TACIT KNOWLEDGE VISUALIZATION THROUGH ORGANIZATIONAL EXPLICIT KNOWLEDGE WAREHOUSES: A PROPOSAL FOR RESEARCH METHODOLOGY DESIGN AND EXECUTION

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─Abstract ─

Knowledge visualization can be used in several fields from medical imaging to industrial engineering. Although there could be variety of applicable research areas, our consideration will be the tacit knowledge visualization in organizations. This proposal aims to suggest a study to develop a tacit knowledge visualization framework to support know-where requirements of the organizational knowledge. With the implementation of our framework in a software application, it is aimed to create a virtual environment, where subject-based knowledge requirements will be answered by the visualized tacit knowledge of individuals and possibly the relations among individual members of the organization.

Key Words: *Knowledge visualization, tacit knowledge, research methodology design*

JEL Classification: D83 - Search; Learning; Information and Knowledge; Communication; Belief; M15 - IT Management

1. INTRODUCTION

In general terms, Knowledge Visualization can be defined as the visualization of cognitive aspects of a subject for the individual perspective. Then Tacit Knowledge can be understood as the individual cognitive knowledge, which is hard to explain, and Explicit Knowledge can be understood as codified, documented knowledge, which is easily accessible in organizational base.

In the history, there were different visualization techniques, for example the technique that was given in the study of Dalbello and Spoerri (2006). In nineteenth century, the books provided the basic tools for visualized information and knowledge. The relations and visualized information were done through shapes. It can be admitted that in present there are similar tools, with different

perspective of visualization, like given in Boyak et. al. (2002). The visualization was done like a topographic map.

Recently, different technological applications to support information and knowledge visualizations are becoming more available. However, in the literature, given knowledge visualization applications are mostly generic and the given systems stay on a level of visualization which tries to implement every kind of relations within a general structure, forcing the researcher away from the real requirements of what is really needed to visualize.

Besides, the given systems for visualization are generally based on mostly data mining tools. However, having acknowledged that, these systems still stay for the static datasets. Static datasets can be seen as a good base for explicit knowledge gathering, but they are far away to be a good answer for tacit knowledge utilization.

Accordingly, how the tacit knowledge structure of the organization could be visualized with the existing explicit knowledge warehouse of the organizations is the major research question we have. Whether the visualized tacit knowledge structure could be implacable to a different organization with a different knowledge structure is another research question that complements this major one.

With respect to these definitions, explanations, understandings and questions; the purpose of this study is to propose an intelligent framework dynamic and specifiable for visualizing the tacit knowledge structure of the organizations from the perspectives of individual members and their relationship between each other, and explicit subject bases. So first of all, it is needed an integrated concept for tacit and explicit knowledge visualization. Another point that deserves attention is the requirement of displaying a more dynamic structure. Because our concern is related with the cognitive content, a dynamic human related approach, and a system that could understand and guess the tacit knowledge of the organization members is needed.

After this introduction, the next part will present a brief overview of the theory and related studies of the knowledge visualization. Then, the information on research design and methodology, as well as the proposed framework design as the result of the possible execution of the methodology will be provided.

2. BRIEF OVERVIEW OF STUDIES ON KNOWLEDGE VISUALIZATION

Information visualization tends to address organizing and displaying complex information structures for the cognitive understanding of the human beings. (Card, Macinlay&Shneiderman, 1999). Meanwhile, according to Eppler and Burkhard (2004) this concept can be defined as the "use of visual representations to improve the creation and transfer of knowledge between people". The cognitive understanding for information visualization then highlights also these more intangible, tacit aspects as the creation and transfer of knowledge, demanding a combined concept for information, tacit and explicit knowledge visualization.
When we consider the knowledge visualization tools, most of them concentrates on Card's definition, visualization on information level (Boyak, Wylie & Davidson, 2002) (Jurasic & et al,

1998) (Wong & et. al,2006) (Wong & et. al, 2009). On the other hand, some visualization applications are directly related with explicit-to-tacit knowledge transformation (Hou&Tsai, 2008).

Various visualization systems have been used for the purpose of decision support like in Mansmann and Vinnik (2006). In this study, the main concern was the intrusion detection in a university gateway. System works on a online analytical processing (OLAP). Most of the OLAP tools are defined under business intelligence (BI) systems which are also categorized as decision support systems (DSS). Using OLAP tool under intrusion detection was an interesting idea, which requires dynamic data analyses, which, in fact, could be applicable in tacit knowledge visualization. Individual knowledge also evolves and declines with time, so following up this type of a dynamic structure is required.

After pre-processing of the explicit knowledge warehouse, how we can visualize system findings can be found, for instance, in the work of Hou and Tsai (2008). In this study, documentation of the computer assembly procedures are visualized with Virtual Reality Modeling Language (VRML). The idea is simple, a person can better learn with visualized aid rather than reading full documentation. With its possible natural language independency, the study underlines the potential for tacit knowledge visualization. However, their proposed system is mostly proper for virtualized information, not visualized ones.

In Dominguez et. al. (2007) study, for the visualization, the system uses a three layer structure: client, host and data-warehouse layers. Artificial Intelligence is created in the database layer which is composed of a database and a logic system. Logic system has a self learning mechanism via artificial neural network that is using Self Organizing Maps (SOM). This is important, because in the database, according to the gathered data-set information, these sets are organized by themselves, and with the relationship in each dataset (in here we can say clusters), they create information maps. The given system was created for a supervision system which is based on procedural knowledge of a production environment. However, the study focuses on explicit knowledge, and the tacit, cognitive part is missing.

SOM can be a basic technique for the construction of the framework. However, there are always minor possibilities where SOM could fail for visualization. For this reason, other data mining techniques could be needed, such as K-Means or DBSCAN. In Gupta et. al. (2010), an unsupervised clustering method is used and for its visualization, especially DBSCAN is used for creating different clusters.

Studies such as Jurisica et. al. (1998), Wong et. al. (2006) and Hou et al. (2008) then provide cases that applicability of created frameworks can be observed in various domains. Sloane (2007) also studied the knowledge that was required for the software projects. An experiment was conducted based on a framework. In this framework, based on the requirements of software projects' each step, there could be different knowledge requirements arising. Actually, this is important because this system is based on the cognitive knowledge of the individuals. Meanwhile, the study of Herrero (2010) gives us a knowledge based system. This system is based on the qualitative data of the organization, and this data is processed through Cooperative Maximum Likelihood Hebbian Learning (CMLHL) model. Also this study highlights the need of multidisciplinary study for this kind of study. In Jeong (2010)’s study, visual analytical systems are included for the tacit and

explicit knowledge visualizations perspectives as a significant development for visualization studies and applications.

The dataset itself may cause problem with its structure. A dataset comes from a warehouse could bring redundant data, noise and missing data with itself. When building relationships, this could cause missing relationship, even worse relationship with loops which has no connection between other beginning and end of the visualized structure. In Kang et. al. (2008), a visualization system is used to find and visualize these abnormal and unexpected structure inside. When it is tried to extract tacit knowledge in explicit knowledge warehouses, similar problems could arise, and application of this concept could be helpful to address these problems.

Another important issue is handling the number of relations among entities for the knowledge visualization to address any possibility in real life. In a given problem domain, we can accept n as the total number of dimensions that reflects individuals' total number of tacit knowledge subjects, m as related dimensions, when problem arises, and k as number of individuals in the organizations. Then, an optimistic probability could require k*m (n>m) relationships in a considered subject, meaning the problem domain shifts to a multidimensional domain, number of which could be really high, and needs to be decreased. To address this issue of relation decreasing, for instance, least square projection can be applied. Accordingly, as applied by Paulovich et. al. (2008) it is possible to decrease these relations by dimension reduction.

Other different works also provide insights and information regarding the development of a proper methodology to support tacit knowledge extraction and visualization. For instance, Mercler (2007) reflects upon how the tacit knowledge is diffusing in the organizations. Although a software based approach is not used, the given data collection and analysis methods (critical incident technique, cognitive and reflexive interview, organizational network questioning and participating observations, among others) are insightful for developing a supportive technology and methodology for visualization of tacit knowledge in organizations. This also leads us to discussing further the related issues of research methodology and design, as in the next section.

3. RESEARCH METHODOLOGY AND DESIGN FOR DEVELOPING FRAMEWORK PROPOSAL

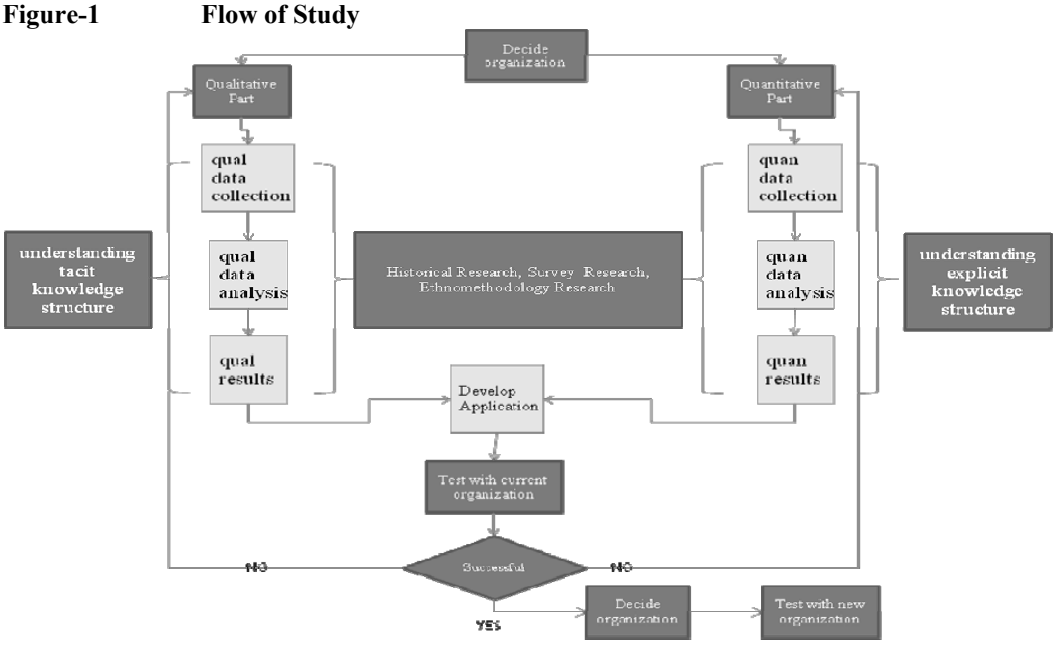
The purpose of this study is to develop a framework that will be used for tacit knowledge extraction from the explicit knowledge structure of the organizations. To address this purpose and questions that are explained in the Introduction, the requirements for the framework development are determined with the methodology. Two basic types of knowledge, tacit and explicit, are then important for our research methodology.

Basically tacit knowledge is considered as the knowledge of individuals who are not sure what knowledge they posses (Polanyi,1966). Also, knowing where or who could posses the required knowledge lead another tacit knowledge of other individuals. In here it is needed to show individual's relationships with other individuals in the organization. This leads to a qualitative approach for the research (Cresswell, 2009). On the other hand, when organizational hierarchy and procedures related with the internal organizational explicit knowledge are considered to

understand numerical descriptions, trends, attributes of individual members and generalize findings to the whole organization it, a quantitative approach will be required (Cresswell, 2009).

The qualitative and quantitative part of this research leads to a mixed methodology. Accordingly, triangulation design can be applied (Cresswell, Clark, & et. al, 2003) to obtain different perspectives of the organization and use these perspectives to gain complementary data (Morse, 1991). Under the triangulation design, the convergence model can be applied for supporting the flow of qualitative and quantitative parts together. Accordingly, the below figure (Figure 1) illustrates the flow of this study.

Figure-1 Flow of Study



This figure could actually be divided into three phases. First Phase will be started from deciding the organization and will be end with the development of an application. Second Phase will include developing application and testing it with current organization. Third Phase is to continue further tests with other organizations.

3.1 Phase 1: Decide and Collect

This study will be started with the selection of an organization. In the defined organization at least five primary functions must be established inside. These functions are human resources, accounting and/or finance, strategy decision, information systems, and main function as defined by mission and vision statements of the organization.

After deciding the organization, to understand tacit and explicit knowledge structure, a sequential flow will be required. Accordingly, first of all, "Historical Research" will be conducted on

organization and department-related documentations. This research will give us the possible source of procedural and hierarchical structure and possible explicit knowledge warehouses of the organization. This will lead to the comprehension of the departmental structure of the organization that will help to decide main departments. For collecting quantitative data of the defined departments, "Survey Research" to the management will be conducted. Then a sample of the department will be selected and "Ethnomethodology Research" will be conducted on them. With the result of "Historical Research" and "Ethnomethodology Research", the data will be brought together, giving the qualitative data. For this phase the suggested instruments could be given as the following table (Table 1)

Table-1 Research Type and Basic Instrument

Research Type	Main Instruments	Explanation
Historical Research	Documents	The documents related with the organization will give the explicit and tacit information related with organization. For the documentation, the internet documentation related with organization, inside organizational documentation and internal information system that is used for knowledge storage, sharing and creation will be included in this research.
Ethnomethodology Research	Interview and questionnaire and observation	To understand the individuals' understanding of the explicit knowledge of the organization and how they include their tacit knowledge to this structure will be examined based on their daily activities. Interviews and specifically prepared questionnaires will be implemented.
Survey Research	Interview and questionnaire	To understand what the related department do and bring main explicit knowledge subject into the ground interviews and questionnaires will be implemented to the management personnel of the department.

The collected data will define the structure of the framework. And this framework will be implemented in the application. The details are given under the second phase.

3.2 Phase 2: Build the System and Check Internal Validity and Reliability

This phase corresponds two sub-phases, building the system, and checking its internal validity and reliability. A candidate framework will be visualized in a software base, as illustrated in Figure 2.

After the data analysis are concluded, the results will provide the first artificial neural network structure which is called explicit subject extraction/inclusion engine. To train this engine, the explicit knowledge structure of the organization will be used.

The dynamic tacit knowledge structure will be created with the information of individuals such as education, family and previous work experiences. The tacit knowledge extraction engine will be used to create and structure subject-based or individual-based tacit knowledge clusters. Here, because of the possible delay/decay of the individual knowledge, the tacit knowledge structure requires to be updated by this engine.

Tacit knowledge visualization will use the data created by the tacit knowledge extraction engine, and will be displayed based on subject or individual relational base. Formal organizational knowledge visualization will depend on explicit subject extraction/inclusion engine. This will be used to visualize formal structure of the organization, and compare the explicit structure with the tacit structure.

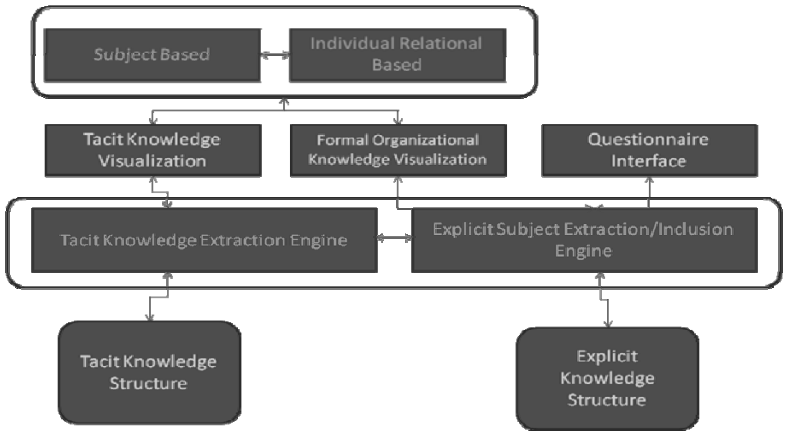


Figure-2 Tacit Knowledge Visualization Framework

Table-2 Framework Components and Main Instruments

Component	Main Instruments	Explanation
Subject and Individual Relational Based	Least Square Projection*	The number of dimensions could be more than 3, so to visualize the related tacit knowledge or tacit knowledge with the explicit knowledge relationship it will require projection
Tacit Know. Visualization	Self Organized Maps	Clustering tacit knowledge according to given subject or individual knowledge could require self organized maps
Tacit Know. Extraction Engine	Data Extraction/ Inclusion/Update	From the subject extraction/inclusion, data structure of the tacit knowledge structure will be extracted/included and updated according to requirement
Formal Organizational Knowledge Visualization	K-Means Clustering	According to distances between explicit subject distances to the related subjects and organizational structure, the explicit knowledge and subject will be visualized
Explicit Subject Extraction/Inclusion Engine	Data Extraction/ Inclusion/Update	From the given questionnaire results, explicit knowledge structure will be able to extract, include or update, when it is needed. Also the main subjects are determined inside of this structure.
Questionnaire Interface	Online Questionnaire	After first collection of the survey and interview, the updated version of the questionnaire will be uploaded and individuals will be able to access.

*For tacit knowledge visualization, a preparation stage will be required so that this least square projection method could be developed and used as one of the system module.

For the internal validity and reliability testing of the system and the validity of the questionnaires, an external interface will be created for the remaining members of the organization. (The initial sample of members was used in the first phase to collect qualitative and quantitative data). Reliability will be measured through re-sampling of the first group who will be asked to fill the questionnaires again from the computer interface. Using the whole first sample or just a part of it will be defined, after testing of the system. For this phase, the instruments for the each component could be given as Table 2.

3.3 Phase 3: Decide to Go on or Return to the Beginning

If the framework is visualized as expected, the test of the external validity will start with the existing application. If not, it is required to update the questionnaires and test it until an internally valid and reliable framework can be built.

4. CONCLUSION

Within this challenging mixed methodology, and after the completion of these phases of research, we can summarize the research questions and possible answers that will come with the proposed framework as the Table 3. In order to address these questions, this paper has first presented a brief overview of the theory and related studies of the knowledge visualization. Then, the information on research design and methodology, as well as the proposed framework design as the result of the possible execution of the methodology has been provided. As a result, an intelligent framework dynamic and specifiable for visualizing the tacit knowledge structure of the organizations from the perspectives of individual members and their relationship between each other and explicit subject bases has been proposed.

Table-3 Research Questions and Possible Answers' Sources

Research Question	Possible Research Answer Source
How the tacit knowledge structure of the organization could be visualized with the existing explicit knowledge warehouse of the organizations?	The historical data on the organizational documents and the given Information System infrastructure of the organization will reveal the explicit knowledge structure. With the inclusion of Ethnomethodology Research data the existing tacit structure inside the explicit structure will be visualized or mapped
How reliable the predetermined formal organizational structures are, when the informal structure of the organization is considered?	If the main subjects of the organizations are properly visualized with the existing tacit structure, it will give the reliability value of the organization's formal structure.

For future work, questions such as how reliable the predetermined formal organizational structures are, when it is considered the informal structure of the organization, as well as whether the informal structure of the organization could be visualized with the social network hierarchy could also be considered. An application into a suitable and feasible small or medium enterprise could also be suggested for an initial test of the framework.

ACKNOWLEDGEMENT

This paper is adapted from a proposal submitted to METU Informatics Institute, as a partial fulfillment of class work for the Research Methodology course instructed by Soner Yıldırım in Summer 2010.

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