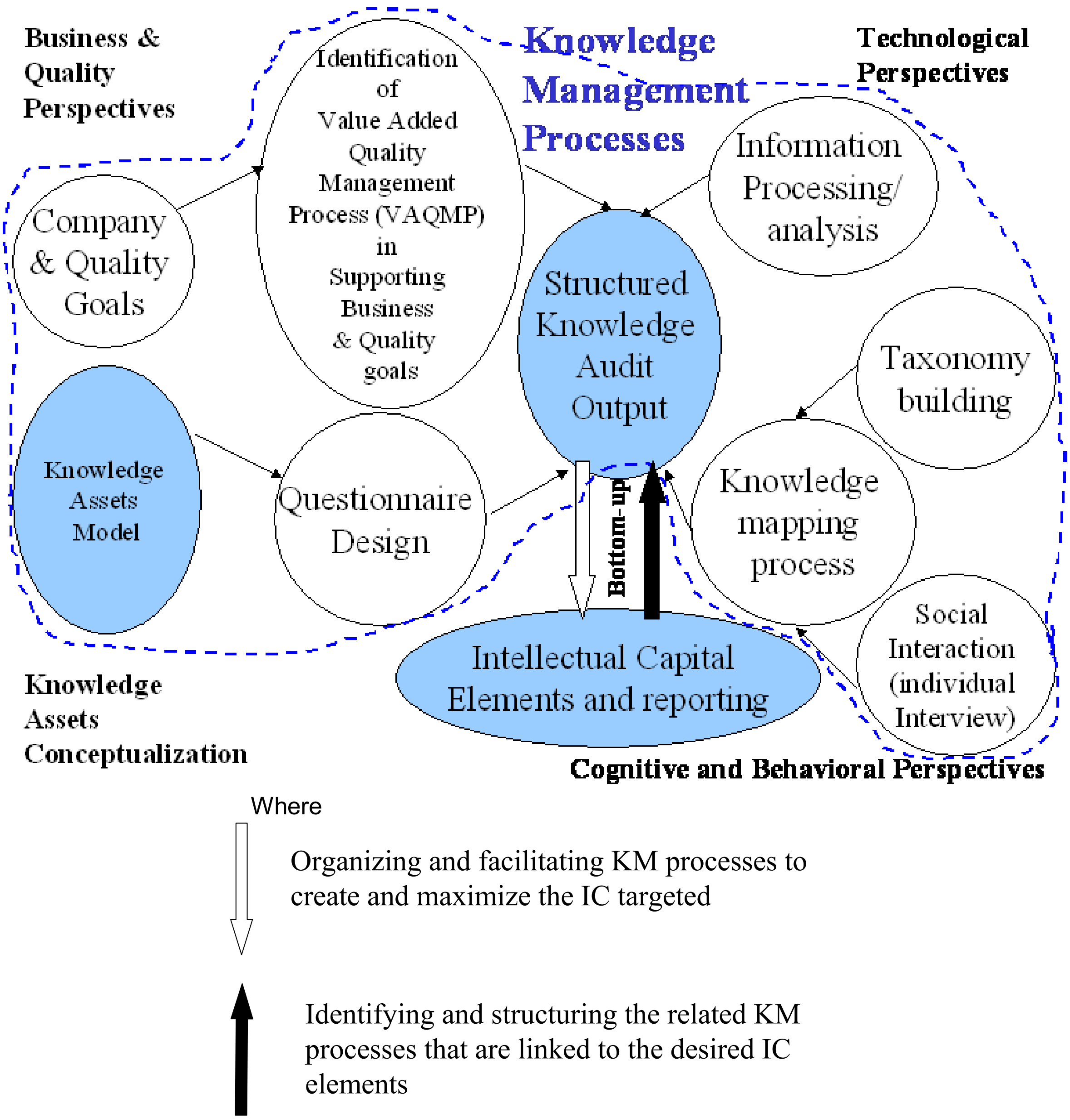


Figure 2: A design framework of an intellectual capital reporting method with structured knowledge audit on business process-oriented "bottom-up" approach the relationship between IC and KM, (source: adapted from Zhou A. Z., Fink D. (2003))

In this paper, the terminology of "Human Capital" (also referred to as human centered assets, employee competence), "Structural Capital" (also referred to as infrastructure assets, internal structure) and "Relational Capital" (also referred to as market assets, external structure and customer capital) are used for further discussion. Human Capital (HC) is defined as the combined knowledge, skill, innovativeness and ability of individual employees to complete the business process task. Human capital also includes value, culture and philosophy of an organization, but it cannot be owned by the organization (Edvinsson and Malone, 1997b). Structural Capital (SC) is defined as the hardware, software, database, organizational structure, patents, trademarks and other organizational capabilities that support the productivity of employees. Differing from human capital, structural capital can be owned by the organization (Edvinsson and Malone, 1997b). Relational Capital (RC) is the knowledge embedded in the relationships with any stakeholder that influences the organization. It is used to show the external structure and includes relationships with customers, suppliers and other stakeholders, as well as the importance of the external environment. It encompasses brand names, trademarks and image of the organization

In the New Economy Analyst Report (2001), Edvinsson explained that one of the intellectual capital components is people (Human Capital), and the other type of knowledge assets is what surrounding people in an organization, and is called Structural Capital. Structural Capital left behind when people are leaving, and it helps organizations in enabling their Human Capital to become more productive. People work smarter with Structural Capital, so it represents the value of an organization, and Edvinsson emphasized that "it is not financial capital, not human capital, but structural capital".

4. Research methodology

The design framework of an intellectual capital reporting method with a structured knowledge audit tool application is shown in **Figure 2**, and such structured knowledge audit tool is called Strategic Tools to Capture Critical Knowledge and Skills (STOCKS). This was further re-designed as well as applied in this research, and is outlined. The details of the knowledge audit for Value Added Quality Management Processes (VAQMP) in the corporate and plant level Quality Assurance Departments of a company called GPBI are described. STOCKS was adopted for conducting a knowledge audit in the case study at GPBI on six key quality management processes under VAQMP. Due to the practical approach and time arrangement, face-to-face individual interviews were conducted in phase 3 instead of the STOCKS workshop, and the STOCKS forms were filled in during the individual interviews. The modified seven phases of the STOCKS Knowledge Audit Approach were further developed into nine phases. The additional two phases are the identification of intellectual capital indicators and the construction of an IC value tree as well as IC reporting prior the recommendation phase for continuous quality improvement. With the findings and analysis results, an in-depth interview with selected staff was conducted for data validation. Comments on the use of knowledge and knowledge needs for the business processes were also collected from the stakeholders during the interviews. The aim was to get pertinent information and gain a deeper understanding of the stories behind the collected data before making any recommendations. The issues that should be achieved after the data validation include (i) Consensus and common understanding of the collected data and audit results, (ii) Making sense to the audit results, (iii) Increasing the accuracy of the results, (iv) Overriding of the results if it is needed, (v) Adding remarks to the amendments. The phases of application of the design framework are shown in **Figure 3.**

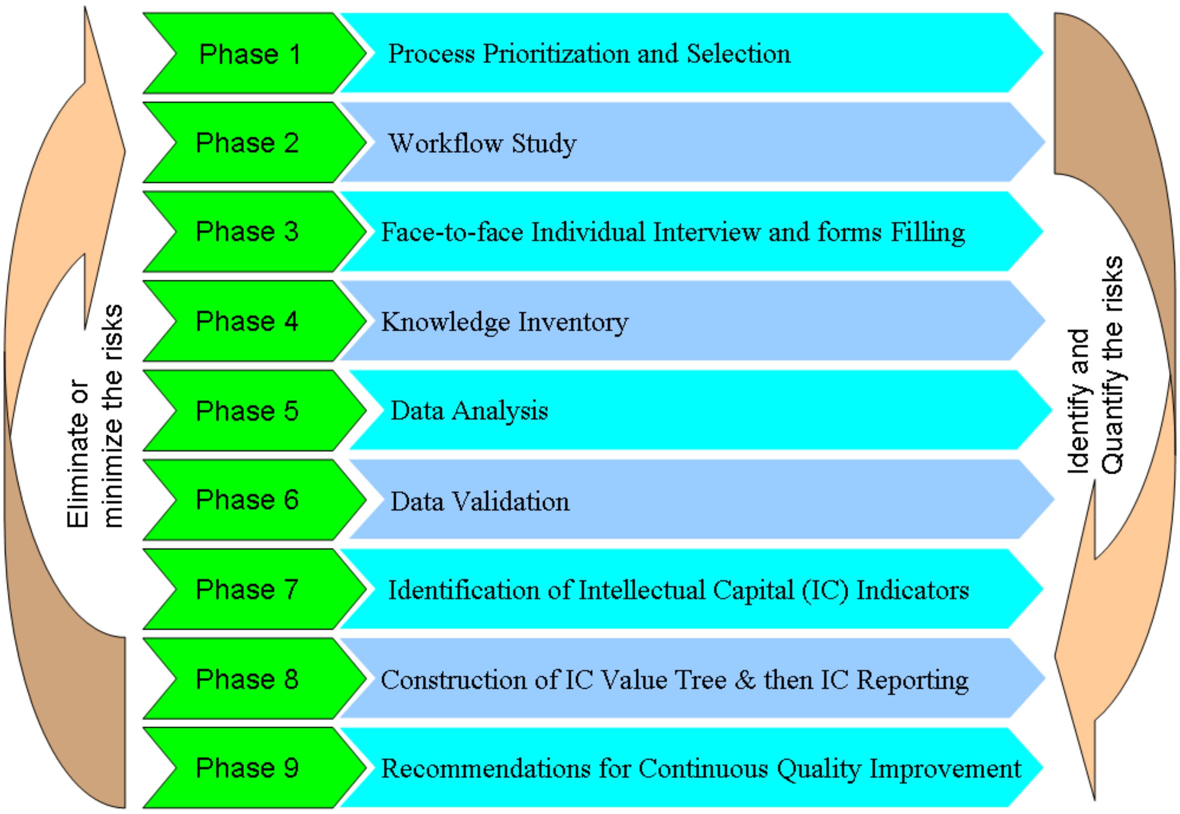


Figure 3: STOCKS is composed of seven phases (Lee et al., 2007) but phase 3 was re-designed in this research by face-to-face interviews instead of conducting a workshop together with the addition of phases 8 and 9 for IC elements identification and IC reporting respectively.

The STOCKS approach is designed as a process-oriented tool, so the critical business process in supporting the business goal should be first identified. The scope of the knowledge audit was focused on the six VAQMP categories which were identified by a knowledge café workshop among 16 plants' quality managers in the company. For each category, one of the key processes which can represent the respective category as a critical item is suggested for conducting the knowledge audit among the GQA team. According to the six defined key processes, as shown in **Figure 4**, the knowledge audit was conducted with reference to the respective Standard Operating procedures (SOP) in the studied company.

4.1 The deliverables of the knowledge audit

The aim of knowledge audit reporting is to elicit recommendations for review of the existing knowledge management strategy after conducting a knowledge audit. While analyzing the knowledge audit results, some targeted recommendations can be made in regard to the benefits from the knowledge management initiative. A complete knowledge audit report is produced based on the findings from the previous phases. The report outlines the existing status of knowledge assets, the knowledge maps; the plant effectiveness in accomplishing the six key VAQMP, the knowledge gaps as well as recommendations for the organization to drive for continuous improvement. In addition, based on the knowledge inventories, an IC Tree is constructed to define possible IC indicators, together with an IC statement for the GQA department.

4.2 The type of KM and IC tools being used

Besides the usage of the knowledge café and the STOCKS methodology, the knowledge maps in this research were generated through the application of IHMC CmapTools software which allows users to construct concept maps representing an understanding of the overall picture. The software facilitates the construction of large representations and allows for the establishing of other types of resources (e.g. images, videos, sound clips and text) that help explain and complement the information in the map. Knowledge maps visualize the knowledge flows and document the flows of the six VAQMP key processes in the audited plants. Social network analysis (SNA) was also used in this project by the generation of a social network map in each VAQMP from the audited plants, and the freeware Agna was used as a tool to generate the social network maps and sociometric status, after which, an IC value tree was also used.

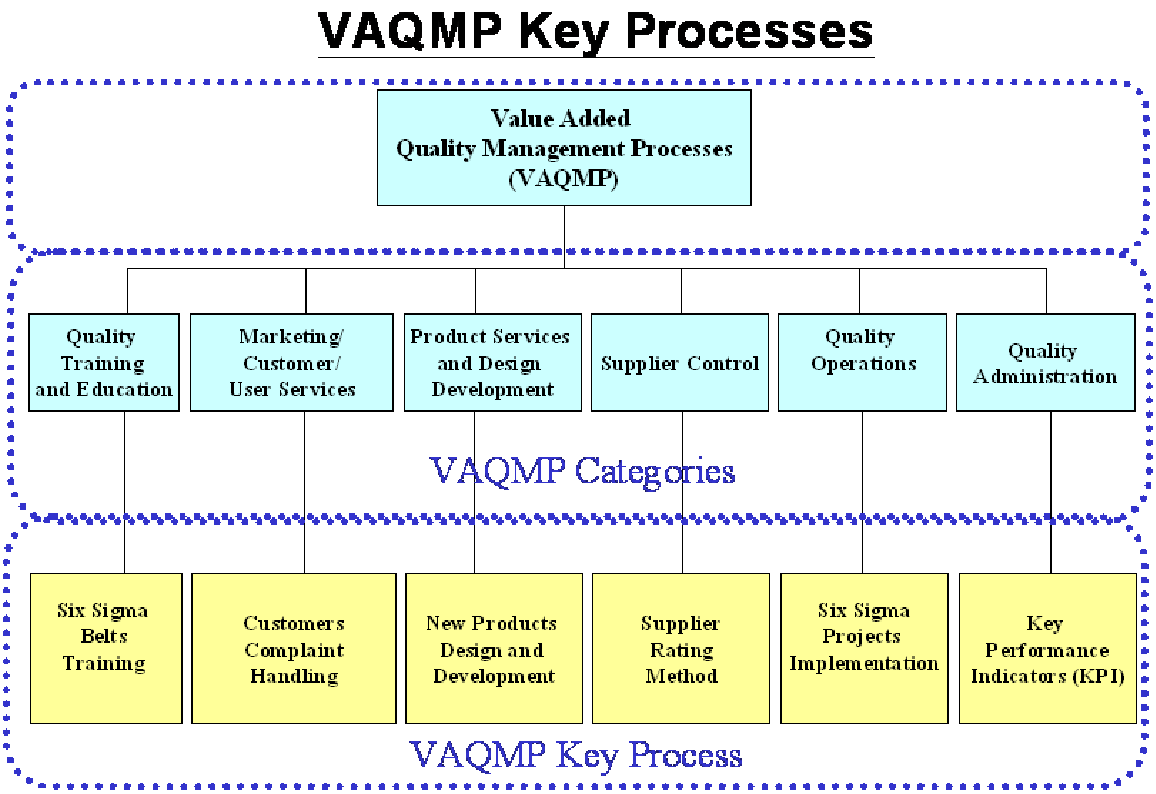


Figure 4: The six Value Added Quality Management Processes (VAQMP) key processes

5. Case study and discussion

5.1 Background of the company

The case study company, GPBI, is one of the leading battery manufacturers in the world. It supplies an extensive range of battery products to original equipment manufacturers and leading battery companies, as well as consumer retail markets under its own brand name. GPBI has been listed on the main-board of the Singapore Exchange Securities Trading Limited since 1991 and is currently a component stock of the Singapore Regional Index. Its production facilities are located in 5 cities and countries of Asia, supported by marketing and trading offices in 16 countries and cities in Asia, America and Europe. The GPBI Quality Assurance Departments of both Headquarters and the production plants have wide knowledge and expertise on quality related issues. Moreover, most of GPBI quality management processes are prevention-based and quality improvement-based, and such key processes are hereby named Value Added Quality Management Processes (VAQMP). In order to manage the knowledge among the VAQMP, knowledge audits have been conducted for assessing the knowledge assets.

This research project selected two GPBI production plants for identifying the knowledge assets and knowledge flows of the VAQMP through STOCKS knowledge audit methodology. The two plants are named DGCB and DGYF in the knowledge audits. The original STOCKS approach was modified because of the limitations and suitability, and the main difference was that face-to-face individual interviews were conducted instead of the STOCKS workshop in order to collect audit data. The application of design framework, with re-designed STOCKS is composed of nine phases which include process prioritization and selection, workflow study, face-to-face individual interviews and forms filling, building knowledge inventory, data analysis, data validation, identification of IC indicators, construction of IC value tree and IC reporting followed by recommendations for a knowledge management strategy of continuous quality improvement. Apart from time management, the face-to-face individual interview was one of the most challenging tasks in this project. The interviews also required the interviewer to be skilful in asking questions. For instance, tacit knowledge is related to un-codified and intangible items, such as experience and skills, and the participants should be guided to discover their know-how, which they may regard as common and normal, otherwise the audit data would be incomprehensive or incomplete, as the participants would be unable to provide the relevant information through the STOCKS forms. Therefore, the STOCKS interviewer needs necessarily to be well trained and familiar with the covered subject matter before the knowledge audit implementation. Moreover, the interviewer should minimize bias from personal opinions that may creep into the interview.

5.2 Results and discussion

74 staff, 4 corporate functions and 5 departments in two plants, from different work levels in six key processes from each plant, were involved in the knowledge audit. 52 STOCKS forms were filled in and 29 participants were interviewed.

5.2.1 Knowledge inventory

Knowledge inventory in STOCKS knowledge audit methodology was used to develop a comprehensive inventory of knowledge assets and to prioritize the assets through locating, describing and classifying the existing knowledge. Both explicit and tacit knowledge inventories were created after consolidating the data from the STOCKS forms.

Table 1 shows a summary of the explicit and tacit knowledge statistics for the six VAQMP key processes. Generally, the ratios of explicit knowledge (e.g. documents) to tacit knowledge (e.g. experience and skills) items were found to be 111:164 in DGCB and 127:200 in DGYF. This phenomenon is particularly serious in the VAQMP key process 2, involving customer complaint handling in both plants, where the number of tacit knowledge items is more than double the number of explicit knowledge items. It indicates that the amount of intangible knowledge assets was high, and an immense amount of knowledge assets would be lost when these knowledge owners leave the organization. A snapshot of knowledge inventories is shown in **Appendix 1**.

Table 1: No. of explicit and tacit knowledge items of six VAQMP key processes

VAQMP Key Processes	DGCB Plant		DGYF Plant	
	No. of tacit knowledge items	No. of explicit knowledge items	No. of tacit knowledge items	No. of explicit knowledge items
1. Six Sigma Belts Training	17	12	24	15
2. Customer Complaint Handling	53	22	37	18
3. New Product Design and Development	28	19	57	36
4. Supplier Rating Method	34	27	27	18
5. Six Sigma Project Implementation	13	12	22	19
6. Key Performance Indicator	19	19	33	21
Total	164	111	200	127

5.2.2 Stakeholders analysis

Stakeholder analysis in the STOCKS knowledge audit methodology was used to describe the processes in the departments that are likely to contribute to explicit and tacit knowledge. According to the knowledge inventories, the knowledge owners can be identified in each key process. The large stakeholder group may result in a high knowledge throughput. In this case, the major stakeholder groups of all VAQMP key processes were within GPBI and both audited plants, so the risk of knowledge leakage can be minimized. **Figure 5** shows the distribution of the stakeholders for one key process, and the results revealed the various dissimilarities in both audited plants, DGCB and DGYF.

5.2.3 Distribution of explicit knowledge

Distribution of explicit knowledge analysis in the STOCKS knowledge audit methodology is used to identify and classify the explicit knowledge items into five categories, which are common, critical, focus, abundant, and normal.

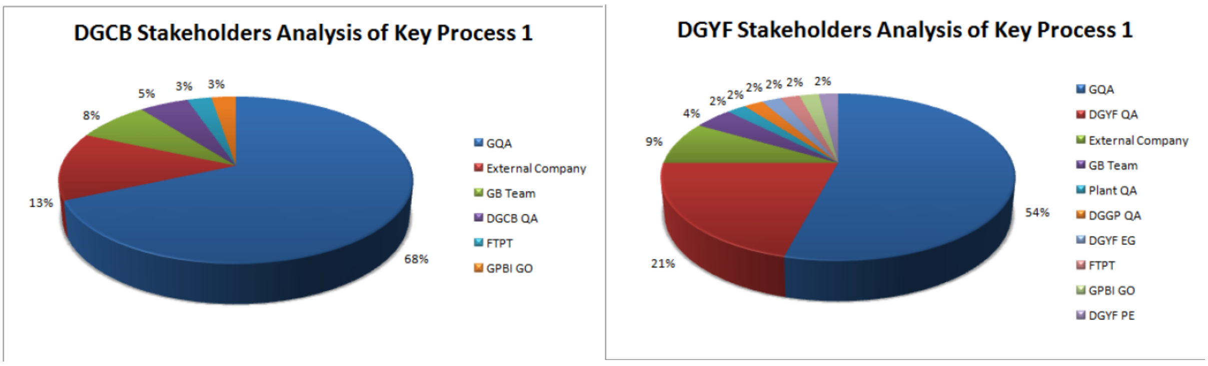


Figure 5: Stakeholders' analysis of six sigma belts training for the two knowledge audited plants

The classifications are based on the criteria of the number of users and average score for importance and frequency. The classifications are listed below:

- Common documents that are widely used by many users inside the process: the interviewed participants rate the average score in importance and frequency of those documents as mid-high.
- Critical documents are used by numerous users inside the process: the interviewed participants rate the average score for importance and frequency of those documents as high.
- Focus documents are used by few users inside the process only: the interviewed participants rate the average score for importance and frequency of those documents as high.
- Abundant documents are used by numerous users inside the process: the interviewed participants rate the average score for importance and frequency of those documents as low.

- Normal documents are used by several users inside the process: the interviewed participants rate the average score for importance and frequency of those documents as low.

Each classification category should be managed with different approaches according to the knowledge management initiative of the organization, but organizations should always concentrate on the critical knowledge. **Figure 6** shows the distribution of explicit knowledge of a key process in both audited plants in detail.

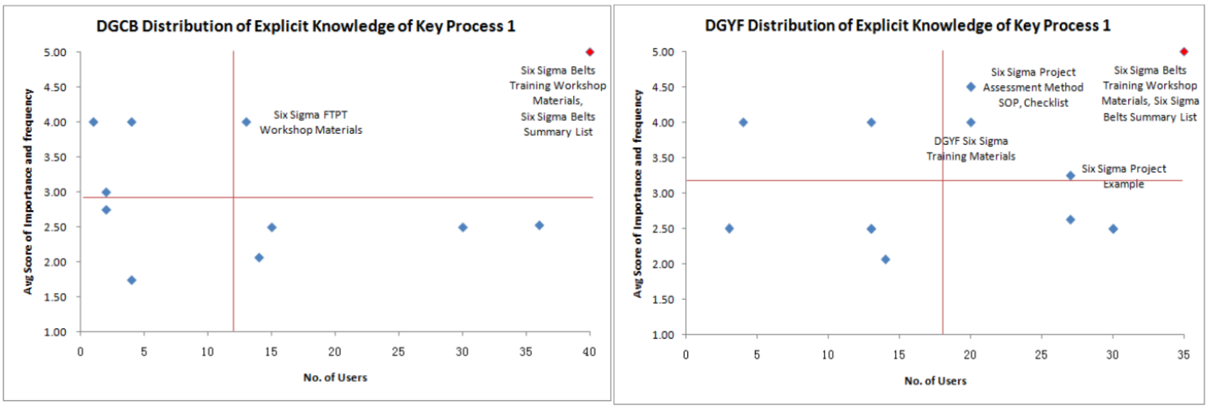


Figure 6: Distribution of explicit knowledge of six sigma belts training in two audited plants

5.2.4 Distribution of knowledge worker

Similar to the distribution of explicit knowledge, staffs involved in each key process are shown on a scatter chart based on the number of knowledge items they owned, together with their corresponding average score of importance and frequency. **Figure 7** shows an example of the distribution of each knowledge worker in the chart. It can be seen that people on the upper right corner that possess a greater number of knowledge items and higher scores are identified as the most critical knowledge workers in the process. Moreover, a beneficial insight for the management is the identification of critical knowledge workers who can contribute to mentoring programs.

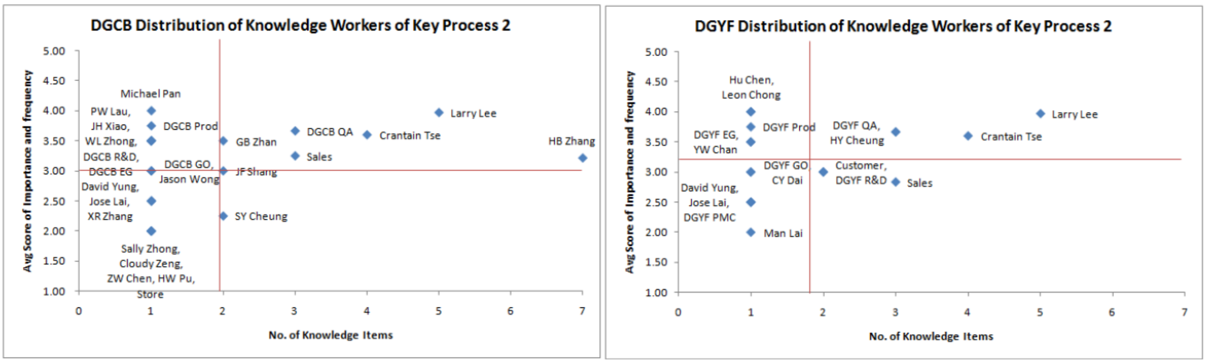


Figure 7: Distribution of knowledge workers of customer complaint handling process in two knowledge audited plants

5.2.5 Distribution of knowledge in the tasks

Distribution of knowledge in the tasks analysis in the STOCKS knowledge audit methodology aims to identify the knowledge fountain and the knowledge discovery point of the process and the knowledge needed to support the tasks in the key processes. All the audited key processes were reviewed task by task, hence the tasks of each key process were assessed based on two criteria, task uncertainty (the ratio of numbers of identified tacit to explicit knowledge items) and task interdependence (the number of shared knowledge involved in each task). According to Shek (2007), the task assessment results, as indicated in **Table 2**, show that the most valuable tasks for embedding knowledge management processes are identified as the Knowledge Fountain" and the"Knowledge Discovery Point". These tasks rely heavily on knowledge in the key processes and are the potential areas for developing knowledge management processes to capture and retain knowledge.

Table 2: Characteristic of knowledge fountain / knowledge discovery point source: Shek (2007)

	No. of Shared Knowledge	No. of Identified Document	Work Model
Knowledge Fountain	High	High	Collaborative
Knowledge Discovery Point	Low	High	Small Group/ Individual
	High	Low	Small Group/ Individual

Task interdependence indicates tasks that depend on the efforts of collaborative work. Therefore, a large amount of shared explicit and tacit knowledge items in a task would be regarded as collaborative work, otherwise it is considered as individual work if the explicit and tacit knowledge items are self-used only.

Figure 8 shows a chart of the distribution of knowledge in the tasks that classify the four typologies of knowledge assets which are based on the task uncertainty and the task interdependence. For instance, tasks that had a large ratio of codified knowledge items (e.g. explicit knowledge items) and involved a large ratio of shared explicit and tacit knowledge items (e.g. collaborative work) were classified as public knowledge and are shown plotted as the upper right quarter of the chart. **Figure 9** shows an example of the distribution of knowledge in the tasks in the two audited plants.

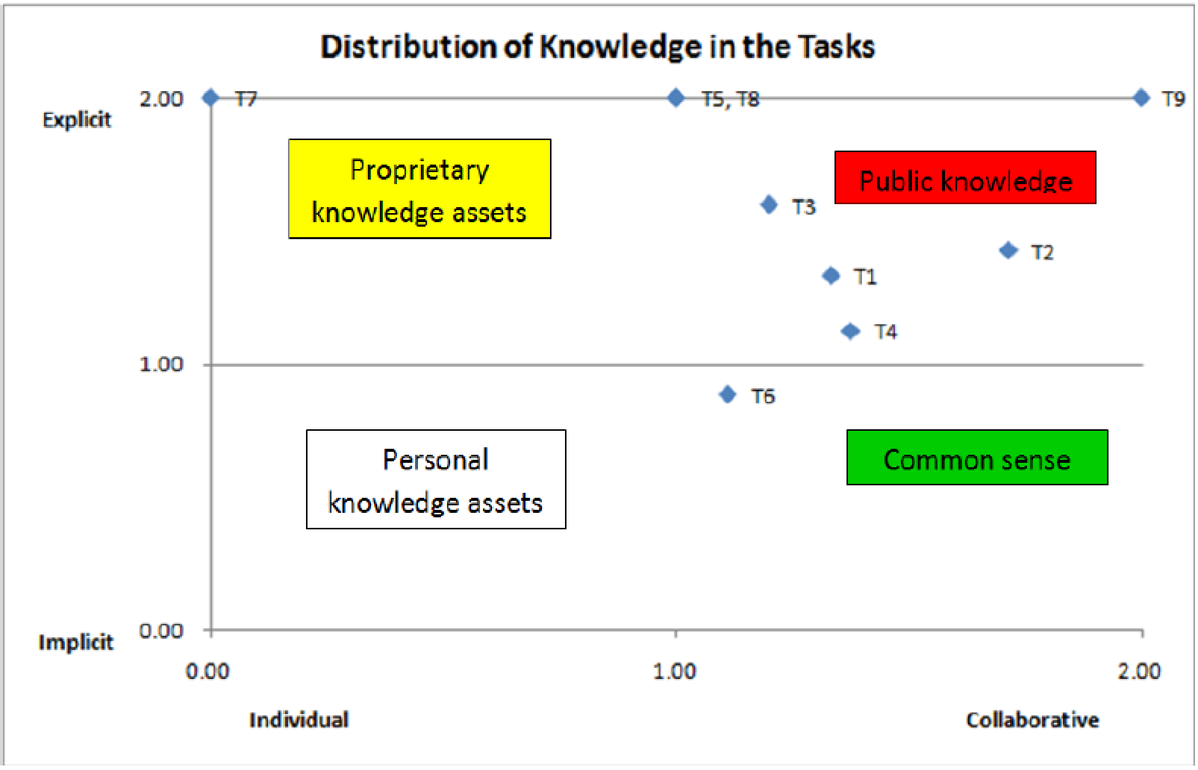


Figure 8: Example chart of distribution of knowledge in the tasks

5.2.6 Knowledge map

The details of the documents and knowledge as well as the corresponding ratings were incorporated into the explicit and tacit knowledge inventories. Therefore, knowledge maps can be compiled to show both the formal and informal networks of knowledge sharing. A knowledge map in the STOCKS knowledge audit methodology aims to visualize knowledge and document flows in the organization. A knowledge map shows the source and transmittance of knowledge within an organization. It links all the information to show the knowledge exchange path in daily operations and makes the key knowledge suppliers and customers visible. This visual display of captured information from the knowledge audit results uncovers the primary knowledge sources and users, models the current knowledge flows between knowledge stores and the process dynamics and understands the relationship and communication among different parties, both internally and externally. It helps to assess the knowledge culture of the organization as well as identifying conflicting or competing issues. **Figure 10** show an example of a knowledge map and a document map for the customer complaints handling process in the DGCB plant.

Task No.	Task Name
T1	GPBI Six Sigma Master Plan
T2	Six Sigma Yearly Plan for Plants
T3	Training Workshop Materials Preparation
T4	**Belts Training Workshop**
T5	Examination
T6	Six Sigma Project Coaching
T7	Six Sigma Project Closure
T8	Six Sigma Project Assessment
T9	Six Sigma Belts/Project Certification and Qualification

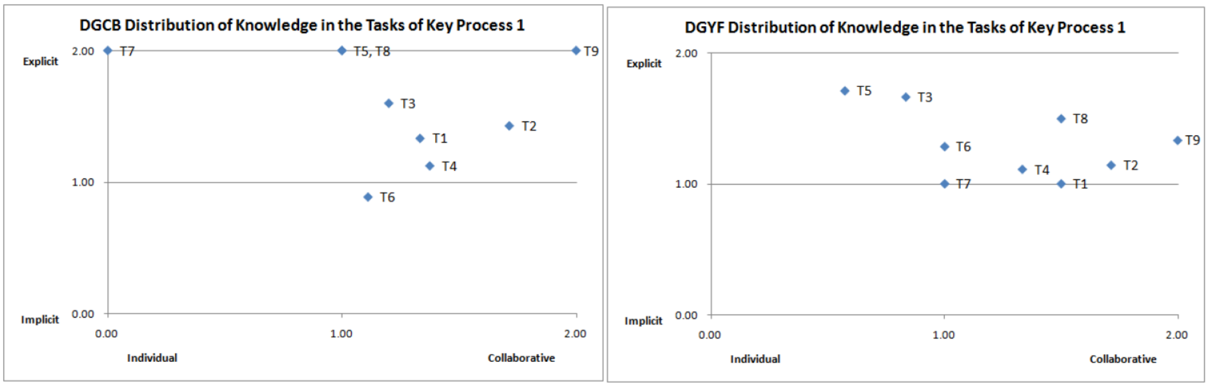


Figure 9: Distribution of knowledge in the tasks of six sigma belts training in two audited plants

5.2.7 Sociometric status

The sociometric status of each node of the social network is considered as weighted and directed. The sociometric status of a node is the sum of all its reception and emission degrees, relative to the number of all other nodes in the network. People with the maximum sociometric status are the key knowledge brokers, having the most knowledge connections with other parties. As shown in **Figure 11**, Social Network Analysis (SNA) can help in studying the communication relationships in groups, organizational analysis, and team building behavior of knowledge workers in the organization. Here, SNA can be used as an IC indicator to reflect the process culture and healthiness status, as shown in **Figure 12**.

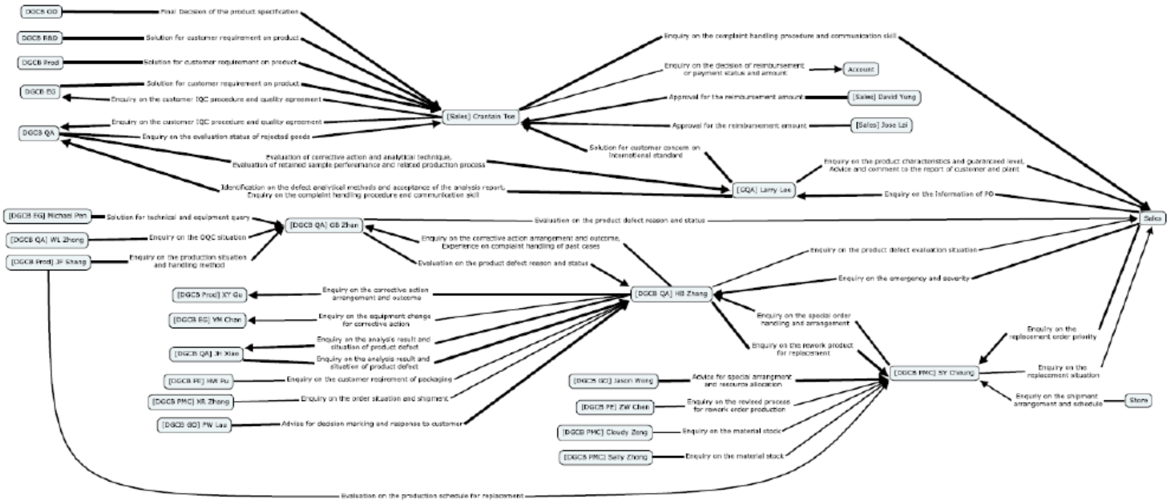
5.3 IC Report of Quality Assurance Department

5.3.1 IC value tree and IC reporting

Based on the knowledge inventories, for both explicit and implicit aspects, and the Intellectual Capital Model as described by Edvinsson and Malone (1997a), the six VAQMP key processes are compared in the two audited plants. Intellectual capital (IC) of a quality assurance department is defined according to the assessed contribution towards creating value for stakeholders in prevention of quality issues (problems/crisis) through VAQMP key processes. Eight IC indicators have been identified, with four indicators under structural capital, two indicators under human capital, and the remaining two indicators under relational capital. All the eight IC indicators are under the six VAQMP key processes. In addition, the IC indicators are calculated and shown in **Table 3**.

Distribution of Knowledge Map (VAQMP Key Process 2 - Customer Complaint Handling)

DGCB - Knowledge Flows



DGCB - Document Flows

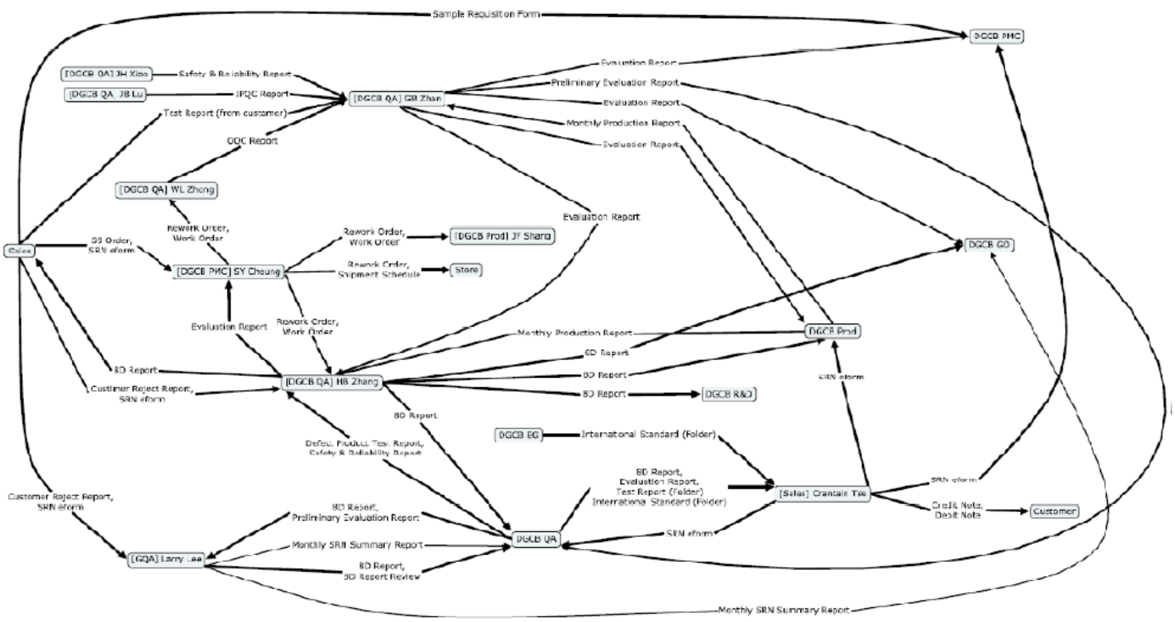


Figure 10: An example of knowledge map and document map for the customer complaints handling process in DGCB plant

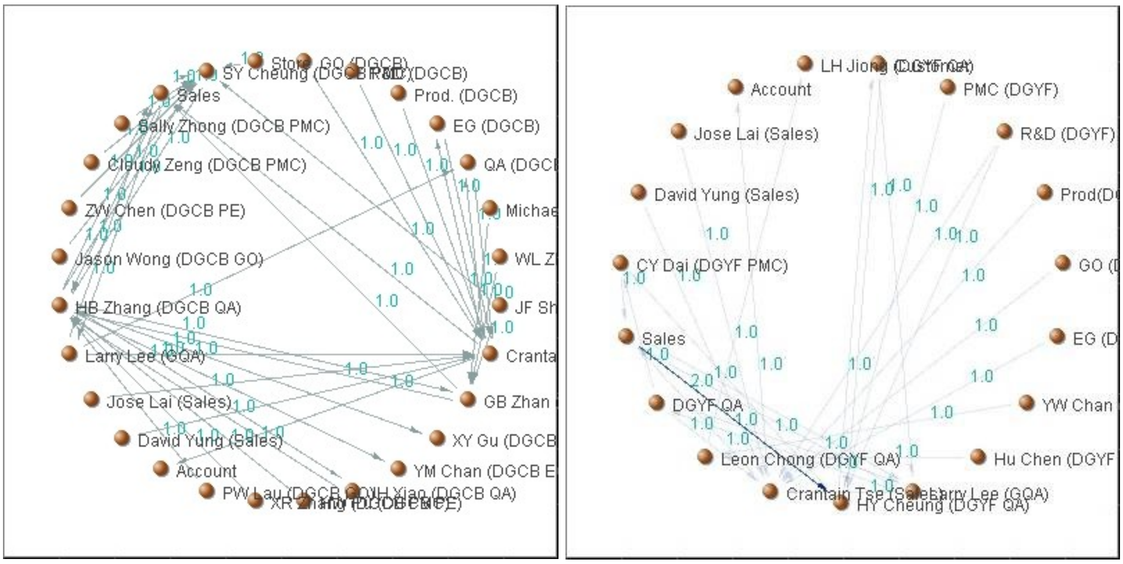


Figure 11: A snapshot of Social Network Analysis (SNA) for measuring the flow of knowledge in a customer complaint process in two studied plants

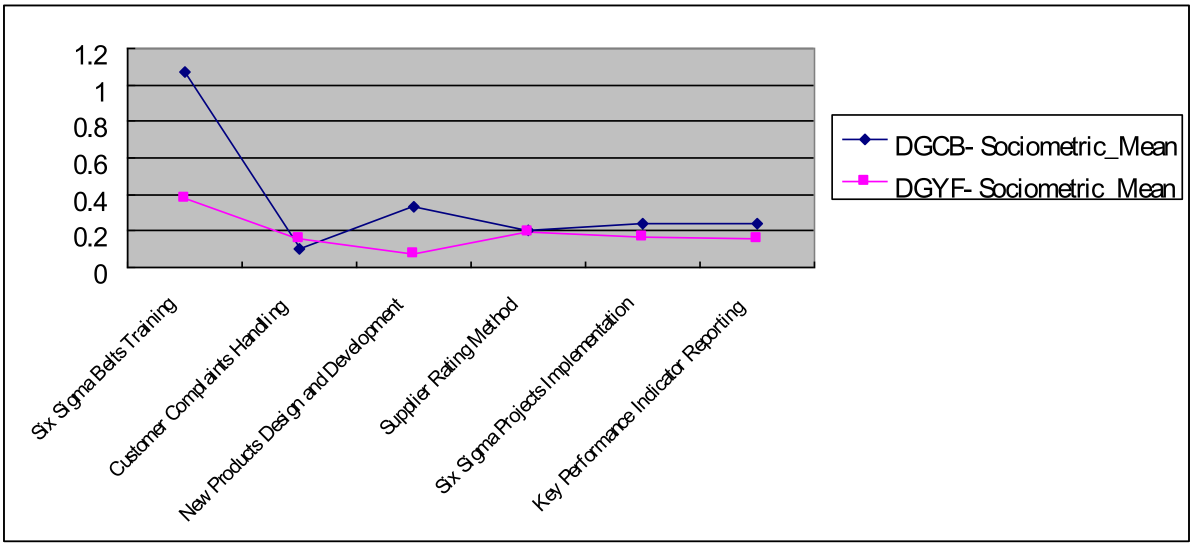


Figure 12: A comparison of sociometric status mean between two audited plants as an IC indicator to show the healthiness or culture of the communication relationship status on each VAQMP

An IC value tree has been constructed for the two studied plants as shown in **Figure 13**. After consolidation of all the IC indicators from each VAQMP, an IC report for the Quality Assurance Department for the two audited plants has been generated for IC reporting as well as for comparison purposes, as shown in **Table 4**. In addition, comparison of explicit and tacit knowledge items on the VAQMP key processes for the two studied plants is shown in **Appendix 2**.

5.3.2 Targets setting for IC indicators

This study shows to compare the same process among quality function in two different production plants. The comparison which shows the differences and similarities in each audited plant, in terms of IC indicators, provides a critical insight to the organization for intellectual capital management implementation and identification of knowledge asset in both headquarters and production plants from bottom-up approach. Therefore, a similar idea is generated to benchmark the same process in different workspaces or workgroups. It is beneficial to the management for identifying the best operating practice in knowledge and intellectual capital management aspects, so as to minimize the risks and losses from the department of the most knowledgeable and valuable employees. As the first important phase of the intellectual capital management initiative, such IC reporting should provide entire reflection of the process performance with comparisons. IC involves target setting by the comparison of baseline values of each plant, then selecting the best values for the organization to pursue, as shown in **Table 4**. In addition, the yearly IC policy of keeping, reducing or increasing the particular IC indicators is also specified in the same table.

Table 3: Identification and calculation of IC indicators under the six VAQMP key processes

Quality Assurance Department's IC Indicators generated from knowledge inventories from STOCKS knowledge audit

			Structural Capital				Relational Cpaital		Human Cpaital			
	VAQMP Category	No. of Knowledge Worker in each key process	Staffs Development Program	Knowledge Tasks	Design of IT infrastructure	Documented Procedures and Quality Records	Relations with Regulatory or Certification Bodies	Relations with External and Internal Stakeholders	Professional Knowledge, Know-how, Skills	Healthiness of Knowledge Sharing Culture (Sociometric Status)		
	Intellectual Capital (IC) Indicators' Formula	No. of persons involve in the KM process with "knowledge sharing and transferring"	No. of training item per Knowledge Worker	No. of knowledge tasks per Knowledge Worker	No. of IT sharing platform per Knowledge Worker	No. of document (SOP, WI, Report, Records, etc.) per Knowledge Worker	No. of agencies (or distributors) per Knowledge Worker	No. of stakeholders per Knowledge Worker	No. of tacit knowledge items per Knowledge Worker	mean	Standard Deviation	Relative Entropy (%)
DGCB Plant	1. Six Sigma Belts Training	6	0.5	1.5	0.166666667	1.67	0.666666667	1	2	1.0667	0.524934	8.068356
	2. Customer Complaint Handling	28	0.035714286	0.5	0.178571429	0.642857143	0.035714286	0.392857143	1.428571429	0.10582	0.128953	15.97639
	3. New Product Design and Development	12	0	0.916666667	0.25	1.25	0.166666667	0.583333333	1.916666667	0.33333	0.324257	14.80658
	4. Supplier Rating Method	17	0.058823529	0.529411765	0.176470588	1.529411765	0.294117647	0.529411765	1.588235294	0.20588	0.151228	8.776694
	5. Six Sigma Project Implementation	10	0	1	0.1	1.3	0	0.6	1	0.24444	0.252396	17.21969
	6. Key Performance Indicator	13	0	0.692307692	0.230769231	1.538461538	0	0.769230769	1	0.24359	0.220386	12.17744
	Overall for DGCB	86	0.058139535	0.720930233	0.186046512	1.186046512	0.139534884	0.569767442	1.453488372	0.26133		
DGYF Plant	1. Six Sigma Belts Training	11	0.454545455	0.818181818	0.090909091	1.363636364	0.363636364	0.909090909	1.090909091	0.38182	0.306944	12.44161
	2. Customer Complaint Handling	19	0.052631579	0.736842105	0.210526316	0.894736842	0.105263158	0.631578947	1.526315789	0.1579	0.142227	11.67416
	3. New Product Design and Development	37	0	0.297297297	0.081081081	1	0.027027027	0.405405405	1	0.07658	0.104016	15.34667
	4. Supplier Rating Method	16	0	0.5625	0.0625	1.0625	0	0.5	1.3125	0.19167	0.174603	11.63049
	5. Six Sigma Project Implementation	16	0	0.625	0.1875	1.25	0	0.6875	1.125	0.16667	0.156347	12.29263
	6. Key Performance Indicator	20	0	0.45	0.15	1.1	0	0.5	1.2	0.15263	0.127733	9.926564
	Overall for DGYF	119	0.050420168	0.521008403	0.12605042	1.075630252	0.058823529	0.554621849	1.18487395	0.15815		

5.3.3 Risk management for the IC elements

After generating the IC report for the quality department, the risk management items can be evaluated, like valuable knowledge can be stolen or lost, important knowledge workers might leave the enterprise, poor stakeholder relations might cause loss of clients or suppliers, and poor attention to regulatory/certification bodies might result in regulatory action against the enterprise. In order to reduce such potential risks, based on the IC management report, the company can improve data security, identify and protect commercial secrets, improve staff management for talent retention to prevent turnover, pay attention to the requirements of regulatory compliance and protect intellectual capital elements. Risk analysis and mitigation can be addressed through a list of the main risks identified, with an indication of their relative importance and a simple description of the measures the company intends to take to reduce risks. Continuous quality improvement and business process development by projecting and setting objectives in the future can be based on the outcome of the IC Report, as shown in **Table 4**, where measurable indicators are shown, giving an indication of the intention to raise, maintain or reduce the value of the elements.

5.3.4 Limitation of the research

Some of the assumptions may not reflect the whole situation in an organization. The studies described in this paper regarding intellectual capital reporting were only focused on VAQMP key processes but not the whole organization's business processes. With the huge amount of data from the STOCKS knowledge audit, rather than using a lot of manual time of data entry, the project team used supplementary software, "AutoSTOCKS" from the Hong Kong Polytechnic University, to consolidate the audit data systematically. The knowledge auditors need to be well trained and several practiced in the trial tests prior to conducting the formal audit. The organization needs to train-up quite a lot of knowledge auditors prior to extending such research to the whole organization.

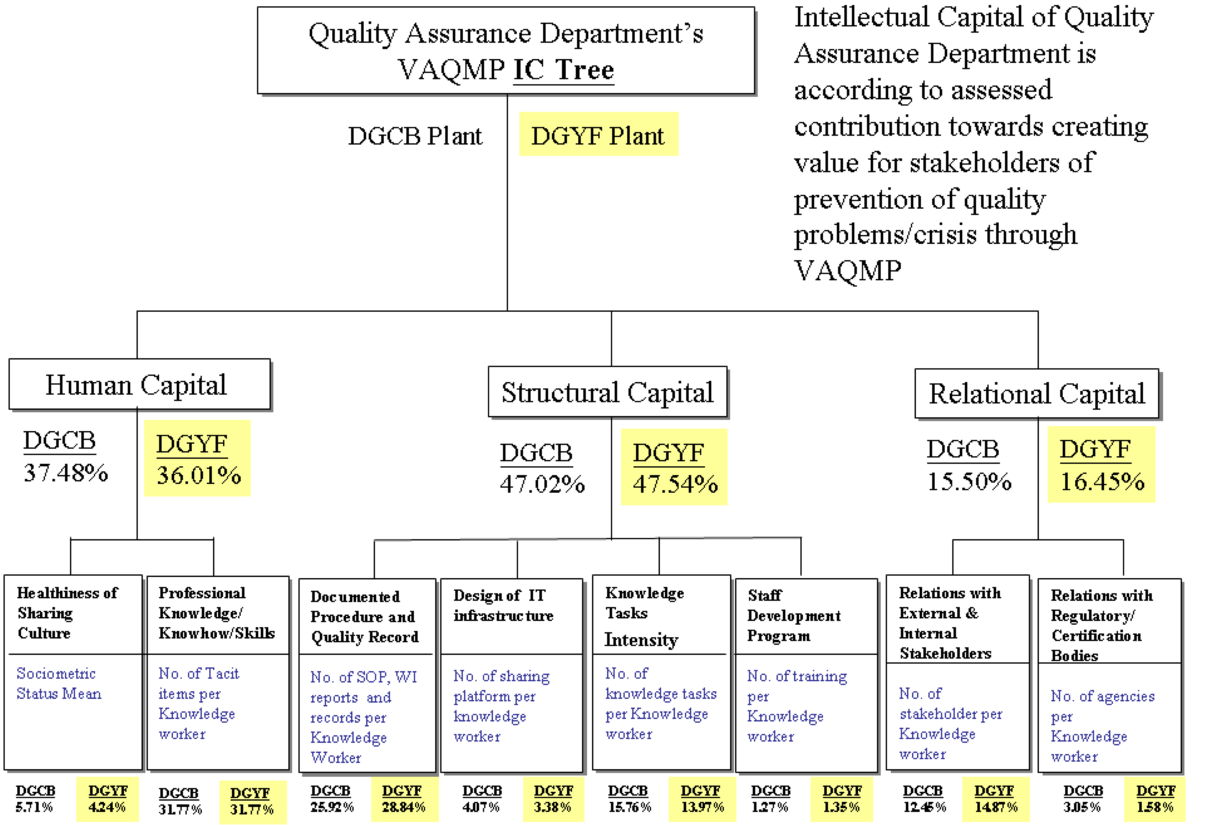


Figure 13: IC value tree and IC Indicators for IC reporting under VAQMP of Group Quality Assurance (GQA) department for two studied production plants.

Table 4: IC Report of IC indicators comparison and targets setting for the two studied plants

STOCKS IC Statement/Report for GQA Department for Year 2009/2010

	STOCKS IC Indicators on VAQMP key processes	Calculation Formula	Number in 2009/10		Target in 2010/11		2010/11 GQA Policy
			DGCB	DGYF	DGCB	DGYF	
Structural Capital	Staffs Development Program	No. of training item per Knowledge Worker	0.058	0.050	0.5	0.5	Increase
	Knowledge Tasks	No. of knowledge tasks per Knowledge Worker	0.721	0.521	1	1	Increase
	Design of IT infrastucture	No. of IT sharing platform per Knowledge Worker	0.186	0.126	0.2	0.2	Increase
	Documented Procedures and Quality Records	No. of document (SOP, WI, Report, Records, etc.) per Knowledge Worker	1.186	1.076	1.5	1.5	Increase
Relational Capital	Relations with Regulatory or Certification Bodies	No. of agencies (or distributors) per Knowledge Worker	0.140	0.059	Maintain	0.14	DGCB - Maintain, DGYF - Increase
	Relations with External and Internal Stakeholders	No. of stakeholders per Knowledge Worker	0.570	0.555	Maintain	Maintain	Maintain
Human Capital	Professional Knowledge, Know-how, Skills	No. of tacit knowledge items per Knowledge Worker	1.453	1.185	1	1	Reduce and to be codified into SC
	Healthiness of Knowledge Sharing Culture (Sociometric Status)	Sociometric Status Mean	0.261	0.158	Maintain	0.25	DGCB - Maintain, DGYF - Increase

6. Conclusion

Most of intellectual capital (IC) assessment tools are based on a “top-down” approach which does not explore deeply into the particular business process and the specific knowledge needs. In this study, six key Value Added Quality Management Processes (VAQMP), in two production plants in an electronic company, were selected for conducting structured knowledge audits with intellectual capital reporting from the “bottom-up”. A structured knowledge audit tool, STOCKS, was selected. STOCKS, refers to “Strategic Tools to Capture Critical Knowledge and Skills”, and is a process-oriented knowledge audit approach for evaluating the ‘knowledge health’ of an organization. Prior to the commencement of individual interviews, participants working in different departments and at different levels were invited to fill in various questionnaires to identify the frequency of use of IT platforms, document flows, knowledge flows and the corresponding knowledge sources, as well as the critical knowledge deployed in each task in the process.

Several analyses were then made, including stakeholders’ analysis, identification of critical explicit knowledge and the corresponding knowledge workers, the knowledge fountain of the process, as well as knowledge maps. These can show the Group Quality Assurance (GQA) department where to put more effort for knowledge management implementation. Based on all the standard findings and the analysis results from STOCKS, an additional comparison on the VAQMP was made to provide deeper understanding of the performance of the two audited plants in terms of STOCKS data rather than financial results. Intellectual Capital (IC) indicators were identified by the utilization of the structured knowledge audit results. These IC indicators from the knowledge flow data can be used to reflect the “healthiness” of the studied KM processes.

The bottom-up knowledge audit, with the IC reporting approach, helps to identify critical organizational knowledge that needs to be captured, and shared, for the healthy operation and sustainability of the quality management processes in order to prevent quality crises. Finally, after the consolidation of the explicit and implicit knowledge inventories, as well as constructing an IC value tree, an intellectual capital statement for the GQA department was generated from a bottom-up approach. In addition, based on the IC report, the GQA department can conduct risk management and set IC annual targets for continuous quality improvement in the company. Using such a bottom–up approach in building an IC value tree, and then reporting to the GQA Department, is a first in both the academic and industry worlds.

7. Further work

Since the knowledge audit with IC reporting approach should keep the knowledge assets under review, the system should allow the company or the plants to update the intellectual capital indicators as well as knowledge inventory on a regular basis. It is because the knowledge audit with IC reporting is only a snapshot of the key VAQMP processes. Any change in knowledge workers or knowledge assets will affect the original knowledge audit results. Therefore, it is recommended to link up such IC reports with the human resources system, for any change in knowledge workers or knowledge assets inside such key processes, and the knowledge audit with IC reporting exercise is recommended to be conducted again.

As a questionnaire-based knowledge audit tool, STOCKS should overcome the physical limitation for international organizations. It is difficult to gather staff from different regions to participate in the face-to-face individual interviews. Therefore, video conferencing can be applied to enhance the project execution by time saving in travel and better coordination. Integration of the knowledge audit tool and intellectual capital assessment tool can present a comprehensive picture of knowledge management and intellectual capital management in the organization. The bottom-up approach of such research can supplement the top-down approach of traditional intellectual capital assessment tools. Intellectual capital is all the knowledge, both tacit and explicit, in an organization which can be used to create value. Therefore, it is recommended to extend such a bottom-up approach of IC reporting methodology reported in this paper to other business processes in various departments, organizations and industries for further research and application.

8. Appendix 1: A snapshot of knowledge inventories

A Snapshot of Explicit and Tacit Knowledge Inventories of Customer Complaint Handling Process in DGCB and DGYF plants respectively

Explicit Knowledge Inventory (DGCB VAQMP Key Process 2 - Customer Complaint Handling)

Document Name	Task(s)	Document Format	Where From: People	Where From: IT Tools / Platforms	Major Users	Average Score
8D Report	Evaluation result preparation and submission	pdf	DGCB QA	Email, SRN e-platform	Crantain Tse (Sales)	5
8D Report	Evaluation result preparation and submission Decision on valid or invalid case	excel, pdf	HB Zhang (DGCB QA)	Email	DGCB GO	5
8D Report	Evaluation result preparation and submission Decision on valid or invalid case	excel, pdf	HB Zhang (DGCB QA)	Email	DGCB Prod	5
8D Report	Evaluation result preparation and submission Decision on valid or invalid case	excel, pdf	HB Zhang (DGCB QA)	DGCB QA Shared Drive	DGCB QA	5
8D Report	Evaluation result preparation and submission	pdf	Larry Lee (GQA)	Email	DGCB QA	5
8D Report	Evaluation result preparation and submission Decision on valid or invalid case	excel, pdf	HB Zhang (DGCB QA)	Email	DGCB R&D	5
8D Report	Evaluation result preparation and submission	pdf, word	DGCB QA	Email, SRN e-platform	Larry Lee (GQA)	5
8D Report	Evaluation result preparation and submission Decision on valid or invalid case	excel, pdf	HB Zhang (DGCB QA)	SRN e-platform	Sales	5
8D Report	Evaluation result preparation and submission	pdf	Larry Lee (GQA)	Email	Sales	5
8D Reports Review	Evaluation result preparation and submission	email	Larry Lee (GQA)	Email	DGCB QA	5
Customer Reject Report	Customer Complaint Notice	email	Customer (External Company)	Email	Crantain Tse (Sales)	4.59
Customer Reject Report	Customer Complaint Notice SRN Creation	pdf	Sales	SRN e-platform	HB Zhang (DGCB QA)	4.59
Customer Reject Report	Customer Complaint Notice	pdf, word	Sales	SRN e-platform	Larry Lee (GQA)	4.59
Defect Product Test Report	Evaluation result preparation and submission	excel	DGCB QA	DGCB QA Shared Drive	HB Zhang (DGCB QA)	4
Evaluation Report	Evaluation of rejected goods	pdf	DGCB QA	Email, SRN e-platform	Crantain Tse (Sales)	4.88
Evaluation Report	Evaluation result preparation and submission	pdf	GB Zhan (DGCB QA)	Email	DGCB GO	4.88
Evaluation Report	Evaluation result preparation and submission	pdf	GB Zhan (DGCB QA)	DGCB QA Shared Drive, Email	DGCB PMC	4.88
Evaluation Report	Evaluation result preparation and submission	pdf	GB Zhan (DGCB QA)	Email	DGCB Prod	4.88
Evaluation Report	Evaluation result preparation and submission	pdf	GB Zhan (DGCB QA)	DGCB QA Shared Drive, Email	HB Zhang (DGCB QA)	4.88
Evaluation Report	Preparation of work order Replacement	word, excel	HB Zhang (DGCB QA)	Email, SRN e-platform	SY Cheung (DGCB PMC)	4.88
International Standard (Folder)	Evaluation result preparation and submission Notification in writing and settlement suggestion to customer	pdf	DGCB QA	Email	Crantain Tse (Sales)	4
International Standard (Folder)	Evaluation result preparation and submission Notification in writing and settlement suggestion to customer	pdf	DGCB EG	Email	Crantain Tse (Sales)	4
IPQC Report	Evaluation result preparation and submission	excel	JB Lu (DGCB QA)	DGCB QA Shared Drive, Email	GB Zhan (DGCB QA)	5

Tacit Knowledge Inventory (DGCB VAQMP Key Process 2 - Customer Complaint Handling)

Department	Knowledge Owner	Knowledge Item: Level 1	Knowledge Item: Level 2	Task (s)	Communication Channel	Major Knowledge Customers	Score Average
DGCB R&D	DGCB R&D	Product Specification	Solution for customer requirement on product	Evaluation result preparation and submission	Telephone, Email	Crantain Tse (Sales)	3.5
Sales	David Yung	Reimbursement Approval	Approval for the reimbursement amount	Preparation of credit note to customer and debit note from customer	Face to Face	Crantain Tse (Sales)	2.5
Sales	Jose Lai	Reimbursement Approval	Approval for the reimbursement amount	Preparation of credit note to customer and debit note from customer	Face to Face	Crantain Tse (Sales)	2.5
Sales	Sales	Complaint Handling Skill	Enquiry on the emergency and severity	Customer Complaint Notice	Telephone, Email	HB Zhang (DGCB QA)	3.25
Sales	Sales	Product Traceability	Enquiry on the information of PO	Customer Complaint Notice	Email	Larry Lee (GQA)	3.25
Sales	Sales	Replacement Arrangement	Enquiry on the replacement order priority	Preparation of work order Replacement	Telephone, Email	SY Cheung (DGCB PMC)	3.25
DGCB GO	DGCB GO	Product Specification	Final Decision of the product specification	Evaluation result preparation and submission	Telephone, Email	Crantain Tse (Sales)	3
DGCB GO	Jason Wong	Emergency Plan	Advice for special arrangement and resource allocation	Intervention from plant management Decision on valid or invalid case Preparation of work order Replacement	Telephone, Email	SY Cheung (DGCB PMC)	3
DGCB GO	PW Lau	Complaint Handling Skill	Advise for decision marking and response to customer	Intervention from plant management	Face to Face	HB Zhang (DGCB QA)	3.5
DGCB PMC	SY Cheung	Replacement Arrangement	Enquiry on the replacement situation	Replacement	Telephone, Email	Sales	2.25
DGCB PMC	SY Cheung	Replacement Arrangement	Enquiry on the special order handling and arrangement	Preparation of work order Replacement	Telephone, Email	HB Zhang (DGCB QA)	2.25
DGCB Prod	DGCB Prod	Product Specification	Solution for customer requirement on product	Evaluation result preparation and submission	Telephone, Email	Crantain Tse (Sales)	3.75
DGCB QA	GB Zhan	Failure Analysis	Evaluation on the product defect reason and status	Evaluation of rejected goods Evaluation result preparation and submission	Face to Face, Telephone, Email	HB Zhang (DGCB QA)	3.5
DGCB QA	GB Zhan	Failure Analysis	Evaluation on the product defect reason and status	Evaluation of rejected goods Evaluation result preparation and submission	Telephone, Email	Sales	3.5
DGCB QA	HB Zhang	Corrective Action	Enquiry on the corrective action arrangement and outcome	Evaluation of rejected goods Evaluation result preparation and submission	Face to Face, meeting	GB Zhan (DGCB QA)	3.22
DGCB QA	HB Zhang	Corrective Action	Enquiry on the corrective action arrangement and outcome	Evaluation result preparation and submission Decision within twenty one days Intervention from plant management Decision on valid or invalid case	Telephone, Email	XY Gu (DGCB Prod)	3.22
DGCB QA	HB Zhang	Corrective Action	Enquiry on the equipment change for corrective action	Evaluation result preparation and submission Decision within twenty one days Intervention from plant management Decision on valid or invalid case	Telephone, Email	YM Chan (DGCB EG)	3.22

9. Appendix 2: Comparison of Value Added Quality Management Processes (VAQMP) of two studied plants

Apart from the Intellectual Capital indicators comparison and analysis results, the overall analysis of the six VAQMP key processes in both audited plants was compared under two criteria, which are the number and average importance score of explicit and tacit knowledge items. The utilization of STOCKS with six key processes in two different production plants for comparison can provide deeper understanding of the performance in term of STOCKS knowledge audit data rather than the financial results. Furthermore, the comparison would be also based on company profile of the two audited plants. In the knowledge management aspect, the discussions of the comparison results provided another perspective for the management to reveal the actual working performance among the production plants. **Figure 14** shows the comparisons of the number and average importance scores of explicit and tacit knowledge items in the two audited plants.

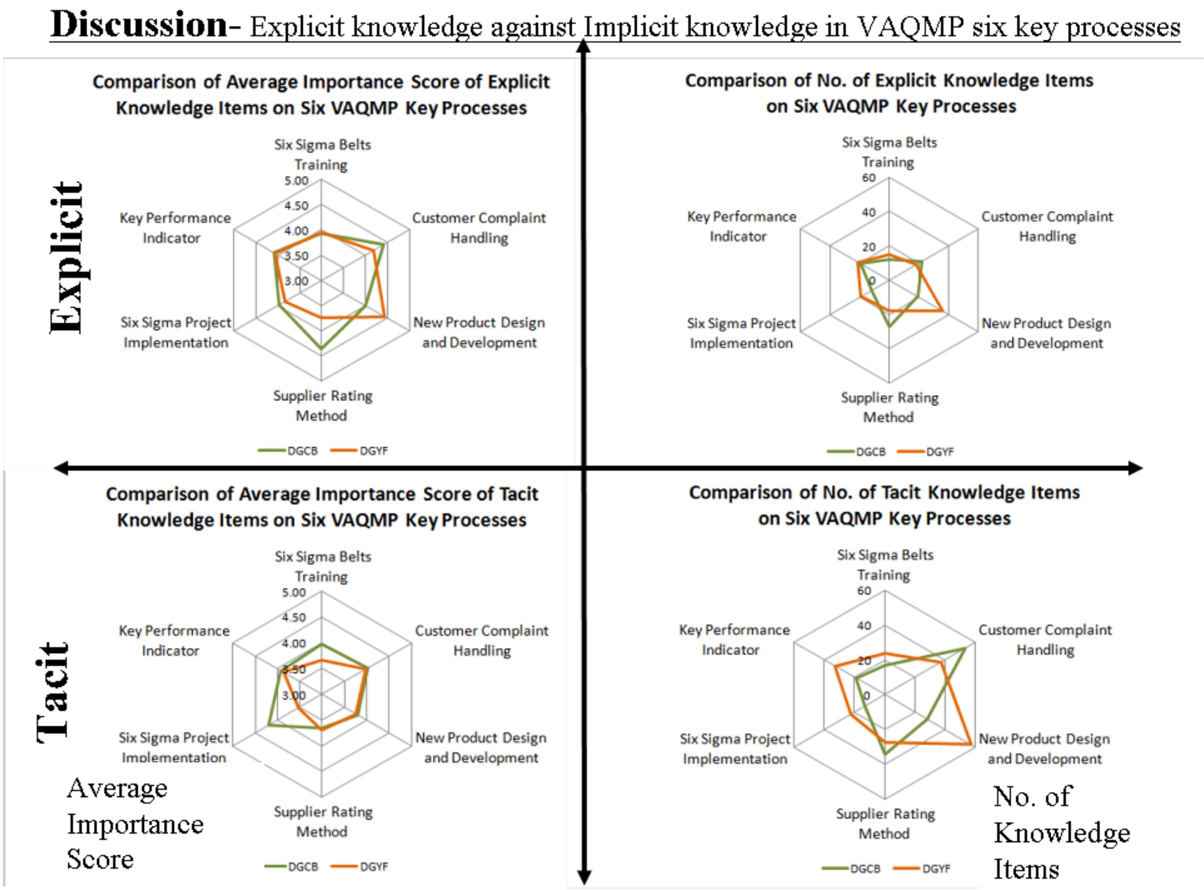


Figure 14: Comparisons of the number and average importance score of explicit and tacit knowledge items in the two audited plants.

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