

# **Tacit Knowledge Externalization among Geographically Distributed Small Groups**

By

Jamal Ahmad El-Den

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Jamal El-Den

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*To Najwa, Sarira, and Souad*

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## Abstract

Currently, organizations are shifting their activities and processes from information-based to knowledge-based as a result of the emergence of organizational knowledge as the main, if not the only, competitive advantage between rival organizations. Accordingly, the management of what an organization knows and the activities of knowledge externalization, which incorporates creation, articulation, capture, transformation, nurture, and retention, as well as knowledge measurement has become a field of serious research. Two main obstacles have emerged as a result. One is associated with the definition of knowledge, and the second is whether in fact knowledge in general and tacit knowledge in particular can be managed, externalized and measured.

The literature does not provide a universal knowledge definition. Accordingly, knowledge is defined contextually by both researchers and organizations. As a result, researchers and organizations work to manage knowledge, externalize it and measure it dependent on how they define it or on available definitions.

Fortunately, the majority of researchers agree that knowledge is a duality, namely, tacit and explicit, and that its management should encompass both. Explicit knowledge management proved to be easy and successful because of its information-like nature and also because it could be implemented using existing information-based concepts and tools. In contrast, work on managing tacit knowledge proved to be difficult and unsuccessful because of the illusive nature of this type of knowledge, and because its capture and transformation in its entirety is extremely difficult, if not impossible. In addition, the majority of the literary work on knowledge externalization and measurement is associated with face-to-face interactions between individuals. Similar work which addresses the externalization and measurement of tacit knowledge among geographically distributed individuals is very limited if not non-existent.

This dissertation identifies the difficulties associated with managing tacit knowledge in its entirety among distributed individuals and proposes its categorization into types/kinds as a solution for its effective externalization and measurement. The categorization process implies the identification of those types or kinds of tacit knowledge which could be externalized and measured easier than others. This is in line with most researchers' beliefs; that there are parts of tacit knowledge which cannot be externalized and measured, such as intuitions, feelings, instincts, expertise and such. The parts which can be externalized and measured based on observations, learning, and experimentation are expertise, know-how and the like; while the parts which can be externalized and measured if articulated and nurtured are opinions, ideas and similar

The thesis, drawing upon Hevner's design theory, develops an artifact for the effective capture and transformation of categorized types of tacit knowledge among distributed small groups. It proposes opinions and ideas as types of tacit knowledge which can easily be externalized and measured among distributed individuals. It introduces concepts regarding how to nurture articulated opinions and ideas among such individuals. It also proposes an externalization process, as an amendment of

Nonaka and Takeouchi's 1995 face-to-face process, which identifies the stages of the externalization of the types in distributed environments.

The dissertation is organized into two main tasks. Firstly, an elaborate literature review, which paves the ground for the introduced methodology, is undertaken. Secondly, an experiment was conducted on small groups of students who used a developed example tool for their distributed cooperation and opinions and ideas externalization. The dissertation's methodology identifies four essential steps for the externalization and measurement of tacit knowledge. The experiment, which was based on Sarker's (2004) experimental guidelines, encompasses the use of a developed example tool by the students.

The thesis presents the findings of the experiment, and based on the analysis of the data collected from a questionnaire administered to the students, it demonstrates that the externalization and measurement of tacit knowledge can be successfully accomplished if it is categorized.

## **CHAPTER ONE - Introduction**

### **1.1- Background**

Knowledge Management (KM) which encompasses the creation, sharing, nurturing, transformation, retention and measurement of knowledge, whether explicit and/or tacit, is a topic which is poorly addressed by scientists, researchers, businesses, and organizations. Consequently, research and success stories are scarce, especially on the management of tacit knowledge. This is mainly attributed to factors such as the illusive nature of knowledge in general and the misunderstanding as well as interpretation of the term 'knowledge' itself. Initially, knowledge was classified and/or defined based on the researchers' type of work, their perception of the term, and on the context of their work. Consequently, they were faced with the difficult task of finding out ways to externalize the classified knowledge as the literature of past experiences did not make their task easy. As a result of this and the diversity of contexts, definitions and knowledge's illusive nature, the process of sharing, transforming, and measuring knowledge remains a challenge and awaits some kind of change of approach or methodology.

Recently, the majority of researchers and scientists have shared the view that KM should address both tacit and explicit knowledge. Hildreth and Kimble (2002) assert that, "most approaches to the management of 'soft knowledge' are flawed and that the KM industry is in danger of falling into the same trap as previous attempts – simply trying to capture, codify and store knowledge – that is, take an IRM approach" (pp. 142). Consequently, it is imperative to find a way to manage this 'less structured' soft knowledge.

As a result, while developing an understanding of KM, the number of literary definitions, debates, difficulties, research projects, and expertise on KM was overwhelming with very little help for the proper management of organizational knowledge. Moreover, the majority of questions posed about how knowledge can be defined, managed, and measured, and the different answers to these questions did not render my task easier. This is mainly due to the existence of two conflicting schools of thought, concerning the epistemological concepts of KM. Nonaka & Takeuchi (2001), in their paper "Reflection



on Knowledge Management from Japan” distinguish the two points of view as the Western and the Japanese views on KM. The former looks at KM from an explicit perspective “the infatuation in the West with KM reflects the bias toward explicit knowledge”. The Japanese view distinguishes ‘tacit’ knowledge as well. The two kinds of knowledge are needed to interact with each other through the actions of individuals within the organization. The differences between the two views are not only concerned with which types of knowledge each camp uses but also the approach.

The Japanese approach centers more on knowledge creation while the Western approach on the management of knowledge. According to Nonaka & Takeuchi (2001) strong emphasis was placed on explicit knowledge in the West, whereas Japan placed similar emphasis on tacit knowledge.

What distinguishes most literary definitions of KM is the obvious observation that it:

- 1- Relies on people’s expertise, views, and ideas. This means that organizations seek what their employees know and more specifically what knowledge they do not share.
- 2- Uses technology for most of the capture, retention, and access of knowledge. This becomes a vital issue among geographically distributed employees particularly in today’s globalization.
- 3- Differentiates between tacit knowledge (embedded within people) and explicit knowledge (in databases, books, documents and such). In simple terms, major work has been done in the last 35 years on organizing information and today the emphasis is on knowledge organization.

The importance of knowledge was raised by the late US president Hayes in 1878 saying that “when knowledge spreads, wealth spreads; and to diffuse knowledge in the world is to diffuse wealth in the world.” This and other current emphases on the importance of knowledge in today’s businesses have urged organizations to encompass business strategies within their KM initiatives. An activity aimed at taking advantage of the

company's existing wealth (databases, knowledge repositories, experiences, expertise, and technology in general.)

This strategic importance of KM was recognized by the World Bank's report (1998) which asserts that KM should not be merely seen as the latest management fashion. It should be recognized as signaling the development of a more organic and holistic way of understanding and exploiting the role of knowledge in the processes of managing and doing work. Furthermore, it is an authentic guide for individuals and organizations to cope with the increasingly changing and shifting environment of the modern economy.

At the opening of the 4th Annual Conference on KM in 2002, it was argued that the management of knowledge should encompass not only the application of normal management functions but also the processes that identify, collect, adapt, organize, transform, share, and create knowledge. In addition, the management of knowledge should identify the organizational enablers of these processes, such as, leadership, culture, technology, and measurement required to support them.

Managements in the post-industrial era not only realized that knowledge was perhaps the critical resource, rather than land, machines and capital (Drucker 1993), but also that their organizations generally poorly managed it (Earl 2001). However, once organizations embraced the concept that knowledge could make a difference to performance and that somehow it should be managed better, they often didn't know where to start. In short, initiating a KM program was a nontrivial issue (Earl 2001). Therefore, there is a need for models or methodologies that can help corporate executives both to understand the sort of KM initiative or investments that are possible and to identify those that make sense in their context.

Leaders, individuals, groups, and the organization at large must build a culture for KM implementation as an integral part for their business processes, using some kind of technology for the externalization and measurement of their knowledge whether explicit or tacit. This would involve capturing, sharing, disseminating, transferring and retaining

their knowledge. Externalizing and measuring knowledge should be embedded within organizational activities for both face-to-face and distributed environments.

Given the prominence of the concept in empirical research, it is striking how little research has been done on how knowledge might be measured. In part, this is because the idea of measuring knowledge triggers exceedingly difficult questions of epistemology and ontology (Borgatti & Carboni 1994).

This thesis is based on both an epistemological and an ontological analysis of this idea. The former addresses the philosophical problems surrounding the theory of knowledge in order to answer questions concerning what knowledge is, how it is acquired, what parts of tacit knowledge can be codified (i.e. transformed into explicit knowledge), and what makes it knowledge in the first place. The latter describes the concepts and relationships that may exist between individuals and among group members in a distributed cooperative set-up.

From an epistemological point of view, the thesis considers tacit and explicit knowledge as inseparable entities, based on Nonaka's (1994) pluralistic view. Moreover, Polanyi's (1966) monistic view, which considers tacit knowledge, as "personal component, which pre-dominates all human thought" (pp. 14-73) will also be addressed.

The fact that many researchers view tacit knowledge as elusive, hard to formulate, articulate, and capture is a debatable issue in most of today's literature. At the same time, there appears to be a tendency towards an informal agreement among researchers that some forms or types of tacit knowledge can be made explicit.

Researchers have proposed ways to transform tacit knowledge into explicit knowledge for face-to-face interaction. Still Nonaka's prominent externalization process to this transformation was criticized by many (Stenmark, 2001) as being difficult and expensive to realize. Others have criticized turning tacit into explicit based on the argument that most of the aspects of tacit knowledge cannot be made explicit because it is personal, and based on expertise, know how, and beliefs. In addition, people may resist sharing their know-how by simply arguing that if they know something, why would they share it? In



many cases, even if knowledge is articulated, there is no guarantee that the exact meaning of the original will be acquired by the receiver.

Polanyi (1962/a, 1966) supports this argument by stating, “we need not hesitate then to conclude that the tacit personal coefficient of knowledge predominates also in the domain of explicit knowledge and represents therefore at all levels man’s ultimate faculty of acquiring and holding knowledge”.

Recently, there has been a shift in the literature towards tackling the issue from a different, narrower perspective. Some questions have been raised on whether or not there are some ‘parts’ of tacit knowledge that might be externalized and made explicit easier than other parts. Scharmer (2001) argued that tacit knowledge has both a simple and easy side which he referred to as embodied knowledge, and a hard, complex, ‘not-yet-embodied’ side. It is difficult, if not impossible, to transform all of an individual’s know-how into a codified form. The know-how, experiences, and feelings are aspects of tacit knowledge which are difficult to convert, or at least their transformation is never complete or a true reflection of their intended meaning. The knowledge of an individual represented in the form of know-how, expertise, perceptions and experiences are in most cases the results of repetition, hard work, instincts, and observations, and their articulation, whether verbal or textual, by an individual does not always necessarily represents an exact and clear transformation, possibly resulting in misinterpretation by others. This argument can be summed up following Polanyi’s (1965) famous words “We can know more than we can tell”. This position simply asserts that our knowledge of something surpasses our explanation of it. As a result, most of today’s research addresses managing the simple (explicit and embodied) side of knowledge, and disregards the hard (tacit and not-yet-embodied). Recently, Collins and Kusch (1998) described what they meant by tacit knowledge in their book “The shape of action” which provides a categorization of actions which can, in principle, be made explicit, and hence performed by machines as opposed to those which remain entirely within the realm of humans.

From an ontological perspective, the thesis considers individuals and groups as the basis for the study of KM, knowledge sharing and measurement. The research addresses



groups which are ‘specialized groups’ where the members, given a predefined set of goals and objectives, have the same or similar levels of expertise, qualification, and background. The groups’ formation, interaction, and memory form the foundation of the ontological perspective in the research.

Organizations realized the importance of externalizing and measuring diverse knowledge from employees, customers, partners, competitors and any other stakeholders. This realization pushed organizations to reinforce the concept of KM and to find ways to externalize these valuable human assets even though as Grayson (1996) declared “although organizations view knowledge as one of the most important assets, it is typically recorded as an expense”. A review of the literature suggests that there have been numerous attempts at quantitatively measuring knowledge capital; however, intangible knowledge within the organization is very difficult to measure (McManus et al 2006). At the same time, the literature shows a wide range of conceptual approaches to knowledge, by KM researchers and practitioners. As a result of such a wide range of appreciation of what knowledge-based resources are, a diversity of strategies for their management has emerged (Garcia-Perez & Mitra 2007).

The purpose of this research is to extend the face-to-face KM process to managing knowledge among geographically distributed individuals with emphasis on introducing a method for people to externalize and measure categorized parts of their tacit knowledge.

## **1.2 Problem Statement**

The management of knowledge gained popularity in recent years regardless of the problems associated with implementing an effective KM strategy. This happened because of the conflicting knowledge definitions and the lack of a methodology which would assist in the externalization and measurement of organizational “tacit” knowledge. In addition, the organizational impact of globalization resulted in a new structure of work where collaboration, knowledge sharing, transformation, measurement, and management among geographically distributed individuals become a necessity. This new trend compelled researchers and businesses to develop both theoretical as well as technological

support for such work. The management of the know-how and expertise of cooperating individuals emerged as a vital theoretical discipline for the KM processes and the knowledge conversion activities. Moreover, this led to the development of various support tools for both the processes and the activities.

Management plays an important role in identifying the knowledge required for successful implementation of organizational processes and tasks in their attempt to improve, change and measure these processes and tasks. "Value is often associated with some form of measurement. Today we have slowly learned to value immeasurable things like knowledge but to value even more intangible things like knowledge is unusual" (Haldin-Herrgard 2000). McManus et al (2006) believe that the impact of knowledge is measurable, as well as the impact of elicited tacit knowledge.

Originally, because of the illusive nature of knowledge as well as the lack of standards for its processes, activities, externalization, management, and measurement, the management of business knowledge is in a phase of uncertainty. The literature showed a quest to develop supportive tools, systems and networks for the emergence of asynchronous interaction and cooperation. However, it fell short in standardizing the KM definition process and cycle, the knowledge conversion activities, and the measurement of knowledge.

Given the prominence of the concept of measuring of knowledge in empirical research, it is striking how little research there has been on how knowledge might be measured. The question of how knowledge held by individuals and groups, given the latest interests by researchers in organizational learning and KM has been discussed by Brogatti and Carboni (1994).

Garcia-Perez and Mitra (2007) have designed a methodological framework for tacit knowledge discovery and management that spans over two phases: one for identifying and locating the tacit knowledge-based resources, and the second one for their verification and measurement. The methodology has been designed in such a way that it can be applied at different levels in organizations or in teams with diverse characteristics

and structures. Also, Richards and Bush 2001 introduced a methodology aimed at better measuring tacit knowledge in an organizational context. Their methodology focuses on the externalization of what they call articulated tacit knowledge (ATK) and is based on previous work by Stenberg (1995, 1998a, 1998b, 1999).

Consequently, the available tools emerged with limited support for the activities associated with all aspects of organizational management of knowledge. As a result, contextualization became the prominent approach to deal with the required theories and tools for the process, the activities and the artifact. Accordingly, we have seen the emergence of an endless array of knowledge definitions; KM processes (cycles), knowledge transformation/conversion techniques and measurement, as well as various supporting tools. The context influences what kinds and/or types of knowledge people choose to create, use and share, and thus, influencing what problems can be solved and how they are solved (Augier, Shariq & Vendelo 2001). Researchers, namely Nonaka (1991, 1994, 1996, and 2001) Nonaka and Komo (1994) and Nonaka and Takeouchi (1995, 1996, and 2001) consider transforming knowledge as part of the KM process. They also distinguish between different categories of knowledge; however, all agree that it is a duality comprising both tacit and explicit components. Consequently, knowledge transformation becomes a spiral of tacit to explicit transformation.

In an attempt to find solutions to some of the literary debates for this situation, the thesis introduces a methodology which shows how to devise a testable method for the externalization and measurement of parts of tacit knowledge among geographically distributed individuals. Organizations may benefit from this and similar methodologies in their attempts to find solutions to knowledge externalization and measurement.

Measuring the success of the externalization of knowledge is integral to organizations involved in KM and they'd be advised to devise methods to accommodate its processes.

The thesis does not focus on face-to-face settings where tacit knowledge transformation was rigorously addressed by researchers and scientists with effective solutions regarding its cooperative meaning as well as what governs the interaction among individuals and



members in groups and communities. Conflict resolution, problem solving techniques, individual's involvement, contribution and responsibilities are the main difficulties in such settings.

The thesis addresses and tries to find solutions for knowledge externalization and measurement in asynchronous settings where individuals are collaborating in geographically remote areas, as this is an issue which has many unsolved problems. Currently, such problems are mainly due to the novelty of the topic, the reliance on existing face-to-face KM processes for the manipulation of organizational knowledge, the persistent terminological ambiguity about knowledge and its conversion, and the lack of coordination and communication tools. Theories and concepts for managing and transforming knowledge in its entirety, especially tacit knowledge, without considering the difficulties and even (for some researchers) the impossibilities in such management, transformation and measurement have failed drastically. In addition, the lack of an integrated support tool for communication, coordination and cooperation among the distributed individuals adds to the slow development of the research in the field.

This thesis introduces concepts related to tacit knowledge categorization, KM processes and activities as well as its conversion and measurement activities among geographically distributed individuals working together in small groups towards the fulfillment of a set of predefined goals and objectives.

### **1.3 Motivation for the Dissertation**

The initial motivation behind this dissertation was to introduce a method for geographically distributed individuals to manage and measure the value obtained by externalizing their tacit knowledge in the form of opinions and ideas, in order to improve their work as well as organizational work. In order to achieve these goals, it was imperative to develop a method for measuring the knowledge externalization among such individuals. This method of measurement is, in Hevner's (2004) interpretation, treated as an artifact which introduces a process for managing identified types of knowledge, the process and method of its measurement. Initially, this artifact categorizes tacit knowledge into types in order to identify possible easy to articulate parts of that knowledge. The

literature suggests that it is difficult, if not impossible, to articulate tacit knowledge in its entirety and types of that knowledge which are easier for the articulation need to be identified. Second, identify the type of technological support they need for their cooperation as well as the externalization of their articulated knowledge. Finally, devise a measurement method for the transformation of the categorized parts.

Consequently, the focus of this paper was to concentrate initially on identifying types of tacit knowledge, followed by either building a piece of software technology, or using an existing one or existing techniques as an example for the externalization of those parts. Finally, the intention is to devise a measure for the success of the types' transformation among geographically distributed individuals.

The identification of types of tacit knowledge will make it easier for organizations and businesses to externalize those parts of their intellectual capital's know-how and expertise in an effective way. Such identification also results in a more accurate measure of an organization's knowledge, as attempts to externalize and measure tacit knowledge in its entirety have failed dramatically.

As the research progressed, it became apparent that in order to provide solutions to the above question it was necessary to integrate many approaches and different disciplines because of the interdisciplinary nature of KM, knowledge externalization and group formation. This explains the multi-disciplinary nature of the research as it integrates concepts, rules, and regulations from Computer-Supported Cooperative-Work (CSCW), Groupware, Group Memory, Groups Formation, KM, Systems Development Life Cycle and others.

Also, it became apparent that working on knowledge is difficult, and in many cases misleading, given the large number of researchers who attempted to deal with individual, groups, and organizational knowledge without a standard definition. They ended up introducing different arrays of definitions to suit their context. This has resulted in as many definitions on knowledge as there are researchers. Consequently, the contextualization of knowledge definitions has also resulted in numerous knowledge

management cycles. Without a standard definition of knowledge, researchers working on KM had to choose a definition of knowledge that suits them the most and either use the existing KM cycles, alter them, or invent a new one in order to manage their knowledge.

Given this hostile environment, and because the literature suggests that tacit knowledge in its entirety cannot be managed, the approach is to focus on the categorization of tacit knowledge into opinions and ideas, and on their transformation and measurement among dispersed members. It was also decided to address such transformation among small groups of distributed students in different subjects in their development of their term projects. The aim was to demonstrate how such distributed individuals can share their opinions and ideas to improve the quality of their projects. As a result, a spiral for parts of tacit knowledge transformation among dispersed people is introduced in chapter 2 (Table 2.2) as well as a knowledge management cycle (Diagram 2.2). Historically, similar studies have been conducted mostly among people in face-to-face settings. On the other hand, similar studies among distributed individuals were based on e-mail exchanges and Lotus notes, and lately on blogs and wikis.

According to Sharmer's (2000) description of tacit knowledge as embodied and not-yet-embodied knowledge, the not-yet-embodied type is the least addressed by researchers working in KM because of its illusiveness. It hides itself within the individual, is based on an individual's past experiences, instincts, intuitions, and know-how, and finally because the individual may not even be aware of its existence.

The treatise proposes a methodology for the categorization, implementation and measurement of parts, opinions and ideas of tacit knowledge among geographically distributed individuals. The methodology needs to show how to devise a testable method for the externalization of those parts and how it can be applied to other categorized types of tacit knowledge.

From what preceded, it appears that there is a general agreement among researchers, scientists, and organizations that tacit knowledge can be externalized and measured, but a systematic approach is to be developed in order to fulfill these difficult tasks. This



research will show that one way to solve this problem is the proper analysis of tacit knowledge in order to identify different parts within it which can be more easily captured, shared, and measured than others.

To achieve this aim, the thesis introduces the following:

a- Categorization of tacit knowledge into opinions and ideas:

Other researchers may categorize other types of tacit knowledge such as thoughts, talents, know-how and such in order to run similar tests on different types of that knowledge. It is worth mentioning that the categorization of knowledge is poorly addressed in the literature. Polanyi's (1966) categorization of knowledge as tacit and explicit is still dominant and to nearly all researchers, tacit knowledge is an entire entity which they attempt to externalize. Some researchers (Ho, Wu & Hsu, 2006) have categorized tacit knowledge as: simple knowledge, complex non-unique knowledge, advantage added knowledge, expert knowledge, and spurious knowledge. They relate each of these types of knowledge to different tasks or functionalities within the firm or organization. By doing so, they have added more problems to the management of such knowledge. What is needed is a type of categorization of tacit knowledge which is easier to transform to other types. Giving different names to tacit knowledge makes it more problematic as a notion as well as its management. Boisot (1995) argued that "the issue is one of choosing which items to make tacit and which to ones to codify" (pp. 489-506). In this argument, it is suggested that the problem relies not on the difficulty of the notion of knowledge itself, but simply on which type(s) of knowledge should be addressed.

b- An example of a technology tool for distributed individuals' cooperation and knowledge externalization:

This tool might also be used by others for different categorized tacit knowledge types. Recently social computing tools (such as blogs and wikis) have developed to provide an unstructured, self-governing approach to the transfer, capture and

creation of knowledge through the development of new forms of community, network or matrix. However, such tools for the most part are still based on text and code, and thus represent explicit knowledge transfer. These tools face challenges in distilling meaningful re-usable knowledge and intelligible information and ensuring that their content is transmissible through diverse channels, platforms and forums. In addition, the success of these tools has not been tested or measured properly.

- c- A KM definition for the above mentioned cooperation, as well as value and transformed knowledge definitions
- d- A KM cycle which proposes the steps of externalization of the individuals' knowledge
- e- A model for knowledge transformation (tacit to explicit, tacit to tacit, explicit to tacit, and explicit to explicit) in remote settings
- f- A model for knowledge creation
- g- An experiment for the measurement of the success of opinions and ideas transformation.

#### **1.4 The Research Approach**

The primary goal of the research was to explore the process of tacit knowledge externalization and measurement among distributed individuals. As a consequence, a process would be introduced which might assist the quest of today's management to find ways to externalize and measure their intellectual capital, in the form of easy types of tacit knowledge during the knowledge management process. Also, the aim was to demonstrate that such a process results in helping them achieve better work results. The best approach was to work on real groups of people working asynchronously on real cases. The practical approach in this research involves people, who are the originators of knowledge, and technology, which is the infrastructure for their work. Therefore, it was imperative to find the people, who were students in this case, and provide them with a tool to assist them in their cooperation, knowledge externalization and measurement. This explains the interdisciplinary nature of the dissertation which integrates topics from KM,



computer-supported cooperative-work (CSCW), groupware, group support systems (GSS), and knowledge retention.

Students from different disciplines in a semester long subject are the sample for the study in this thesis. All of the students have previously taken a KM subject, and as well have used the different technological examples available for distributed cooperation among individuals. Furthermore, they were advised to use the developed tool as an example of such technology. A questionnaire was developed and distributed to the students at the end of the semester in order to collect data about the extent of knowledge transformation. The questionnaire data was analyzed and measured, and results were studied and reported.

## **1.5 The Empirical Work**

To evaluate the relative performance and the effectiveness of the proposed methodology, it was imperative to find a setting in which all three aspects of the methodology could be directly implemented and tested. Students were introduced to the method and were encouraged to articulate their opinions and ideas as part of the development of their term project. The questionnaire, which was administered to the students at the end of the semester, contained a mix of questions which elicited answers on the effects of some independent variables (see chapter 5).

The conducted experiment forms the basis of the empirical work of the thesis, as it provides guidelines for the measurement of the transformation of individuals' opinions and ideas among a group of geographically distributed people. The outcome of the questionnaire based experiment is a method which:

- 1- Categorizes tacit knowledge into two different types; namely, opinions and ideas
- 2- Sets an environment for the experiment where participants used a developed tool as an example technology
- 3- Measures the transformation of opinions and ideas

In order to lay the ground for the experiment, the thesis introduces concepts related to knowledge management, knowledge capture, transformation, retention, and accessibility.

The ultimate goal of the development of the tool was to help group members engage in asynchronous cooperative externalization of parts of their knowledge through the release and nurture of their opinions and ideas.

The basis of the empirical study was organized in the following stages:

- an elaborate study of KM
- an elaborate study of knowledge and its types with an emphasis on tacit knowledge and explicit knowledge
- an elaborate study of CSCW, groupware, and group memory with an emphasis on why it is necessary to integrate them
- the design and development of a cooperative tool with emphasis on tacit knowledge capture and transformation
- the evaluation of the system through its use in a real case study.

## **1.6 Contribution to the literature**

Given the current literary research on KM and tacit knowledge measurement and transformation, this research provides a few interesting contributions. The most prominent contribution is the proposed categorization of tacit knowledge into types which are easier to externalize among distributed individuals than others. The literature addresses the externalization of such knowledge in its entirety without much attention to its specifications and without consideration to the difficulties associated with measuring the success of its transformation. This issue had been addressed in the literature and there is a widespread belief among researchers that “measuring knowledge itself is challenging, if not impossible”, (Foray & Gault 2003). The thesis argues that the main reason for this failure is associated with the attempts by researchers to externalize and measure ‘all’ of tacit knowledge. The thesis categorizes tacit knowledge into opinions and ideas and asserts that they are parts of that knowledge and that they are easier to externalize and manage. Other types could be categorized and the introduced methodology can be followed as in this thesis.

In addition an example of a cooperative tool was developed based on the concepts and definitions introduced in the thesis for distributed students' cooperation and knowledge externalization. A questionnaire was developed and distributed to groups of students who used the tool to develop their semester long term projects. The results from the questionnaire were used to measure knowledge sharing and transformation among the groups' members. The results showed that there was considerable knowledge transfer among the members in most of the variables in the questionnaire.

Theoretically, the thesis contributes to the existing literature through the introduction of definitions of KM and two new types of knowledge definitions. Finally, the thesis introduced a KM cycle.

In summary, the thesis introduces a novel methodology for the externalization of categorized types to tacit knowledge and also it demonstrates the retention of those parts on shared knowledge documents. The process included the categorization of the parts, implementation using a developed example tool, and proof of the articulation and transfer of opinions and ideas using an experiment on small groups of students. Finally, it analyses the results of a questionnaire developed to enable measurement.

## **1.7 Organization of the Thesis**

The dissertation is presented in seven chapters which highlight the literature review, the methodology, the design, and the approach followed to satisfy the research question.

Chapter one introduces the directions of the thesis. Chapter 2 highlights the current and major literary work to date on knowledge, KM, and knowledge externalization. Chapter three introduces the methodology. Chapter four introduces the dissertation's proposed concepts and theories in the form of definitions, KM cycle for knowledge externalization among distributed small group members. The chapter also introduces a model structure which shows the walkthrough for knowledge creation, nurture, transformation, and retention. It also purports that the opinions and ideas of individuals are among the easiest parts of tacit knowledge to be transformed to explicit knowledge. It also highlights the importance of representing knowledge as an object in the form of a shared document.

Chapter five introduces the literature available regarding technological tools used for the different processes of the externalization process. It also introduces a developed example tool used in the experiment. Chapter six presents the experiment conducted and the results and findings of the analysis of the questionnaire (Appendix A). Finally, chapter 7 presents the conclusion and recommendations for future work as well as identifying the limitations of the dissertation.



## **CHAPTER TWO - Literature Review, hypotheses, and assumptions**

This chapter introduces the literary work on knowledge, KM, cycles, and transformation. It describes what knowledge is and how it is perceived among KM researchers. Theoretical questions of KM and knowledge transformation are addressed. The concepts of explicit, tacit embodied and not-yet-embodied knowledge are discussed and definitions on knowledge (value and transformed), KM, and group memory are introduced. The chapter reviews some of the prominent researchers' work on this issue and how they perceive it. The concepts of transforming knowledge among cooperating group members, the type of group support systems needed, and what types of knowledge are required for the transformation are also introduced.

### **2.1 Theory of Knowledge and its Classification**

#### **2.1.1 Knowledge in Perspective**

Today, the statement 'Knowledge is power', appears on every other current research paper and in most organizations' literature. It is believed that this power is to be identified, shared, used, transformed, retained, and measured. The power of knowledge is in its ability, once acquired, to provide the holder with considerable competitive advantage. Knowledge, and its transformation and measurement have been put under the close attention of researchers and organizations. What is knowledge? How is it created? How is it acquired? How is it transformed and shared? How is it externalized? How and where is it retained? These issues and whether or not it can be measured are only a few examples of the types of work and research mostly addressed in the literature today. Whitley (1991) emphasized that "The topic of knowledge has begun to gain a new wave of attention in recent years. This is partly due to computerization, and in particular studies into artificial intelligence and technologies to manage and maintain the knowledge found in organizations".

The Oxford Dictionary 2008 defines knowledge as "the facts, feelings or experiences known by a person or group of people". Knowledge is associated with people and is exchanged among individuals and groups to enrich both, and consequently organizational knowledge. Knowledge could be derived from information but it is richer and more meaningful. It includes familiarity, awareness and understanding gained through experiences or study, and results from interacting, making comparisons, identifying consequences, and making connections. Some experts include wisdom and insight in their definitions of knowledge. In organizational terms, knowledge is generally thought of as being 'know how', 'expertise', 'applied information', 'information with judgment' or 'the capacity for effective action' (Collins English dictionary 2008). It is not always concrete and in general it is hard to express, manage, externalize, and measure. When we think of knowledge, we usually think of what we know (Gessner & Geter 2001). Not all of an individual's know-how can be fully articulated. Importantly, the recipient may not fully understand what the knower intended.

Paul S. Adler (2003) in his paper "Market, Hierarchy, and Trust..." distinguished knowledge from all other resources by stating that "...most forms of knowledge grow rather than diminish with use" (214-234). The importance of this account is the implication about the existence of different types of knowledge and that knowledge is dynamic, and changes its shape and content over time. The dynamicity of knowledge is dependent on its type; that is, some knowledge growth is dependent on individual experiences and some is the result of interaction among individuals in face-to-face and/or in geographically dispersed settings. Knowledge growth is a result of repetitive task accomplishment and/or a result of interacting individuals' perception and reflection on each others' thoughts, opinions and ideas. In addition, depending on the work context, the process of knowledge growth requires different tools for its acquisition, sharing, conversion, transference retention, and measurement at each stage.

Classification of, and familiarity with knowledge are vital for organizations' quest for the management of knowledge. A combination of knowledge types is critical for problem solving.

### **2.1.2 Knowledge Classification**

The classification of knowledge as a duality, tacit/explicit, forms the basis of the epistemological discussion in the thesis. Explicit knowledge is integral for the transformation as is tacit knowledge. The thesis deals with those parts of tacit knowledge which can be transformed into a codified form. The dissertation assumes that knowledge, whether explicit or tacit, is an object in the form of a shared document. An individual's release or articulation of his/her know-how, expertise, opinions, and ideas forms the content of the shared document, hence the analogy with the object representation. In this representation, an object has two sides, one is physical, being the creation of a document, and the other is the contents of the object released and augmented.

This object's structure provides distributed individuals with a common or shared space as a platform for their cooperation, knowledge release, and knowledge nurture. Or in Nonaka and Komo's (1997) words, it is a 'Ba', a context or a shared space that serves as a foundation for knowledge externalization. A shared space for emerging relationships could be mental, physical, and/or virtual and is integral for relationships and idea generation in face-to-face situations.

When people are geographically distributed their 'Ba' or shared space, is virtual by nature and calls for an infrastructure to support interactions among the members as well as idea generation, discussions, nurture etc. In such circumstances, communication and collaboration have to rely on advanced technology which provides an infrastructure for the virtual space where the cooperating members can release, discuss, nurture, transform and retain their work. It is necessary for remote groups to be supported by an effective group-support system or a cooperative tool where among its main facilities is a shared document, a 'Ba', as the means of communication and cooperation. This shared document represents the space for individuals' released knowledge both explicit and tacit in a contextually categorized form. The shared document captures the articulated knowledge of the group in the form of mental analysis, skills, experiences, opinions, ideas and expertise.



This object structure is the basis for the representation and manipulation of both types of knowledge in the dissertation. What an individual/group knows constitutes the object’s contents which are released, captured, represented, transformed, and retained as a result of interaction and discussions with other distributed individuals in the group. The representation of knowledge as an object is useful for the conceptualization of building applications because it allows its transferability and measurement. Hence, the object representation of knowledge is a representation of the content which is retained in a shared document form. This object representation was considered to be a representation for both tacit and explicit knowledge. Belohlavek (2006) addressed the issue of representing knowledge as an object and asserted that “Knowledge is an object serving the community and the individual”, adding that the object can later be used when its content is needed.

Additionally, the field of logic has inspired important knowledge objects, notably concepts, attributes, values, rules and relationships. Concepts are the things that constitute a domain, e.g., physical objects, ideas, people and organizations. Each concept is described by its relationships to other concepts; the same way objects are related, in the domain by their attributes and values. Table 2.1 summarizes the literary classification of knowledge by key researchers.

Type of Knowledge	Researcher(s)
Shallow Deep Reasoning (Analogy, case-based) Formal	Awad & Ghaziri (2004)
Procedural Declarative Semantic Heuristic Conditional	Awad & Ghaziri (2004) Vanconcelos et al. (2000) Hackworth (2004)
Declarative/Procedural Tacit/Explicit Object/Process Group/Individual	Milton (2003)
Embrained Embodied Encultured Embedded Encoded	Collins (1993) Blackler (2000) Granovetter (1985) Seribner (1986)



Knowledge that Knowledge how	Ryles (1999)
Knowledge about Knowledge of acquaintance	James (1950)
Tacit/Explicit	Polanyi (1965), Nonaka (1990) Sharmer (2001)
Simple knowledge, Complex non-unique Knowledge, Advantage added knowledge, Expert knowledge, Spurious knowledge	S. Ping Ho, Pei-Chi Wu, Hsu (2006)
Articulated knowledge	

**Table 2.1 Extracts from the Literature’s Classification of Knowledge**

## 2.2 Tacit vs. Explicit Knowledge:

### 2.2.1 Tacit knowledge

The literature provides an endless array of definitions on tacit knowledge. Following is a selection of them.

- 1- “Knowledge, which we acquire through our experience of acting in the world. Not book knowledge acquired through formal education.” (Inglis, Ling, & Joosten, 1999).
- 2- “Knowledge developed and internalized by the knower over a long period of time... incorporates so much accrued and embedded learning that its rules may be impossible to separate from how an individual acts.” ([www.stcsm.gov.cn/learning/lesson/guanli/200220416/20020416-6.asp](http://www.stcsm.gov.cn/learning/lesson/guanli/200220416/20020416-6.asp))
- 3- “Know-how and information processed by an individual that has not been available to others. Opposite to explicit knowledge.” ([64.224.94.100/itimergroup/astd\\_web/glossary.htm](http://64.224.94.100/itimergroup/astd_web/glossary.htm))

Tacit knowledge was introduced by Polanyi (1965) and later had a renaissance with the work of Nonaka (1994) and Nonaka and Takeuchi (1995). Even though Nonaka (1994, 1995) claimed to base his externalization theory on Polanyi’s work, he diverged considerably from the intended meaning by Polanyi. While Polanyi considers tacit knowledge as the basis of all other knowledge and against which all other actions are

understood, Nonaka considers that tacit knowledge is a particular knowledge that is difficult to express. There had perhaps been less confusion had Nonaka used the term implicit knowledge instead of tacit knowledge (Stenmark 2002).

Other scientists and researchers (Cook & Brown 1999, Tsoukas 1996) have referred to tacit knowledge based on Polanyi's arguments and come to different conclusions. Tsoukas (1996) argued that tacit and explicit knowledge are mutually constituted, yet should be viewed as separate types of knowledge. Cook & Brown (1999) also in agreement with Polanyi, claim that tacit knowledge and explicit knowledge are two distinct forms of knowledge, and that the transformation from one type to the other is not possible. Molander (1996) treated tacit knowledge as separate from explicit knowledge but only because they are viewed as two separate aspects of knowledge and not as different sorts of knowledge. Finally, Collins (2001) considered tacit knowledge to be the basis of all human knowing, and that it is critical in all disciplines. Tacit knowledge is considered to be a property of both individuals and groups. Others have centered their work on the basis that tacit knowledge belongs to individuals only.

Tacit knowledge is acquired through interaction with the world and is heavily based on experiences, and developed and internalized by individuals over a long period of time. It has been systematically investigated in the literature (Polanyi 1965, 1966, Reuber et al 1990, Nonaka 1994, Sveiby 1997 & Vasconcelos 2000). Current tacit knowledge definitions have been influenced by Polanyi's statement "we can know more than we can tell". This report clearly proposes that not all knowledge can be articulated. Part of our knowledge, which is gained through years of experiences, is a property of the individual and is acquired experimentally. The intellectual property of an individual or organization, and its organizational culture are examples of tacit knowledge. Knowledge in the form of project experiences, task heuristics and human competencies that are difficult to capture and externalize are examples of tacit knowledge within the work environment (Vasconcelos 2000).

There is also a general agreement that tacit knowledge is acquired through an individual's direct experience of whatever their tacit knowledge concerns (Gourlay 2004). In keeping

with the emphasis on the individual, Horvath et al. (1999) stress that tacit knowledge is acquired with little help from others (Gourlay 2004). This claim contradicts the logic of this thesis which argues that tacit knowledge is amplified, augmented, transformed, and shared through interaction among people. Gourlay's claim is in contrast to Collins (2001) and Leonard & Sensiper (1998) who believe that interaction and observation are critical factors in knowledge acquisition.

Tacit knowledge is basically rooted in individuals as long as it is not articulated, then becomes the property of the group once articulated. By definition, it is based on thoughts, experiences and know-how, and has its origins in the individual. It remains as such as long as the individual does not engage in an act of cooperation. Articulation of knowledge by the individual makes his/her knowledge accessible to others and its retention makes it a property of the group; that is, it becomes the collective group knowledge. Based on Polanyi's 1995 words "we can know more than we can tell", the articulated knowledge by the originator is incomplete, and is not an articulation of the individual's full knowledge. Part of that knowledge resides in the individuals because expressing tacit knowledge does not reflect all of the intended meaning by the originator which simply may be because he/she is not aware of it.

There is always an unarticulated part(s) of an individual's tacit knowledge (not-yet-embodied knowledge). Only the tacit embodied knowledge, also referred to as implicit knowledge (Sharmer 2001) could be fully articulated by individuals because in most cases it is a description of a process or know-how accumulated through work practice and years of experience.

As for the not-yet-embodied knowledge, the articulation is difficult and does not reflect the complete intended meaning within the individual. Accordingly, the collective tacit knowledge is not a true reflection of all group members' knowledge.



The articulated or released tacit knowledge can be augmented and amplified as a result of interaction with support for high level of discussions among the group members. This is a result of a process in which the group members release their knowledge, hence, it becomes accessible, discussed, and may be amplified as a result of exchanging opinions and ideas among the group. This process is supported by the developed example tool in this research. Polanyi (1996) supports this idea by stating “One person draws inferences from another’s ideas that the latter did not anticipate”. This can be explained by reference to different individuals operating in different situations, and does not require a notion of foreknowledge implying some kind of predictive powers (Gouraly 2004). Knowledge creation evolves in a spiraling movement between the explicit and the tacit knowledge held by individuals, teams and the organization (Nonaka & Takeuchi 1995). In a reply by Fred Nicolas to At De Lange ([www.learning-org.com/00.02/0055.html](http://www.learning-org.com/00.02/0055.html)), he suggested “my definition of tacit knowledge follows Polanyi’s account that ‘We can know more than we can tell.’ By that definition, tacit knowledge cannot be articulated. So, given the definition of tacit knowledge I use, it is a complete waste of time to try to persuade me that it can be articulated. By definition, it can’t.” This message clearly supports those who consider tacit knowledge as difficult to be transformed to other forms of knowledge.

### **2.2.2 Explicit knowledge**

Some definitions of explicit knowledge are:

- 1- “Knowledge that has been formally expressed and transferred.”  
([www.sims.berkeley.edu/courses/is213/s99/Projects/P9/web\\_site/glossary.htm](http://www.sims.berkeley.edu/courses/is213/s99/Projects/P9/web_site/glossary.htm))
- 2- “Knowledge that has been expressed in words and numbers and shared in the form of data, scientific formulae, specifications, manuals, etc. It is easy to distribute and it is "slippery". Explicit knowledge, which is also known as "codified" knowledge, is the opposite of tacit knowledge.  
([www.sims.berkeley.edu/courses/is213/s99/Projects/P9/web\\_site/glossary.htm](http://www.sims.berkeley.edu/courses/is213/s99/Projects/P9/web_site/glossary.htm))

- 3- “Knowledge that can be readily expressed and recorded within information systems.”  
([wps.prenhall.com/wps/media/objects/505/517554/glossary.html](http://wps.prenhall.com/wps/media/objects/505/517554/glossary.html))
- 4- Know-how and information that has been expressed and is available to others; opposite of tacit knowledge.  
([64.224.94.100/itimegroup/astd\\_web/glossary.htm](http://64.224.94.100/itimegroup/astd_web/glossary.htm))
- 5- Knowledge that can be articulated in formal language including grammatical statements, mathematical expressions, specifications, and manuals (Nonaka & Takeuchi 1995).
- 6- Knowledge that is made manifest through language, symbols, objects, and artifacts (Choo 1998).

Explicit knowledge resides traditionally in easy accessible physical media such as databases, books, files, and organizational or group memory; it can be easily interpreted and used by individuals for a variety of purposes. The individual can then either alter the contents or reflect on them to amplify his/her embodied and not-yet-embodied knowledge. Dutta (1997) clared that “Codified knowledge is amenable to the printed page and can easily be transmitted, such as in designs and specifications, and is therefore less proprietary than tacit knowledge, which is more difficult to imitate” (343-356).

The thesis argues thatthe above types, explicit and tacit, encompass most, if not all, of the types of knowledge introduced or discussed in the literature. A summary of the above discussions on the types and classification of knowledge can be:

- 3 Skills, cognitive ability, knowledge of facts (knowledge that, knowledge about);
- 4 Action-oriented, how to do things (know how, knowledge of acquaintance), experience, practice;
- 5 Contextual, problem solving, situational knowledge rather than abstract;
- 6 Shared understanding (socially constructed and open to negotiation);
- 7 System terms and relationships (technologies, roles, formal procedures, emergent routines);
- 8 Signs and symbols (books, manuals, codes of practice, technology).

9 Table 2.2, summarizes some of the literature's aspects of tacit and explicit knowledge

Tacit Knowledge		Explicit Knowledge	
1.	People carry in their minds/people's Experiences	Found in books, documents, databases etc. Easy to capture	
2.	Difficult to access / not easily shared/ Hard to identify, locate, quantify	Easy to store in databases and documents	
3.	People are unaware of / people do not Recognize	Shared with high degree of accuracy	
4.	Valuable	Structured or unstructured	
5.	Provides context for people, places Ideas, experiences	Information written in electronic form	
6.	Requires extensive interaction among People	Easily accessed	
7.	Not codified / not written down	Can be captured easy using technology	
8.	Embodied in researchers and in Companies' intellect	Can be expressed in rules or guidelines	
9.	Based on habits, cultures, experiences	Can be managed	
1	Can be transmitted via training	Know what	
0.			
1	Gained through personal experiences	Found on physical media	
1.			
1	Know-how as opposed to know-what And know-why	Know what and not necessarily why	
2.			
1	Ways of learning and skills	Educational	
3.			
1	Crucial to innovation during	Mainly supports released	
4.	development	ideas/opinions	
1	What we know but can't tell or	What is there to get	
5.	express		
1	Knowledge we feel. Needs stimulus	Retained Knowledge. Needs access	
6.			



1	Embedded in groups, core values,	Embedded in physical media
7.	assump- tions and beliefs	
1	Difficult to manage	Comparatively easily managed
8.		

**Table 2.2: Aspects of Tacit and Explicit Knowledge**

In summary, it is apparent that knowledge is treated as a state of mind relative to some domain of information which is extremely difficult to manage and is represented as an object. This is the reason why most definitions of knowledge are contextual and developed for a specific purpose hence the lack of a common standard. This results in hard work by those trying to manage knowledge as they are faced with the dilemma of which knowledge to manage.

Table 2.3 presents a list of some of the prominent researchers who have addressed tacit knowledge and their views on whether it is a trait of individuals or individuals and groups:

	Individual and Group	Individual
Aadne (1996)	Individual and collective aspects (personal)	
Wagner & Stenberg (1985)		Individual
Janik et al (1990)		Individual
Collins (2001), Collis (1996), Spender (1996), Leonard & Spender (1998)	Individual & Group (Collective)	
Von Krogh (1996)		Strictly individual resides In relationships
Baumard (1999)	Individual & Group (collective)	
Choo (1998)	Individual and Group	
Roos (1995), Borial (2002), Fleck (1996)		Individual
Polanyi (1965, 1967)		Individual

Johannessen et al (2001), Ambrosini & Bowman (2001)		Individual
Nonaka & Takeuchi (1995, 1996)	Group & individual	Highly personal rooted in individuals
Sharmer (2000)	Individual & Group	

**Table 2.3- literature’ views on individual and group knowledge**

An individual with lots of expertise, know-how, ideas, opinions, and thoughts, who cannot articulate what he/she knows, is doomed by ignorance among his/her peers. The articulation of what someone knows gives him/her a competitive edge in terms of capability and credibility among his/her peers.

### 2.3 Individual and Group Knowledge

Organizational knowledge is multidisciplinary, hard to formalize, and generated in discussion with competing viewpoints (Shum 1997). This understanding of knowledge was the basis for distinguishing two other types of knowledge, individual and group knowledge (Vasconcelos et al. 2000). Individual knowledge is of no value if it is not shared with others. Knowledge can be interpreted as a property of an individual, resides in his/her head, yet it gains more value and importance when shared.

Research has made it clear that a team of interacting individuals can build and nurture knowledge that transcends the knowledge of each of the individuals (Walsh 1995). Consequently, there is a clear understanding that the transfer of individual knowledge from the ‘I’ to the ‘we’ can only be achieved when the ‘I’ interacts with other ‘I’s’ in a given context to solve a particular problem or during a development process. Hutchins (1995) suggested “that knowledge attributes are not solely found in individuals, but rather are distributed through a social workgroup, which work together” (40-51). The result is a collective acquaintance and possibly adoption and consequent amplification of the opinions, ideas and thoughts of the ‘I’ by the ‘I’s’.

It is apparent from the above discussions and the definition presented, that knowledge is always associated with a value of some sort. This value could be represented as thoughts, ideas, feeling, experiences, and procedures in the case of knowledge which is hard to articulate and express, or as a tangible asset written or documented.

## **2.4 Michael Polanyi's perception on Tacit Knowledge**

Hedesstrom and Whitley (1995) argued that the problems with tacit knowledge are the misinterpretation of Polanyi's (1966) notion "we know more than we can tell". Different interpretations and applications of tacit knowledge are found in the literature because of the misuse of the term and "translated" (Cabrera & Cabrera 1997) to fit their own particular needs, ideas, and context.

Polanyi's (1965) book "The Study of Man" explains in detail his comprehension of human knowledge. The book paved the way for his later masterpiece "The Tacit Dimension." The Study of Man commences: "Man's capacity to think is his most outstanding attribute. Whoever speaks of man will therefore have to speak at some stage of human knowledge" (Polanyi 1965).

Thus the study of man is not complete unless one studies his/her achievements. What is peculiar about this is that when man searches for knowledge, his aim is to find knowledge that "will stand up on its own" (Polanyi 1965), objectively. However, when he tries to reflect on his own knowledge which he previously assumed to be objective he finds himself unconsciously defending it. Thus his knowledge becomes purely subjective. Polanyi attributes this peculiarity to the very definition of human knowledge; it is of two distinct kinds, Tacit and Explicit.

Polanyi (1969) claimed that people know tacitly that their explicit knowledge is true and that tacit knowledge lacks the objectivity of explicit knowledge and might be considered lacking the quality of real knowledge. This can not be easily overruled but there is no way that the knower produces explicit knowledge, without his personal contribution, tacit knowledge (Polanyi 1965). He added "the essential logical difference between the two kinds of knowledge lies in the fact that we can critically reflect on something explicitly



expressed, in a way in which we cannot reflect on our tacit awareness of an experience” (Polanyi 1965).

Polanyi (1965) claimed that relying on explicitly formulated knowledge is risky, but its advantage lies in the ease of reflecting on its contents critically. Tacit knowledge on the other hand is the understanding of things that can only be tested by going through the experience again (Polanyi 1965).

Words can explain information and knowledge; algebraic symbols can explain mathematical formulas; maps can explain the topographical peculiarities of a piece of land; but words, symbols, and maps do not communicate an understanding of themselves even though they might be arranged in a way to give meaning. The communication takes the form of message exchange between a sender and a receiver.

The message sender will have to rely on the intellectual understanding of the message receiver. Only by comprehension, the main tacit contribution, can the message receiver fully acquire the knowledge when he is presented with maps, words, or symbols. Polanyi (1965) argued that explicit knowledge has no meaning by itself, as its true meaning lies within the person who uttered it in the first place. In conclusion, tacit knowing predominates altogether in the domain of explicitly formulated knowledge (Polanyi 1965).

When visiting Polanyi’s later work, *The Tacit Dimension*, we notice a change of heart. He reconsidered his prior thoughts and came to his famous conclusion that “we can know more than we can tell.” (Polanyi 1967. Polanyi argues that the statement “we can know more than we can tell” proves that there is always a hidden part of human knowledge which cannot be articulated.

Tacit knowledge is an indispensable part of knowledge; thus removing any personal element in the formation of knowledge will therefore deem all knowledge worthless. “I think I can show that the process of formalizing all knowledge to the exclusion of any tacit knowing is self-defeating.” (Polanyi 1967) All research starts from a problem, and the success of a research is determined by the problem...i.e. if the problem is good then

the research is good. But how can the researcher see the problem? And if he sees it why didn't anybody else see it? (Polanyi 1967) "To see a problem that will lead to a great discovery is not just to see something hidden, but to see something of which the rest of humanity cannot even have inkling." (Polanyi 1967) If all knowledge were to be explicit, then a problem would be impossible to recognize.

Concluding his argument on tacit knowledge, Polanyi (1967) declared that tacit knowing accounts for the following:

- 1- A valid knowledge of a problem,
- 2- The scientists' capacity to pursue it, guided by his motivation to reach a solution,
- 3- A valid anticipation of yet indeterminate implications of the end discovery.

"We must conclude that the paradigmatic case of scientific knowledge, in which all the faculties that are necessary for finding and holding scientific knowledge are fully developed, is the knowledge of an approaching discovery. To hold such knowledge is an act deeply committed to the conviction that there is something there to be discovered. It is personal, in the sense of involving the personality of him who holds it, and also in the sense of being, as a rule, solitary; but there is no trace of self indulgence." (Polanyi 1967)

The notion of tacit power in Polanyi's discussion of human beings is discussed as the "way we actively shape or integrate new experience to discover and believe new knowledge" (Walsham 2001, 599-608). Tacit power is the originator of our knowledge which is different from one person to another. Polanyi (1969) defined tacit knowing as a triad:

- 1- subsidiary things
- 2- creation of meaning from subsidiary things
- 3- integration of meaning things

2.5 Ikujiro Nonaka’s Perception of Tacit and Explicit Knowledge

Nonaka & Takeouchi (1995) expressed that, drawing from Polanyi and others (Plato, Descartes) the duality of knowledge as tacit and explicit is to be conceptualized. They also discussed the difficulties associated with tacit knowledge, because it is personal and context-specific, while explicit is easier and can be transformed in formal and systematic language.

Tacit knowledge and explicit knowledge are not totally separate but mutually complementary entities. Without experience, we cannot truly understand. But unless we try to convert tacit knowledge to explicit knowledge, we cannot reflect upon and share it organizationally. Through this dynamic interaction between the two types of knowledge, personal knowledge becomes organizational knowledge. And the organizational knowledge or intellectual infrastructure of an organization encourages its individual members to develop new knowledge through new experiences (Nonaka & Takeouchi 1995).

This dynamic process is the key to organizational knowledge creation. This interaction between the two types of knowledge brings about what we call four modes of knowledge conversion as described in Nonaka and Takeouchi’s (1995) SECI model. In detail, socialization is transformation from individual tacit knowledge to group tacit knowledge. Secondly, externalization is conversion from tacit knowledge to explicit knowledge. The third is combination which is from separate explicit knowledge to systemic explicit knowledge, and finally, internalization is from explicit knowledge to tacit knowledge (Nonaka & Takeouchi 1995).

	To Tacit Knowledge	To Explicit knowledge
From Tacit knowledge	Socialization	Externalization
From Explicit knowledge	Internalization	Combination

Table-2.4: Nonaka and Takeouchi’s Externalization Model



### **2.5.1 The Knowledge Creating Company**

Nonaka & Hirotaka (1991) provided the following statement as their views on what makes a successful company.

“In an economy where the only certainty is uncertainty, the one sure source of lasting competitive advantage is knowledge. When markets shift, technologies proliferate, competitors multiply, and products become obsolete almost overnight, successful companies are those that consistently create new knowledge, disseminate it widely throughout the organization, and quickly embody it in new technologies and products. These activities define the ‘knowledge-creating’ company, whose sole business is continuous innovation.”

They added that the success of Japanese companies is attributed to their skills and expertise at organizational knowledge creation, that is, the capability of a company to create new knowledge, even though the organization may be disseminated, and embody it in products, services, and systems.

They also argued that a primary source of Japanese companies' competitive advantage stems from their ability to create new knowledge. Japanese managers have been more successful than American managers at converting tacit knowledge, which is relatively difficult to understand and communicate, into explicit knowledge, which is relatively easy to describe, codify and convert into manuals.

Srivastva and Barrett (1988) have demonstrated in their discussion on organizational learning that the imagery in the language of a group changes over time, because with time, people develop new metaphors during discussions, which others may later adopt and further develop.

Nonaka et al. (2001) argued that the one sure source of lasting competitive advantage is knowledge. Managing the creation of new knowledge allows companies to respond quickly to customers, create new markets, rapidly develop new products, and dominate

emergent technologies. Everybody in the knowledge creating company is a knowledge worker. Inventing new knowledge is a way of behaving; a way of being.

Furthermore, he explores the way individuals make knowledge available to others; how the different types of knowledge, tacit and explicit, are created and transferred; and how managers manage the processes of knowledge creation. In other words, he was interested in how structures and practices translate, via metaphors, analogies and models, a company's vision into innovative technologies and products.

### **2.5.2 The Concept of Ba**

The concept of Ba was originally proposed by Japanese philosopher Kitaro Nishida and further developed by Shimizu (1992). Nonaka (2001) adapted this concept for the purpose of elaborating his SECI model of knowledge creation. Ba is a context, which harbors meaning. Thus, Ba can be considered as a shared space that serves as a foundation for knowledge creation.

According to Nonaka, "Ba" can be thought of as a shared space for emerging relationships. This space can be physical as in an office or dispersed business space; virtual as with email or teleconference); mental as in shared experiences, ideas, and ideals, or any combination of them. Ba provides a platform for advancing individual and/or collective knowledge (Nonaka & Komo 1997).

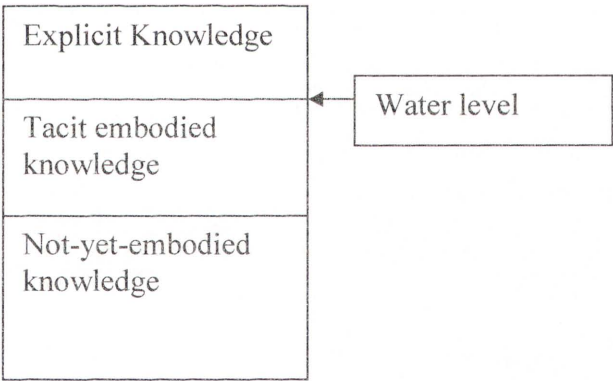
There are four types of 'Ba'; namely, 'originating Ba', 'interacting Ba', 'cyber Ba', and 'exercising Ba', and each corresponds to the four stages of the SECI model. Each category describes a Ba especially suited to each of the four knowledge conversion modes. These Ba offer platforms for specific steps in the knowledge spiral process. Each Ba supports a particular conversion process and thereby each Ba speeds up the process of knowledge creation (Nonaka & Komo 1997).

## **2.6 Claus Otto Scharmer's knowledge perception**

Scharmer (2001) introduced the underlying proposition that knowledge management in the next decade will revolve around the interplay, not only between Polanyi’s tacit knowledge and Nonaka’s tacit/explicit, but around three forms of knowing: explicit, tacit embodied and self-transcending knowledge (not-yet-embodied knowledge).

The self-transcending knowledge adds new insight into the KM discussion. Scharmer’s theoretical argument is that tacit embodied and self-transcending knowledge have their background in different epistemologies as well as different context. His principle ideas are based on a practical argument which emphasizes that managing and nurturing tacit embodied and self-transcending knowledge requires managers to create different types of learning infrastructures (Sharmer 2001).

Scharmer’s epistemology is based on identifying three types of knowledge as described in Figure-2.1:



**Figure-2.1: Scharmer’s Epistemological Model**

Scharmer (2001) assumes two tacit forms of knowledge besides explicit knowledge. He distinguishes explicit knowledge as the least difficult to disseminate and distribute, and tacit embodied knowledge more difficult to disseminate but able to be described in human action. He added that it is a process; an argument similar to Nonaka and Takeouchi’s (1996). This phase is characterized as the interplay between tacit and explicit knowledge. Knowledge creation evolves in a spiraling movement between the



explicit and implicit knowledge held by individuals, teams and the organization (Nonaka & Takeouchi 1995).

Self-transcending knowledge focuses the attention on the thought conditions that allow processes and tacit knowledge to evolve in the first place. Nonaka and Takeouchi (1996) (year) left one question unanswered; namely. what is the force that drives the knowledge spiral itself? (Scharmer 2001). The literature provides examples of this form of knowledge:

- 1- Nonaka & Takeouchi (1998) as Originating Ba
- 2- Schon (1993) as reflection-in-action
- 3- Von Krogh (1998) as notion of 'care'
- 4- Senge (1990) as personal mastery
- 5- Kappler (1993) as pre-scencing
- 6- Jaworski, Gozdz and Senge (1997) as emergent field
- 7- Scharmer (1999) as not-yet-embodied knowledge

All of these scholars point to a formative state of knowledge that precedes the separation of subject and object, or knower and known (Sharmer 2001). We conclude two types of tacit knowledge:

- tacit embodied
- not-yet-embodied

Tacit embodied knowledge considers knowledge as a process not a thing embodied in human action. KM is the interplay between explicit and tacit knowledge. Nonaka and Takeouchi's work described earlier is a good interpretation of this kind of knowledge, which is considered to be embodied in day-to-day practice.

Not-yet-embodied knowledge is an incipient, not yet enacted reality that is brought into existence by an act of action intuition (Nishida, Abe & Ives 1990) or self-processing (Heidegger 1993). It is a state of mind that transcends the distinction between 'inside' and 'outside', between 'I' and 'thou' and between knowing and acting (Scharmer 2001).

Embodied knowledge is marked by the individual's own awareness and articulated in the form of procedures and processes. The not-yet-embodied knowledge relies on factors, which are purely personal and requires the individual's analytical abilities, reflections, synthetically abilities, logical analysis, and creativity. It is articulated in forms such as solutions, design, innovation, design, opinions, and ideas.

Scharmer (2001) concluded by saying "explicit knowledge is based on the separation between the knower and the known, whereas both forms of tacit knowledge are based on the unity of subject and object. Because aesthetic experiences are often described as being simultaneously inside oneself (acting) and outside of oneself (observing), the various types of self-transcending knowing all qualify as genuine aesthetic experience." Embodied knowledge is marked by the individual's own awareness and articulated in the form of procedures and processes.

Diagram-2.1 (El-Den 2006 a, b) represents the thesis's interpretation of the different types of knowledge. The diagram also presents examples of the required inputs and outputs for each knowledge type.

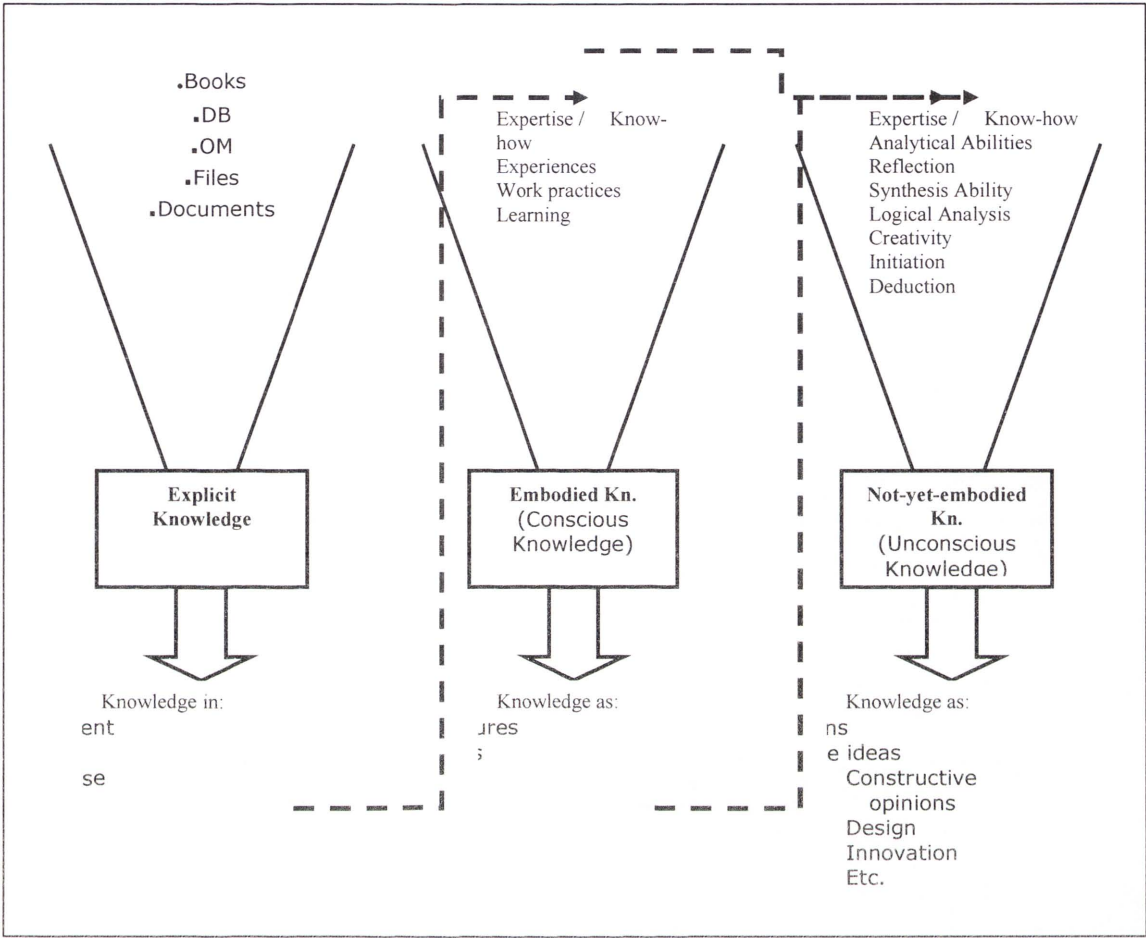


Diagram-2.1: Knowledge Interpretation

2.7 Tacit Knowledge Transformation

Knowledge is created through interactions between tacit and explicit and not from either tacit or explicit alone (Nonaka et. al 2000). The question of whether tacit knowledge can be transformed into another form remains critical and debatable. It is hard to transform such knowledge because it is hard to articulate it, hard to express it, and in most cases it is not-yet-embodied. Researchers had different views regarding the transformability of tacit knowledge summarized in Table 2.5:

Researchers Views on tacit Knowledge transformation



Von Krogh & Ross (1995)	Tacit knowledge cannot be communicated
Baumard (1996, 1999)	Difficult but can happen through socialization
Choo (1998)	Had some doubt, but may be transformed
Nonaka & Takeouchi (1995)	Simply aver that it is difficult but proposed externalization
Aadne et al. (1996)	Difficult to transform
Patel et al. (1991)	Cannot be expressed in written verbal form. Can be transformed
Collins (2001), Tsoukas (2003) Herbig & Bussing (2003)	Cannot be transformed
Torf (1999), Fleck (1996), Boiral (2002), Spender (1996), Wagner & Stenberg (1986, 1991)	Difficult to express but can be made explicit
Polanyi (1965)	Did not even address the issue. Sometimes he referred to tacit made explicit through writing
Berger & Luckmann (1967)	Knowledge cannot be objective or universally applicable
Gallier & Newell (2000)	Only data can be transformed not information or knowledge
Hayes & Walsham (2000), Walsham (2001), Schultze (2003)	Knowledge is neither a commodity nor a quantifiable asset. Cannot be transformed
Foray & Steinmueller (2003)	Codification of knowledge is possible
Dick Stenmark (2003)	Transformation is possible
Cook & Brown (1999)	Transformation not possible. Tacit cannot become explicit and vise versa.
Kothuri (2002)	Transformation is possible. Implicit knowledge.

**Table 2.5- Literature's Views on tacit knowledge transformation**

There is widespread disagreement among researchers regarding whether tacit knowledge can be transformed or not. There are many reasons for this debate in the literature, first because of its imbedded illusiveness, second it is ill defined, and third it has many types. It is not surprising to find claims that the notion is under-specified; that it carries too many meanings; or that we only have a nascent understanding of tacit knowledge, and it resists operationalization (Gourlay 2004).

Tsoukas (2003) explained that this disagreement is a result of misunderstanding Polanyi's 1965 'ineffable' views on tacit knowledge. The fact that citation of Polanyi's concepts on tacit and explicit knowledge is integral to any research work had made it difficult for those who believe that tacit knowledge or at least some types or forms of it, can be transformed because they would then be 'swimming against the current'.

Not all tacit knowledge is incapable of being uttered or articulated. Cited in Gourlay (2002), Collins (2001) proposed that tacit knowledge can only be passed on by personal contact. Shum (1998) and Swan, Newell, Scarborough and Hislop (1999) realized that the management of tacit knowledge "poses significant challenges in comparison to the explicit capture/codify/store approach" (262-275). Polanyi's (1967) interest was in the kind of knowledge, which we routinely use and take for granted, such as the ability to recognize the face of a friend. It is irreducible to explicit prepositional knowledge and cannot be articulated.

The two most prominent works on KM are those of Polanyi (1967) and Nonaka (1991). The former argues that tacit knowledge is "Known but cannot be externalized because it is inaccessible" and that "we can know more than we can tell". The latter argues about the difficulties associated with tacit knowledge because it is personal and hard to formalize. But he and Takeuchi (1995) demonstrated that through externalization, tacit knowledge can become explicit. They also argued that tacit and explicit knowledge are mutually complementary and that the creative activities of human being are the result of the interaction between the two. Leonard and Sensiper (1998) further proposed that individuals often know more than they can realize.

Additionally, Nonaka (2001) emphasizes that the sharing of tacit knowledge requires physical proximities and that it takes place through interactions among people. Alavi & Leidner (2001) argued that only individuals who have a requisite level of shared background can truly exchange knowledge.

Teece (1998) agreed with Polanyi (year), Nonaka (year) and others about the difficulties in articulating tacit knowledge. Huang (1997) shares Nonaka's view that although it is difficult to articulate, tacit knowledge can be captured. Finally, Von Krongh (1998) argued in the constructionist approach about the social construct of tacit knowledge and that it is a duality consisting of explicit and tacit knowledge

Belohlavek (2006) has identified knowledge as being "Intellectual knowledge, which has to do with the knowledge of ideas. Real knowledge, which has to do with the elements of the individual's external reality that he, seeks to understand."

It is important to note that the tacit and explicit knowledge categories are mutually constituted, not mutually exclusive (Alavi 2001). This means that tacit knowledge is the basis of all knowledge and that it can be converted into explicit knowledge through linguistic expressions. And explicit knowledge is always grounded on a tacit component (Polanyi 1975). Also, Lehner and Lehmann (2004) argued that although it is much easier to stimulate, combine and communicate explicit knowledge than tacit knowledge, there are many situations in which tacit knowledge cannot and will not be wholly converted into explicit knowledge.

Imel (2003), argued that "Tacit knowledge, the knowledge possessed by employees but not articulated, is associated with terms such as 'skills,' 'know how,' 'working knowledge,' and 'expertise' that are used to describe knowledge about and ability to perform work", This argument is also shared by Cooke (2003), Farrell (2001), Hager (2000), and Sveily (1999). Learning that takes place through apprenticeships (Collis & Winnips 2002; Gamble 2001) draws heavily on tacit knowledge, and it has been connected with informal learning (Eraut 2000) and organizational learning (Collis & Winnips 2002; Lindley & Wheeler 2001). Recently, its role in KM has been explored (Gourlay 2002; McInerney 2001).

In summary, if tacit knowledge is to be used in KM it is imperative to find a way to make it accessible. I agree with most researchers' views regarding the difficulties in capturing the not-yet-embodied knowledge part of tacit knowledge, but I also believe that not all



aspects of this type of knowledge is not transformable or at least might be transformable through a process of discussion and interaction. However, pioneers in the knowledge management industry have found a middle ground. Some knowledge believed to be tacit can be transformed into explicit knowledge producing a body of knowledge known as implicit knowledge (Frappaolo & Wilson 2002). Implicit knowledge is the subset of tacit knowledge that can be transformed into explicit knowledge. Knowledge which could be codified if subjected to some type of data mining or translation process is another view of implicit knowledge (Kothuri 2002).

Faced with the elusiveness of tacit knowledge, Stenmark (2000) provided three reasons for the difficulties in transforming it.

1- We are not necessarily aware of our tacit knowledge

The thesis argues that interactions and communication in cooperative work would raise the individual's awareness. From an individualistic perspective, Stenmark's argument is valid. A stimulus is needed for raising awareness about what a person really knows. Possibly cooperation, collaboration, and discussions could be part of the answer as they act as a trigger for the awakening of dormant knowledge in the brain of individuals as a result of interaction.

2- On a personal level one does not need to make tacit knowledge explicit in order to use it

The thesis argues here that in today's global business environment tacit knowledge is not a trait of individuals and that it has no value to businesses if not shared. Consequently, given that today's businesses are conducted collaboratively, Stenmark's basis for his claim seems to be irrelevant. The need for the individual's know-how and expertise in general is imperative to success and competitiveness in businesses. The only way for businesses and groups to benefit from this knowledge is through sharing it with others; otherwise, it would have limited or no value.

3- Individuals may not want to give up a valuable competitive advantage

This is a very general assumption which does not apply to cooperative work, which is a small group of people with common aims of fulfilling a defined task. In such an environment, it is the individual's interest to surrender his/her tacit knowledge and to share it with others in the group in order to gain credibility and competitiveness within his/her group. Technology might give incentives to individuals to increase their sharing of tacit knowledge in virtual cooperative settings given that this technology does not only capture the knowledge but also ownership of personal contribution. As a result, obstacles that hinder individual contribution and articulation of his/her knowledge because of fear of other's claims on it would be overcome.

It is obvious that transforming all aspects of tacit knowledge would be difficult, because of the personal nature of such knowledge. It would not be easy to capture and transform the thoughts and experiences of individuals. The knowledge gained by humans through years of trial and errors is hard to articulate and in many cases, and equally hard to be conceived properly by others. Hall and Andriani (2002) argued that the major challenge of an organization should be the achievement of balance between the tacit knowledge developed by individuals and the explicit knowledge needed for effective communication and integration. The suggestion was to make the bulk of organizational knowledge explicit. Therefore one must look at the easier parts of tacit knowledge and try to capture the experiences. In this research, as claimed earlier, the opinions and ideas of individuals might form the basis for the sharing, capture, and transformation of parts of tacit knowledge into explicit form.

## **2.8 Knowledge Management, Knowledge Transformation, and Measurement**

Knowledge suffers from what might be called "terminological ambiguity" because of the different classifications which explain the meaning of knowledge in relation to the beliefs and perception of the person who is classifying, defining or measuring it.

Interestingly, today's debate in the KM circles is on whether the focus should be on the acquisition of tacit knowledge or on sharing of explicit knowledge more effectively.

Many researchers have described knowledge in KM to be of the following types (Table 2.6):

Researcher	Type of Knowledge
Scharmer (2001)	Tacit embodied, explicit, and self-transcending (not-yet-embodied) knowledge
Imel, S (2003)	Tacit vs Explicit
Nonaka (1991), Lye A (2003)	Tacit vs Explicit
Logut and Zander (1992)	Information vs. Know-how
Conklin (1996)	Formal vs. Informal
Rulke, Zaheer & Anderson (1998)	Transitive vs. Resource
Seely Brow &, Duguid (1998)	Know-how vs. Know-what
Leonard & Sensiper (1998)	almost tacit vs. almost explicit
Hildrteth et al. (1999, 2002)	Hard vs. Soft
Spender, J (1998)	Explicit, implicit, individual, Collective
Collins, H (1993), Blackler (1995)	embodied, embedded, embroiled, encultured, encoded
Boisot (1995)	Proprietary, public, personal, and Commonsense
Polanyi (1964, 1965, 1967)	Tacit knowledge: is the basis for all knowledge
Choo (1998, 2000)	Tacit, explicit, cultural

**Table 2.6: The literature’s pluralistic views of knowledge**

Dick Stenmark (2001) in the Journal of Management Information Systems, stated, “without going too deeply into the philosophical debate of what exactly knowledge is, we may notice that most voices in the KM discourse have abandoned the positivistic view of knowledge as an objectified and monistic absolute truth. Instead, the KM community has adopted a pluralistic epistemology, acknowledging that there are many forms or types of human knowledge.”



In the past, KM was considered part of Artificial Intelligence where knowledge was viewed as information that can be codified, stored, transmitted and easily measured. Expert systems were developed to 'capture' the knowledge of experts in databases, manuals, books, reports and documents. The emphasis was towards managing the knowledge assets that are tangible, easily structured and codified. Davenport and Prusak (1998) stressed that "The most common use of technology in KM is to create a repository of so called 'structured knowledge'. Simply stated, KM was often regarded as Information Resources Management (IRM) (Hildreth, Wright & Kimble, 1999, 2001)."

Recently, there has been a major understanding among researchers and scientists that KM is the management of both tacit and explicit knowledge. Previous approaches to KM have attempted to concentrate on the capture and control of what is termed as 'structured knowledge'. This view, which considered knowledge as an object, dominated the KM discussion. The capture/codify/store approach is technologically dominant and basically centers on explicit knowledge. In recent years, there has been a shift of mindset toward approaching KM from a different angle. It is not surprising to find a great deal of literature on the phenomenon of tacit knowledge in the workplace; however, little in the way of an available methodology for its measurement (Busch & Richards 2001) other than that proposed by Sternberg (1995) and his Yale University research group which make use of a Likert scale for a sequence of scenarios for which respondents are asked to pick a rank and potentially also to write "plans of action" for how they would handle each of the allocated answers below the scale.

This shift is centered on 'less structured' knowledge (Hildreth & Kimble 2002), which cannot be easily articulated, abstracted, codified, captured and stored. This knowledge is also called tacit knowledge. The main argument to the importance of including this type of knowledge in the KM field is that it constitutes a major competitive advantage to the organization, if and only if, it can be captured, transformed, and used. Hildreth and Kimble (2002) continue by stating "most approaches to the management of 'soft knowledge' are flawed and that the KM industry is in danger of falling into the same trap as previous attempts – simply trying to capture, codify and store knowledge – that is, take

an IRM approach. Consequently, it is imperative to find a way to manage this 'less structured' soft knowledge.

The dissertation is based on both an epistemological and an ontological analysis. The former addresses the philosophical problems surrounding the theory of knowledge in order to answer questions concerning what knowledge is, how it is acquired, what parts of tacit knowledge can be codified, and what makes it knowledge in the first place. This thesis distinguishes the pluralistic approach to KM and mainly identifies tacit knowledge as composed of tacit embodied and not-yet-embodied knowledge (Scharmer 2001). The latter will describe the concepts and relationships that may exist for individuals and group members in a collaborative set-up as well as support for the retention and accessibility of knowledge; namely, group memory.

The thesis categorizes two types of tacit knowledge which can be externalized and measured by individuals and group members and at the same time may easily be transformed into explicit knowledge. The thesis also proposes that tacit knowledge can be effectively measured as a result of this categorization. Measuring tacit knowledge into types or parts without identifying and categorizing it, results in the question of, how anyone could measure something which is not manifested in one way or another. It is important for researchers working on tacit knowledge to be able to manifest types or forms of knowledge with lesser complication than its entirety.

From an epistemological point of view, the thesis considers tacit and explicit knowledge as inseparable entities, based on Nonaka's (1997) pluralistic view, and Mildreth & Kimble's (1999) Duality of knowledge. Polanyi's (1966) monistic view, which considers tacit knowledge as the main knowledge in KM, will also be addressed. Both are needed for effective externalization of knowledge as the proper articulation of tacit knowledge is best captured in an explicit form to make use of it later.

The author affirms the views and discussions of many researchers that tacit knowledge is elusive, hard to formulate, hard to articulate, hard to capture, and hard to measure. This has been a debatable issue in most of the literature to date. At the same time, there

appears to be a tendency towards an informal agreement among researchers that some forms or types of tacit knowledge can be made explicit. As discussed previously, Nonaka Takeuchi (2001) and others have proposed ways to transform tacit knowledge into explicit knowledge. Nonaka's externalization process was criticized by many, including Stenmark (2000) as being expensive and difficult to realize. Stenmark (2001) has identified three reasons for the difficulties. Others have criticized converting tacit into explicit based on the argument that most of the aspects of tacit knowledge cannot be made explicit because it is:

- 1- Personal
- 2- Based on expertise
- 3- Based on know how
- 4- Based on believes, opinions, ideas etc.

Recently, there has been a shift in the literature towards addressing the issue from a different narrower perspective. Some questions have been raised on whether or not there are some 'parts' of tacit knowledge that are easy to be transformed into a codified form. If so, the consequences would be their capture and transformation. Accordingly, the categorization of tacit knowledge becomes integral to its externalization as attempts to externalize it in its entirety are extremely difficult if not impossible. The literature lacks techniques and methods for this sharing and measuring. It is not sufficient for organizations to deal with tacit knowledge as comprised of two parts, one which is embodied in skills and the other which cannot be demonstrated and is very difficult to transfer and measure for its successful externalization. Organizations need to realize the importance of finding within tacit knowledge parts or types which are manageable and can be easily articulated and released by individuals in order to start the difficult process of disseminating them within the organizational processes.

From an ontological point of view, this thesis considers individuals and groups as the platform for knowledge capture and transformation, and group memory systems as a



platform for the retention and accessibility of knowledge. The groups in this research are 'specialized groups' where the members have the following characteristics:

- 1- Compatible levels of expertise, qualification, background, and such
- 2- Willing to work towards predefined goals and objective
- 3- Able to work on a context
- 4- Willing to use a cooperative tool or a groupware for interaction

Researchers have presented different methods, which might help in the capture and the transformation of tacit knowledge into explicit knowledge.

- 1- Polanyi (1967) and Nonaka (1991) proposed that the KM approach should follow a cognitive/representational approach, and they simply tried to make soft knowledge hard.
- 2- Lave & Wenger (1991) introduced a process called Legitimate Peripheral Participation (LPP) in Communities of Practices (CoPs) which can assist in the creation and sustenance of soft knowledge. They argued, "Soft knowledge is developed and learnt through being socialized into the community through interaction with existing members".
- 3- Finerty (1997) pointed out that technology has a role to play and that researchers' emphasis should shift from object representation of knowledge to expertise sharing through technology use.
- 4- Davenport & Prusak (1996, 1998) shared a similar view to Finerty and declared that, "...the more rich and tacit knowledge is, the more technology should be used to enable people to share that knowledge directly. It's not a good idea to try and contain or represent the knowledge itself using technology.)
- 5- Cook and Brown's (1999) method is also based on social and physical interactions. They argued about the importance of interaction as being integral for knowing in both the social and physical worlds.
- 6- Hildreth and Kimble's (2002) argument against treating knowledge as made of opposites but as a duality means that both soft and hard knowledge must be

taken into account in any attempt to manage knowledge. Their finding is that, although under certain circumstances tacit knowledge can become explicit, it is perhaps accurate to say that even then only part of what is tacit is made explicit.

It is important to note that these methods require groups to be physically present for the capture to occur.

In summary, the literature stresses that in order to deal with knowledge (tacit or explicit) the followings are imperative:

- 1- Social interaction: Lave & Wenger (1991)
- 2- Physical interaction: Lave & Wenger (1991); Finerty (1997); Cook & Seely (1999)
- 3- Use of technology (almost by all researchers)
- 4- Cognitive/representational approach: Nonaka (1991); Polanyi (1967)
- 5- Learning: Nonaka (1991); Mildreth & Kimble (2002); Collis & Winnings (2002); Camble (2001)
- 6- Sharing: Nonaka (1991); Mildreth (2002)

Knowledge can be captured socially through sharing and interactions using the technology as a platform or using a cognitive/representational approach (El-Den 2003).

It is necessary to provide support to capture knowledge by groups where the members are dispersed over time, space and location. This can be accomplished by providing cooperating individuals with a tool or a group support system which closely reflects the constituents of the actual face-to-face situation where the members are interacting physically, and at the same time.

Unfortunately, not all knowledge can be easily codified and stored; not all explicit; otherwise, there would be no need for a new paradigm. Tacit knowledge is there to stay and it is becoming important in KM to the extent that it is considered by many to be the only differentiating factor in competitiveness. Stenmark (2001) argued about the

importance of the use of technology to locate expertise in businesses as a superior activity to those of simply indentifying, capturing, and transforming tacit knowledge.

The process of knowledge capture is a mental process, which can be accomplished through collaboration, interaction, inter-activeness, and filtration. The following steps show what is required for the capture to occur:

- 1- A platform which would help in the initiation and elicitation of knowledge
- 2- A nurture process which augments the existing knowledge
- 3- A filtration process which would help in extracting the ideas and opinions of the group members from the captured knowledge
- 4- A platform for the retention and accessibility of the captured knowledge

Techniques on capturing knowledge in the literature have focused mainly on the role of the knowledge developer as a facilitator of the process through the use of interviews and questionnaires in order to evaluate the experts and to decide on the level of expertise. I believe that this process could become very complicated whether using the single expert's approach or a multiple experts approach because of the psychological, cultural, situational and philosophical problems associated with such techniques. Such problems could be summarized as:

- 6.2 Creating the right impression for the experts
- 6.3 Understanding the expert's style
- 6.4 Preparing for the interviews
- 6.5 Deciding on the appropriate approach (Ghaziri & Awad 2004)

Other knowledge capturing techniques are (Ghaziri & Awad, 2002):

- 1- Brainstorming
- 2- On-site observation
- 3- Electronic brainstorming



- 4- Protocol Analysis
- 5- Scenarios
- 6- Nominal Group Techniques (NGT)
- 7- The Delphi method
- 8- Concept mapping
- 9- Semantic maps
- 10- Black boarding
- 11- Workspaces
- 12- Group Support Systems

There is no one technique to date that has been adopted on a large scale or become the one used for the capturing of knowledge because of the short-comes and difficulties associated with such techniques.

## **2.9 Computer-supported cooperative-work (CSCW), Groupware, and Group memory**

### **2.9.1 Computer-Supported Cooperative-work (CSCW)**

Paul Cashman and Irene Grief (1984) officially introduced the field of CSCW into the computer science area. Today, many disciplines use the concept of CSCW at the core of their practice, notably, Computer-Supported Cooperative-Learning (CSCL), Computer-Assisted-Software-Engineering (CASE), Computer-Aided Design (CAD), Computer-Assisted Manufacturing (CAM), and Group-Decision Support Systems (GDSS). The multidisciplinary usage of CSCW and its widespread engagement is simply a reflection of its ubiquity in modern computing and organizational work.

CSCW is a place for people from different or same fields to share experiences and work together as a group using a computer. The main concern in CSCW is not building software for people to cooperate, but an understandability of the way people work together. This is because this understandability of the practices of people at work affects the design of support for cooperation.

CSCW aims at building computer systems to support people working in groups. The literature attributes many attempts in building systems for groups together with the new shift of mindset towards globalization. Some of these systems are now being used by major businesses on a global level to support management, employees and major businesses in their attempts to gain competitive advantages. Examples of such systems are Blogs, Wikis, Lotus-Notes, GroupWise 6, 2ndC DocuWise, Group Link, Netscape Communicator 4, and Exchange 2000.

There is no universal definition of CSCW that can be adopted in all disciplines. Bannon (1992, 1998) presented different versions of definitions for CSCW and Kling (1991) sees CSCW as a conjunction of “certain kinds of technology, certain kinds of users and a worldview that emphasizes convivial work relations” (83-88). This definition does not identify the type of technology nor the users or the relationships among those who are involved in cooperation. This is a reflection of the problems of setting standards for the technology used in CSCW; namely, who uses the technology, and the relationships among those using the technology.

Among other definitions, CSCW can be defined as “a multidisciplinary research field including computer science, economics, sociology, and psychology. CSCW research focuses on developing new theories and technologies for coordination of groups of people who work together” (Grudin 2000)

Other researchers have adopted more direct points of view regarding the role of computers in CSCW without too much concern of what relationships govern the work among people. Greif 1985 following this line of thought defined CSCW as “an identifiable research field focused on the role of the computer in group work” (14-18). Bannon & Schmidt (1991) also defined CSCW as “an endeavor to understand the nature and characteristics of cooperative work with the objective of designing adequate computer-based technologies” (3-17). The definition emphasizes that in CSCW it is vital to understand the social organization of work and group work as well as their implications during the design of adequate support technology.

The Study of CSCW is on how cooperative work can be best supported and enhanced by the use of an effective technology. It refers to a special type of products (groupware) as well as to a social movement by researchers in computer science for better technological support to enhance collaboration and cooperation among individuals and members in groups and communities.

The context of the individual's work has major implications on the design of CSCW. In other words, CSCWs are developed based on the needs and support of the groups and communities. In addition, the multidisciplinary nature of CSCW necessitates the building of computer support groupware, which addresses the type of the users involved, the work to be accomplished, and the necessary relationships between users during such work. This varies from one set up to another and from one groupware to another, exemplifying the different group support systems and groupware availability in the literature.

Hughes, Randal, and Shapiro (1992) argue that CSCW should be considered as a paradigm shift rather than a distinct field of study when designing group support systems. Accordingly, CSCW is identified as a support mechanism that is needed in all fields of work especially with today's global business environment. Suchman argues in favour of this statement by describing CSCW as "the design of computer-based technologies with explicit concerns for the socially organized practices of their intended users".

### **2.9.2 Groupware**

Groupware which is defined as "software that provides functions and services that support the collaborative activities of work groups" (Lauden & Lauden 2000) is the building of computer systems that facilitates the work among individuals and within groups and communities. Generally, it refers to a specific class of technologies which relies on modern computer application networks such as email, newsgroups, videophone, Blogs, Wikis, and chats. Greenberg (1991) defined groupware as "A software that supports and augments group work" and which allows distributed individuals to contribute to the different activities and processes within the groups.



The main challenge of CSCW has been to enable members of a group to work together through networking computers. This challenge has resulted from two trends. The first is that people work together in cross-organizational teams and this work has to be coordinated to be efficient. The second is that individual's tasks are now performed through computers; hence, those of the group should also be (Mills 1999).

Due to the nature of cooperative work and the multidisciplinary nature of CSCW, any proposed groupware design should offer a user-friendly platform to encourage users and to accommodate for their effective interactions. In order to fulfill these tasks, it is imperative to involve the future users in the design of the system so that it perfectly fits their needs in terms of satisfaction and connectivity. In this process, usability, individual's psychology, group dynamics, the efficiency of communication and the effects on the organization's structure have to be taken into consideration (Ramage 1990).

A more recent groupware support for managing knowledge and expertise in organizations is growing rapidly (Snis, 2001). The origin of this advancing effort comes from the field of Organizational Memory (OM), which has been widely developed during the last decade (Conklin & Begemen 1988; Ackerman & Malone 1990; Ackerman 1994; Kutti & Virkunen 1994; Kristoffersen 1996; Conklin 1996; McDonald & Ackerman 1998).

CSCW and groupware promise to help the KM process by providing the necessary theories and the tools for either cooperating or collaborating groups and group members.

In collaborative settings emphasis is on building network support that links the different groups as well as support for the interaction among the members within the group and in different groups, especially in situations where involvement of a member spans over more than one group. Group formation in this case takes into consideration task distribution, time involvement in each task, culture within the organization, member's expertise, abilities, and know-how.

In cooperative settings, emphasis is more on building support which helps members in the same group to cooperate in performing their task through the exchange of their know-how without considerations of other groups' performances. There are no task dependencies here and a clear boundary between the groups.

CSCW provides the basis for developing new theories and technologies for coordination support for people working together. Support for cooperation necessitates clear understandability of the nature of work as well as the culture of the people involved. There is no universally available support system that would be applicable to any group work, but there are support systems that are customized for specific contexts.

This thesis introduces a tool as an example of groupware for geographically distributed 'small' group members, such as students, engaged in the development of a semester long term projects.

### **2.9.3 Group Memory**

Group Memory (GM) is a terminology which has not acquired many definitions in the literature. The term 'memory' implies the capacity to encode, store and retrieve information, and the term 'group' is defined as "two or more people working together on the same task or assignment." (O'Brien 2001).

The group memory is part of an organizational memory; which is considered to be the collective know-how of the individuals in the group. It nurtures the organizational memory and augments the organizational knowledge.

A powerful and wealthy organization is one that recursively and positively encourages groups in building their memories through the proper capture of the information/knowledge of the organization's experts. These are domain experts, information management experts, and even experts in the field of research domain of the group.

GMs retain the captured knowledge by documenting members' experiences, ideas, and opinions as well as their know-how.

A group memory system retains the group's accumulated knowledge as one of collaboration on a shared workspace; facilitating the communication between group members and enhancing knowledge retrieval upon request to satisfying users' needs for information.

This knowledge is the subject for discussion, conversation; nurturing, and filtering among the members. Only relevant knowledge will be retained in the group memory. This is the result of a high level support for interaction among the group members on their released knowledge, namely opinions and ideas. These act as a trigger for reflection on the individual's own perception of his/her thoughts, opinions, and ideas. It might also act as stimulus for the other members to reflect on the individual's knowledge and new thoughts, ideas, and opinions might be released as a result.

A group memory shares the context of the personal and managerial aspects of work and encourages people to share their work practices to improve overall organizational performance. At this level, GSS will constitute the platform for collaborative work and the transformation process, from the capture and retention of the knowledge to the organization and retrieval of that knowledge. According to Wenger (1995), group memory refers to "the ability to store knowledge in a group over time and to retrieve it at a later point of time".

The thesis's developed tool has an imbedded group memory which is integral for both the groups' retention of their released opinions and ideas during the term development project and the 'systems' level for individuals' search and access for documents and experts.

## **2.10 Current Tools for the support of distributed individuals**

There is obviously an increase in decentralized organizations among communities and groups as a result of globalization. More focus in research, but without much success, has



been directed towards the development of communicative, collaborative, and cooperative technologies to support co-located groups and individuals, as well as communities of interest and practice. Also noticeable is the extent of work on virtual teams and groups. Such groups are geographically distributed where individuals are to be supported with communicative and collaborative technologies to fulfil specific and critical tasks. An interesting emergent work as a result of such cooperative work has been noticed on managing knowledge which is the result of discussions, expertise, and individuals' problem-techniques among these individuals. This has resulted in attempts to manage such knowledge by organizations as well as researchers in a context specific fashion. Depending on the definition of knowledge, organizational context has a changed meaning in knowledge creation (Kivijarvi 2004).

The organizational context matters in knowledge externalization, use, and measurement. The manner in which one can successfully support knowledge externalization and measurement varies depending on the organizational context. This explains the existence of numerous knowledge definitions as well as KM definitions, cycles, and techniques.

Knowledge transformation as part of the externalization process had a momentum among researchers after Nonaka and Takeouchi's 1995 SECI-process was introduced and became the platform for face-to-face knowledge conversion. The most exiting work in the SECI process was on tacit knowledge capture and transformation which started to gain momentum and considerable importance as organizations identified it as an indispensable, if not the only, element for competitiveness. At the same time, researchers have clearly acknowledged the difficulties of transforming such knowledge and concluded that such knowledge cannot be entirely externalized to other forms of knowledge. This was first proposed by Polanyi 1965 and subsequently by all researchers in the field. Ever since, not much work has been done to identify or categorize tacit knowledge into parts or types which can be easily transformed. Most researchers identified thoughts, know-how, and intuitions as parts of tacit knowledge but without clearly proposing a method or a process on how to be externalized and measured. Based on the literature, the articulation of someone's know-how and expertise is integral in most existing knowledge capture and transformation research work, and that it falls short in

providing a combination of a knowledge definition, KM cycle, and a support tool (GSS) as a basis for such work.

There is a lack of a complete knowledge conversion process among distributed individuals similar to Nonaka's 1995 face-to-face SECI-process. One of the very rare works on the topic was introduced by Imad, Souren and Sureh (2008) who argued that Nonaka and Takeouchi's face-to-face knowledge transformation principles may also be applied in virtual environments, although they did not proffer an explanation as to how this could be accomplished other than following the same phases of the SECI-process. The thesis argues against this claim as the basis of the SECI-process is co-existence and there is a need for a new, or a similar, process which can be adopted by dispersed individuals.

Web-based electronic discussions and chat groups were used as effective and appropriate tools for knowledge transformation (Davenport 1995). Recently, more systematic collaborative platforms emerged as a category of computer software supporting group work using email, calendaring and scheduling, and cataloguing as techniques for communication, collaboration, and cooperation among dispersed individuals. This platform distinguishes three categories of work:

- 1- Team collaboration: file synchronization, ideas and notes in Wiki, task management, full text research, etc.)
- 2- Real time collaboration and communication: presence, instant messaging, web conferencing, application sharing, voice, audio, and video conferencing.
- 3- Social computing tools: blog, Wiki, lotus notes, tagging, and shared bookmarks.

Others have used interactive tools for communication for:

- a- conversational interaction, for example telephone and instant messaging
- b- transactional tools

- c- collaborative interaction, for ideas generation, design creation, achievement of a shared goal)

Businesses have introduced software packages for teams and team member's interactions:

- 1- The HKNet project as a group support system for virtual collaboration using email, video conferencing, and internet phone connections
- 2- GroupSystems (Thinktank), which helps teams achieve group collaboration, providing requirements definition, strategic planning, vendor evaluation and risk assessment using we conferencing, instant messaging, content/document management, and email
- 3- Blogs and Wiki as supportive software for individuals and groups interactions

Churchill and Bly (1999) considered the use of text-based multi-user domains (MUD) as technology supporting collaborative work among co-located individuals where users experience virtual rooms through textual description containing information about objects and other users in the room. Unlike synchronous technologies such as telephone or desktop video conferencing, or asynchronous techniques such as email, MUDs offer support for real time interaction. This use of MUD was criticized by researchers as limited to internet gaming and social chat. An exception is a paper by Evard (1993) who argued about MUD's success in supporting a team of co-workers. He argued that this was because imbedded in it are communication integration and flexibility in providing different ways of interaction among individuals without the need to shift between different tools.

Currently, these tools and software, and/or the integration of them, are used as group support systems and groupware for the interaction between remote individuals in organizations, communities and groups. Their impact on the performance of virtual teams was the subject of several studies but their impact on knowledge creation has not been examined (Majchrzak, Rice, King & Malhotra 2000). These tools have facilitated the interaction, communication, and collaboration among and within distributed groups but not their quest to capture and transform knowledge effectively and efficiently. With



respect to knowledge related issues, past research on virtual teams seems to focus primarily on aspects that are not related to knowledge creation per se. (Imad, Souren & Suresh 2008). Most prior studies dealt with issue like the creation of shared understanding (Cramton 2001, Hollingshead, Fulk & Moge 2002); the impact of work context-related information or performance (Cramton 2001); and knowledge creation by means of brainstorming or idea generation (Connollt 1997, Cummings, Schlosser & Arrow 1996, Pinsonneault, Baki & Gallupe 1999, Ray, Gauvin & Limayem 1996, Valich, Dennis & Connolly 1994, Ziegler, Diehl & Zijlstra 2000).

Bandow (1997), in her paper on geographically distributed work groups and IT, identified telephones, email, computer conferencing, tele and video conferencing, virtual hallways, GDSS and group communication systems as possible IT systems to support virtual groups. She concluded that her research would rotationally contribute to the design of IT which would enable better and more effective communication between groups, and provide a model for effective working relationships at both the individual and group levels. It would also assist in identifying requirements for organizational support for dispersed group members.

In conclusion, group support systems should not only provide interactive support but also support for the externalization of the different types of knowledge. Currently, there are many claims that effective and comprehensive knowledge creation among distributed groups and individuals is possible through the use of existing GSS and groupware in virtual teams. However, none of these claims provide and/or discuss more than the integration of them hoping that this will lead to variations in the level of the resulting knowledge conversion.

Geographically distributed individuals require IT support which provide all the necessary functionalities for their synchronous or asynchronous work and product development. The IT support should imbed techniques for KM, including release, capture, transformation, filtration, and retention, as well as awareness, instant messaging, file transfer, file editing, text editing, idea generation, goals setting, discussions, and expert identification. This support system must be developed based on a proper and clear

process for virtual knowledge conversion. Unfortunately, the literature fell short in providing such a theory and artefact.

This dissertation's methodology is an attempt to fill part of the literature's gap concerning the externalization of tacit knowledge and its measurement. The methodology suggests the categorization of tacit knowledge into types or parts which might be externalized and measured easier than others. These types are implemented using a developed tool, and experimentally measured.

## **2.11 Opinions and Ideas Definitions**

The importance of opinions and ideas is integral to this research as they are the two categorized types of tacit knowledge. The experiment and its results reflect whether the distributed individuals were successful in the knowledge externalization process. To begin with, extracts from the literature's definitions on opinions and ideas are presented as follows:

### **2.11.1 Opinions ([www.hyperdictionary.com/dictionary/Opinion](http://www.hyperdictionary.com/dictionary/Opinion)):**

- 1- "A belief or sentiment shared by most people, the voice of the people"
- 2- "A message expressing a belief about something"
- 3- "The judgment or sentiment which the mind forms of persons or things; estimations"
- 4- "The formal decision, or expression of views of people called upon to consider and decide upon a matter or point submitted"

Other definitions are from dictionary.com

- 5- "A belief or conclusion held with confidence but not substantiated by positive knowledge or proof"
- 6- "A judgment based on special knowledge and given by an expert"
- 7- "The prevailing view"
- 8- "A personal belief that is not founded on proof or certainty"

And from Oxford's advanced Learners Dictionary:

- 9- "Your feelings or thoughts about somebody, rather than a fact"

- 10- “The beliefs or views of a group of people”
- 11- “Advice from a professional person”

#### **2.11.2 Ideas ([www.hyperdictionary.com/dictionary/Opinion](http://www.hyperdictionary.com/dictionary/Opinion))**

- A- “Ideas are special concepts which arise out of our knowledge of the empirical world, yet seem to point beyond nature to some transcendent realm”
- B- “Something, such as a thought or concept, that potentially or actually exists in the mind as a product of mental activity, an opinion, conviction, or principle”
- C- “The ideas are the heart of the message, the content of the piece, the main theme, together with all the details that enrich and develop the theme...”
- D- “Concepts, philosophies, images or issues that provide the psychological stimulus to solve problems or adjust to the environment”

From Oxford’s Advanced Learners Dictionary:

- E- “A plan, thought or suggestion, especially about what to do in a particular situation”
- F- “The aim or purpose of something”
- G- “Used to encourage people and tell them that they are doing something right”
- H- “A feeling that something is possible” “A picture or an impression in your mind of what something or somebody is like” (Oxford’s Advanced Learners Dictionary)

From Webster revised dictionary:

- I- “A belief or conclusion held with confidence, but not substantiated by positive knowledge or proof”

Based on these definitions, the thesis builds a comparative analysis between opinions and ideas and tacit knowledge and concludes by demonstrating their strong association to it. Chapter 4 discusses opinions and ideas in more details and demonstrates in what way they are types of tacit knowledge.



## 2.12 Hypotheses and Assumptions

### 2.12.1 Hypotheses

The thesis proposes the following two hypotheses.

**Hypothesis 1 (H1):** categorization of tacit knowledge into types/kinds is integral for its proper externalization (capture, sharing, transformation, retention) and measurement.

H1 stresses the importance of categorizing tacit knowledge into different types. This categorization is integral for successful externalization and consequential measurement. The difficulties associated with tacit knowledge externalization in its entirety have been discussed earlier in the thesis. In addition, many researchers agree that there is something or some types of that knowledge which can be externalized easier than other types (Polanyi 1965, 1966, Sharmer 2000, and others). The thesis identifies individuals' opinions and ideas as those parts. The more the types are identified the closer researchers come to benefit from the power of tacit knowledge as a competitive advantage.

H1 requires the discussion of the following topics:

- a- Types of knowledge in general and tacit knowledge in particular
- b- KM, in order to lay the ground for the discussion on knowledge capture, transformation, sharing and retention specifically among distributed individuals.
- c- tacit knowledge capture and transformation, in order to identify the difficulties in capturing and transforming tacit knowledge rather than parts of it

**Hypothesis-2 (H2):** It is possible to measure the externalization of different categorized types/kinds of tacit knowledge among geographically distributed individuals.

H2 suggests that among geographically distributed individuals, it is possible to measure whether or not those individuals have succeeded in externalizing their opinions and ideas. The geographic proximity of the individuals necessitates a tool for their cooperation and communication. This tool should provide the individuals with the necessary

functionalities for cooperation, knowledge release, knowledge capture, knowledge transformation, ideas exchange, discussions, and knowledge retention.

H2 requires the discussion of the following topics:

- a- Group support systems, groupware, cooperative tools, among others
- b- groups and group formation as different types of groups may require different tools
- c- Measurement techniques

### **2.12.2 Assumptions**

In order to measure the externalization of the value of the categorized opinions and ideas, an experiment was conducted on small groups of students in different subjects at the School of Business, American University of Beirut. Prior to the experiment, a set of assumptions was developed in order to provide a list of independent variables. These independent variables are essential as they affect knowledge sharing and transfer among the members. The followings are the set of these independent variables:

- 1- The major of the students
- 2- The class of the students, such as freshman, sophomore or other
- 3- The time spent in a particular major or class
- 4- The prior knowledge of the students
- 5- The evaluator's contribution (The evaluator is the professor of the subject)
- 6- The interaction among the members
- 7- The seniority and experiences of the members

These variables have a major contribution on the overall knowledge externalization among the members. In addition, the thesis introduces knowledge sharing and/or transfer as the dependent variable.

The following assumptions are imperative to prove the two introduced hypotheses. They constitute the basis for the experiment and the associated questionnaire. The thesis demonstrates whether these assumptions are true or not and consequently proves the hypotheses.

The argument in the two hypotheses is that the process of tacit knowledge externalization can be introduced so it follows a methodology which should be based on categorizing tacit knowledge into parts. Having done this, the hypotheses then suggest that the sharing and transfer of those types can be accomplished among geographically distributed individuals with the support of a tool or a group support system. Accordingly, the assumptions below show what the bases are for such sharing and transformations in terms of what might affect the success of members' contributions in the development of a product and the amount of knowledge shared and transferred.

**Assumption 1:** the member's released opinions and ideas on key points and issues during the development of the project raises the awareness of the members on each other's ways of thinking and analysis

This assumption asserts that a member's release of his/her opinions and ideas makes others in the group aware of his/her ways of problem solving, ways of thinking, and possibly his/her logical analysis in different situations.

**Assumption 2:** the seniority and the major of the members positively affect the amount of knowledge transferred

This assumption identifies the seniority and the major of the members as a factor which influences the transfer of knowledge within the group. The transfer of knowledge among the members increases in groups where some of its members are in senior years and in technologically oriented majors, such as computer science, and engineering. This transfer is greater than for those who are in junior years and in less technologically oriented majors. In order to test this assumption the number of senior members and their



majors were analyzed in each group and the knowledge transferred in the groups based on these factors was tested to see if transfer of knowledge increases in comparison to other groups with less or no senior students with or without technological orientation. An important observation that can also be drawn from this assumption is whether junior students are affected by the seniority of others where other's seniority and major hinder them from actively contributing to the development of the project because of obvious problems of timidity, reliance, and lack of confidence.

**Assumption 3:** the members who rely on the seniority of others in their group transfer the least knowledge in that group

This assumption clearly supposes that individuals, by nature, rely on others who are in higher academic or professional levels. It argues that individuals take for granted that seniors are more capable and have more knowledge and experiences in solving problems. In order to test this assumption, groups were analyzed to check the level of transfer of knowledge in such groups and particularly for those with high seniority.

**Assumption 4:** the amount of knowledge transferred increases as the number of members with higher seniority and prior knowledge increases

This assumption presupposes that the transfer of knowledge increases in groups where some or all of their members have both higher seniority level and experiences in relation to the topic of their term project. The assumption was tested by identifying groups with members having the above mentioned two dependent variables.

**Assumption 5:** the prior knowledge and experiences of the members on key concepts related to their projects positively affects the transfer of knowledge within the group

This assumption presumes that the transfer of knowledge is a function of prior knowledge of the members, in terms of subjects taken by members, and his/her experiences in topics related to his/her term project. The assumption was tested by identifying within groups

those students with these two independent variables and how they affect the transfer of knowledge among the members in the groups.

**Assumption 6:** the process of nurturing knowledge of key topics among the members results in the formation and transfer of more opinions and ideas by the members.

This assumption is a bit different from the previous ones. It addresses an independent variable which cannot be tested directly from the analysis of the know-how of the members but rather from their group interaction and its effect on the development of additional opinions/ideas, hence creating and transferring knowledge. The nurture of knowledge is a process where members' released opinions/ideas are discussed within the group and amplified as a result. The nurture process by its nature, as described in earlier chapters, is a process which requires:

- a- the acceptability by the members of the importance of a piece of knowledge released by members,
- b- the availability of the released knowledge to all members,
- c- the availability of a platform for communication which facilitates discussions of the released knowledge,
- d- the possibility of augmenting the released knowledge

Group interaction is vital for this assumption. The extent of interaction among the members increases or decreases their transfer of knowledge.

**Assumption 7:** the evaluator's contribution is critical for conflict resolution and transfer of knowledge by members

The independent variable (evaluator) is not a traditional part of members in the group. The evaluator in this research is someone with experiences who can give his/her constructive comments during the development of the term paper. In this case the evaluator is the professor of the subject. This assumption supposes that the evaluator's

contribution, comments, and suggestions are vital for resolving conflict among the members.

The research accepts that it is highly likely that the evaluator plays an integral role in different ways. It is assumed that the evaluator comments and discussions on released opinions and ideas, as well as on the overall progress of the developed term project, is a source of more knowledge release by the members. On the other hand, the capability and credibility factors discussed before are also very much related to the evaluator's involvement with the member's work. As discussed earlier, a capable member is one who is appraised by the evaluator through positive comments on his/her work and hence regarded as capable by his/her peers. The same argument is also valid for credibility.

**Assumption 8:** the evaluator's assessment on the member's released knowledge helps them initiate more constructive opinions and ideas

This assumption presupposes that the evaluator's partial grading and assessment on students' up-to-date work is a key factor in the development of the member's opinions/ideas. Higher grades by the evaluator on members released work increases both the capability and the credibility of the member in the eyes of his/her peers. The same applies to constructive assessment and discussions on members released work by the evaluator, which increases both credibility and capability of the member by his/her peers.



## **CHAPTER THREE Methodology**

This chapter introduces the methodology adopted in the thesis. Firstly, it introduces the literature's foundations upon which the methodology is based and relates it to Hevner et al.'s (2004) design research approach. Secondly, it introduces the thesis's proposed methodological steps. The chapter is devised as a main section introducing the literature's aspects of the design science–research and another section relating the introduced methodology to the literature.

### **3.1 The Thesis's Methodology**

Two paradigms characterize much of the research in the Information Systems discipline. Behavioral Science and Design Science (Hevner et al. 2004) addresses the development and verification of a theory predicting human or organizational behavior. Introducing such a theory is essential for information systems as current IS requirement theories fell short of supporting the process of collective learning in distributed communities (Markus et al. 2002, in Huysman & Wulf 2006). The latter addresses extending the boundaries of human and organizational capabilities through the creation of new and innovative artifacts. Although the literature on online communities is growing, we still do not have a theory about the IS requirements for communities that are geographically dislocated and need technologies to connect (Huysman & Wulf 2006).

The thesis addresses the research problem from a design-science perspective. The research is presented as an exercise in innovative design research to the poorly addressed problem of tacit knowledge externalization and measurement among distributed individuals in small groups. The challenge of the research is to provide a solution to the difficulties associated with the categorization in the literature of different types of knowledge in general and an in-depth analysis of the tacit dimension of that knowledge. The research introduces a methodology in the form of an artifact which identifies the necessary phases to be followed in order to provide a possible solution to this problem. The phases of the proposed methodology can be summarized as:

- 1- Categorization of tacit knowledge into types
- 2- Design of a measurement process for the categorized types
- 3- Choosing a method for knowledge externalization
- 4- Proposing ways to measure the success of knowledge externalization.

In chapter two, the thesis laid the ground for the methodology by introducing two hypotheses, definitions and concepts based on current existing research in the fields of KM, knowledge transformation and measurement. The importance of introducing such a methodology lays in its ability to provide a systematic process for the externalization of parts of tacit knowledge among distributed individuals. This is due to the lack in the literature about the IS requirements for such externalization. In addition, the methodology has been designed in such a way that it can be followed by organizations and groups in a simple and easy way. They have to follow the process in categorizing other types of tacit knowledge, implementing the use of the thesis's example tool or any other cooperative tool, and finally running similar experiments to measure the success of the categorized types sharing and transformation.

### **3.2Steps of the Methodology**

Information systems and the organizations as well as the groups they support are complex, artificial, and purposefully designed (Hevner et al. 2004). They are composed of people, structures, technologies, and work systems (Bunge 1985, Simon 1996, Alter 2003). Much of the work performed by IS practitioners in general, deals with design, which is the purposeful organization of resources to accomplish a goal (Boland 2002).

In order to understand the requirements for the methodological design of the thesis, the seven guidelines introduced by Hevner et al. al (2004) will be followed. They address:

- (1) Design of an artifact,
- (2) Problem relevance,
- (3) Design Evaluation,
- (4) Research contribution,

- (5) Research Rigor,
- (6) Design as a research Process, and
- (7) Communication of the research.

The methodology is summarized by the following diagram:

Steps	Process	Description
Step-1	Categorization of tacit knowledge into types. In this research, opinions and ideas have been chosen as the types.	This step suggests that tacit knowledge should be classified or categorized into types/kinds as this knowledge cannot be externalized in its entirety. Different researchers can categorize different types depending on many factors, such as needs, environment, groups, and communities. The importance in this step is to establish the correspondences between the categorized types and tacit knowledge by establishing common characteristics.
Step-2	Selection of a tool and a measuring process.	This step requires the search for a tool which could best fit the categorized types' externalization. In order to demonstrate the effectiveness of the categorization of knowledge, and that the categorized knowledge can be externalized, a search is undertaken for an available tool or a combination of available tools to be selected. The thesis develops a tool for this purpose as the literature lacks an integrated tool which can be used for the specificities of the research. This tool might be the basis of a similar process for other categorized types.  The choice of the technology varies depending on the application. Different technologies can be suggested here ranging from existing ones (GSS, DGSS, Blogs, Wikis, Lotus Notes, and others) to purposefully developed software similar to the one developed in this research (Chapter 5).
Step 3	Choosing a method for knowledge externalization as a means for data collection on the extent of	This step suggests the choice of a method through which the externalization of the categorized types using the selected or developed tool can be accomplished. Different methods can be used depending on the size of the groups and the categorized types as well as the effectiveness of the selected/developed tool. The thesis used a questionnaire as such a method.



	knowledge externalization through the use of the selected example tool.	
Step-4	Measurement	The measurement of the externalization of the categorized types is accomplished through the analysis of the data collected from the questionnaire. Generally, the questionnaire should encompass all relevant dependent entities for the measurement such as knowledge transfer, knowledge sharing, knowledge retention; and independent entities, where the inclusion of content and the extent of content of such entities are dependent on the context of work. In this research, independent entities, namely seniority, class, prior knowledge, qualifications, and evaluator were addressed.

**Table 3.1: Summary of the Thesis’ Methodology**

**3.2.1 Design Science**

The research is represented as an exercise in innovation design research. Design science creates and evaluates IT artifacts intended to solve identified organizational problems (Hevner 2004). The thesis followed the seven guidelines of design-science approach introduced by Hevner et al. (2004). The fundamental principle of design-science research from which the seven guidelines are derived is that knowledge and understanding of a design problem and its solution are acquired in the building and application of an artifact. Most of the literature related to design requirements for KM systems concentrates mainly on formal modeling and analysis of formal knowledge requirements (Holsapple 2003). These tools support the acquisition and retrieval of codified knowledge in order to improve formal individual knowledge bases rather than support the so-called second generation of KM where the focus is on informal emergent knowledge sharing within communities (cited in Huysman & Wulf 2006).

The thesis tackles the poorly addressed problem of knowledge externalization, combination, and sharing among geographically distributed individuals. The origin of the problem's complexity is a result of the difficulties associated with the very concept of knowledge and its management, particularly tacit knowledge. In an attempt to find a solution the thesis argues, as does the majority of researchers, that tacit knowledge externalization and measurement should address the externalization and measurement of some forms or parts of that knowledge and not all of it based on the literature's acknowledgement that the externalization of tacit knowledge in its entirety is not easy, if not impossible.

Accordingly, the thesis introduces an artifact intended to solve the previously identified problem. This artifact introduces a structured process/method for measuring the transfer of knowledge among distributed individuals. Initially, it categorizes types of tacit knowledge, shows how to externalize them through the use of a purposefully built example technology, and finally measures the success of the externalization of these types based on an experimental analysis.

### **3.2.1.1 Design of an Artifact**

Havner (2004), referring to Walls et al. (1992) declared that design is both a process (set of activities) and a product (artifact), in other words, a verb and a noun. The design-science research requires as its first step the creation of an innovative, purposeful artifact. This artifact is the "core subject matter" (Orlikowski & Lacono 2001) of the problem statement. The research introduces a sequence of three activities that form the design artifact which provides utility of some of the "undiscovered truth" regarding the account of the problem.

In this research, the development of the design-science artifact takes into consideration the constructs, models, and theories introduced earlier. Accordingly, the thesis clearly identifies the artifact as a process for identified parts of tacit knowledge's externalization and measurement. It is an innovative design that is based on the ideas, practices, technical

capabilities, and products through which the introduced hypotheses, concepts, and theories can be verified.

The thesis presents the process as a purposeful artifact which addresses the above mentioned problems and its applicability in a specific context, that being among geographically distributed individuals. The thesis does not claim that this solution is unique or the only solution to the problem or as Hevner et al. (2004) stated “full-grown information system that are used in practice”, but it helps other people in the same domain to follow the same process of categorizing different types of knowledge, and probably find or build similar tools, and conduct experiments to achieve the same or similar results.

### **3.2.1.2 Problem Relevance**

The relevance of this research is demonstrated through the construction of an artifact aimed at providing a possible answer to tacit knowledge transformation and measurement. Recent interest among researchers and the numbers of papers presented on the importance of knowledge within organizations as well as similar interests and research on knowledge externalization and measurement among distributed individuals, constitute the relevance of the research. The thesis aims at the construction of an innovative artifact which might help in achieving success to some of the issues associated with tacit knowledge externalization and measurement.

There is a growing interest among researchers and practitioners to develop a process, method, or methodology which identifies how organizational knowledge can be externalized and measured (Borgatti & Carboni 1994, UNAM 2003). Attempts to externalize knowledge failed dramatically. This failure can be attributed to a variety of factors, most importantly being its treatment as another form of knowledge while disregarding its duality. In addition, most researchers try to externalize tacit knowledge as an entirety. This practice attributes to the failure in effective externalization and measurement of that knowledge. Success in tacit knowledge management can only be



achieved through a thorough identification within this knowledge of parts or types which are easier to transform than others. The process introduced in this research provides a methodology which describes how distributed individuals can successfully transform and measure two identified parts of tacit knowledge. It is a relevant process for researchers in the field as it can be adopted within organizations which might identify or categorize other types of tacit knowledge and follow the same process introduced in this research to measure inter-organizational or groups' knowledge creation, capture, and transformation.

### **3.2.1.3 Design Evaluation**

The papers' design evaluation process is based on a combination of two of Hevner's (2004) evaluation methods, namely, the observational and the experimental methods in order to provide essential solutions and answers to the problem expressed earlier.

This duality in the choice of the design evaluation method is integral as the experimental method was essential to study the introduced artifact in a controlled environment, which was groups of students during the development of a term project, and to study the results of the analysis which were based on a questionnaire distributed to the students at the end of the semester. The groups' work on following the artifact's activities was monitored and changes were made, especially to the design of the example tool, to accommodate for the needs of the users. This activity was part of the observational method adopted in the research which was effective in studying the artifact in the specified field study where it is used by the different groups of students and was also monitored during the semester and changes were introduced when necessary. Chapter 6 provides a thorough analysis of the results based on the two methods analysis. It is imperative to note that considerable effort was put on maintaining consistency among all groups, during the experiment and the observation process, in adopting, in particular, the first and second steps of the proposed artifact. These methods demonstrated the importance and possible adoption of the artifact by other similar studies as the scientific analysis of the questionnaire based results shows successful articulation and transformation of the opinions and ideas among the members of the groups.

In addition, the thesis's evaluation of the design is in the context of knowledge management and knowledge articulation and transformation. The evaluation was not formal in the sense it was not compared to other similar existing research because of the lack of similar process. However, given the growing number of research papers on knowledge management in general and tacit knowledge in particular, this research adopts existing concepts, definitions, epistemologies, and ideas in formulating and understanding the topic.

The thesis uses principles set by other researchers regarding the externalization of tacit knowledge, its management and measurement. Additional study is required to assess the comparative effectiveness of other possible approaches in this or other contexts. There is no such claim in the thesis that the introduced process covers all aspects of knowledge externalization but it simply provides a ground for further research.

#### **3.2.1.4 Research Contributions**

The main contribution of this thesis is the introduction of an innovative artifact to an unsolved problem which categorizes tacit knowledge into types, introduces a support tool, conducts an experiment and presents its results in order to measure the success of the externalization of the categorized types. The research argues that these contributions advance the work and the understandings of those researchers who are seeking a means to externalize and measure tacit knowledge. It provides researchers in the field with an answer to the question of how to devise a testable method for the externalization and measurement of parts of tacit knowledge. It is the belief of the author that this model can be easily adopted by others and applied to other categorized types of tacit knowledge. Based on Hevener (2004), the research contribution can be summarized as follows. Firstly, designing the artifact itself provides a solution to the problem of tacit knowledge management in general. Secondly, its novelty in creating an original and evaluated method which is unique in addressing categorized types of that knowledge; and thirdly,

its use of an experimental as well as an observational method for the evaluation of the artifact and the measurement of the opinions and ideas transformation.

### **3.2.1.5 Research Rigor**

The research has multidisciplinary theoretical foundations in knowledge management, tacit knowledge transformation and measurement, CSCW, groupware, DGSS, and asynchronous interactions. It uses notions of the design of such disciplines and systems and proposes theoretical concepts as well as a design-science artifact to support the process of tacit knowledge externalization among distributed groups. Prior research on similar contexts served as a foundation for this research. The multi-disciplinary construct of the design-artifact is an integral part because of the lack in existing support systems of similar functionalities.

This multidisciplinary nature of the research necessitates the setting of an environment where the hypotheses, the concepts, and the example tool have to be tested. In order to fulfill these tasks, small groups of students, specifically 52 groups of 3-4 students, were randomly formed by the students themselves. There was no intervention from the study supervisor on the groups' formation in order to allow for a mixture of expertise, qualification, and prior knowledge among the members. The groups satisfy an important element of the literature's group formation as the members share a common interest, namely, the submission of the term project at the end of the semester with predefined goals and objectives. In other words, the groups in this research have a high interest in task fulfillment as well as individual contribution. These types of groups are very common in today's organizations as most organizational groups are small groups with a set of predefined goals and objectives working towards a specific task fulfillment and sharing a common interest.

A questionnaire was developed in order to collect data regarding the success of the externalization of categorized types of tacit knowledge among individuals in small groups. It is worth noting here that different researchers may categorize other types of



that knowledge which can also be measured following a similar process and questionnaire with amendment to the questionnaire's questions to accommodate for the specific environment. The thesis's questionnaire concentrates on the capture and transfer of the identified types and others may add, delete, or amend it according to the different type's categorization and objectives.

The questionnaire was carefully designed for the data collection needed for the analysis. Two sets of entities were identified in the questionnaire: first, the opinions and ideas transformation as the dependent entity and second, a set of independent entities. Initially, the questionnaire gathered information on the students' prior assumed knowledge on a few related topics and the time they hold this knowledge. The information from these two questions was critical in the amount of knowledge transformation among the members. The body of the questionnaire introduced 18 questions with answers from 7 (high) to 1 (low) which asked the participants about how the independent variables affected their knowledge capture and transformation. Chapter 7 gives a detailed description of the questionnaire and the different analysis performed.

The design-artifact was tested by groups of students with respect to its effectiveness in categorizing tacit knowledge in order to measure the success of the knowledge (opinions and ideas) externalization, sharing, and transformation among distributed individuals. The main drawback of the design-artifact is the lack of comparable processes and results. The results in chapter 5 have demonstrated the success in measuring the transfer of the categorized two types of tacit knowledge. The results also demonstrated that the tool was effective in providing the remote individuals (group members in this case) with an infrastructure for their cooperation, knowledge release, sharing, capture, and retention.

#### **3.2.1.6 Design as a Search Process**

Given the wicked nature of the problem addressed in this research, it is not possible to determine or explicitly describe its relevant means, ends, or laws. This does not mean that design-science research for the problem is inappropriate but provides a satisfactory

solution. Iteration was central to this research. Available techniques, concepts, and researches were studied and newly introduced design perceptions were taken into consideration. Their use and impact on similar situations were studied, problems identified, and solutions posed and implemented. This was repeated over a period of time until the final artifacts were developed.

The research presents a design-science artifact that addresses a heretofore poorly addressed problem dealing with the design of a process for tacit knowledge externalization and measurement among geographically distributed individuals. Based on a variety of current research and disciplines in IS, it introduced definitions and concepts in relation with asynchronous interactions among such individuals and proposed an artifact which presents the required steps to be followed for the externalization and measurement of categorized parts of tacit knowledge. The aim is to identify an opportunity process that forms the basis for tacit knowledge management in an innovative manner. The methodology can be adopted in organization as a purposeful tool. The outcome from this research is a set of guidelines for organizations, businesses, and researchers which demonstrates to them how to run experiments on categorized parts of tacit knowledge and what type(s) of support tool they may require.

Accordingly, the artifact and the results of the experiment presented in the thesis reflect an iterative process which provides a possible solution to the earlier addressed problem. The artifact was designed to represent the infrastructure of the problem, reflect its ability to satisfy the requirements for the externalization of parts of tacit knowledge, and run an experiment which demonstrates its utility. The experiment and the associated results proved that, given the environment and its limitations, the artifact was effective in the externalization and measurement of the categorized opinions and ideas. Later research, based on the artifact and the results introduced in the thesis, may benefit from these results and follow similar guidelines with different categorized types of tacit knowledge.

3.2.1.7 Communication of the Research

This research presents a design-science artifact/process that addresses a heretofore poorly addressed problem dealing with the design of a process for tacit knowledge externalization. The aim of the research was to identify an opportunity process that forms the basis for tacit knowledge management in an innovative manner.

Although the experiment in this research is aimed at an audience different from the business audience it provides useful results for researchers and organizations. Organizations may adopt this process to categorize their employee’s knowledge, implement it using the thesis’s tool or adopt different tools, and finally run a similar experiment to find out whether there was success in the externalization of the organizational knowledge.

A summary of the methodology’s guidelines as adopted from Hevner et al. (2004) is shown in Table 3.2. The first two columns list the Hevner guidelines and the associated description of each of them and the third column lists the thesis’s application of the guidelines.

GUIDELINE (Hevner et al.)	DESCRIPTION (Hevner et al.)	Application in Thesis
Guideline-1: Design as an artifact	Design-science research must produce a viable artifact in the form of a construct, model, method or an instantiation	The thesis presents the process as a purposeful artifact which addresses the complex problems of tacit knowledge sharing and measurement, and its applicability in a specific context; that being among geographically distributed individuals. In Havner (2004), referring to Walls et al. (1992), design is both a process (set of activities) and a product (artifact), in other words, a verb and a noun. The design-science research requires as its first step the creation of an innovative, purposeful artifact. This artifact is the “core subject matter” (Orlikowski & Lacono 2001) of the problem statement. The research introduces a sequence of three activities (categorization, implementation, measurement) that form the design artifact which provides utility of some of the undiscovered truth regarding the statement of the problem.



Guideline:2 Problem relevance	The objective of design-science research is to develop a technology based solution to important and Relevant business problem	The relevance of this research is demonstrated through the construction of an artifact aimed at providing a possible answer to tacit knowledge transformation and measurement. The thesis argues that success in tacit knowledge management can only be achieved through a thorough identification within this knowledge of parts or types which are easier to transform than others. The process introduced in this research provides a methodology which presents the process of how distributed individuals can successfully transform and measure two identified parts of tacit knowledge.
Guideline:3 Design evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods	The design evaluation process in the thesis is based on a combination of two of Hevner's (2004) evaluation methods, namely, the observational and the experimental methods in order to provide essential solutions and answers to the problem stated earlier. The duality in the choice of the design evaluation method was imperative as the experimental method was essential to study the introduced artifact in a controlled environment (groups of students during the development of a term project) and to study the results of the analysis which was based on a questionnaire distributed to the students at the end of the semester. The groups' work on following the artifact's activities was monitored and changes were made, especially to the design of the example tool, to accommodate the needs of the users. This activity was part of the observational method adopted in the research which was effective in studying the artifact in the specified field study.
Guideline 4: Research contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundation, and/or design methodology	The main contribution of this thesis is the introduction of an artifact which categorizes tacit knowledge into types, and introduces a support tool for opinions and ideas. The result of the experiment externalizes and measures the categorized types. The research introduces a methodology by which tacit knowledge can be categorized for its effective externalization and measurement. Good design influences the expected results and values as a result of the externalization of tacit knowledge. It is worth mentioning here that the proposed artifact is effective for the capture and measurement of individuals' opinions and ideas but not necessarily for other categorized types such as talent and thoughts.
Guideline 5: Research rigor	Design-science research relies upon application of rigorous methods in both the construction and evaluation of the design artifact	The research has multidisciplinary theoretical foundations in KM, tacit knowledge transformation, CSCW, groupware, DGSS, and asynchronous interactions. The groups which formed the basis of the experiment were randomly formed by the students themselves. The groups satisfy an important element of group formation types in the literature as the members share common interests

		<p>with predefined goals and objectives, that of successfully developing a term project. A questionnaire was developed as a basis for analysis for the success of the externalization of the users' opinions and ideas. This questionnaire was carefully designed for the data collection needed for the analysis. Also a model structure was developed which shows the walkthrough for product development.</p>
<p>Guideline 6: Design as a search process</p>	<p>The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.</p>	<p>Given the wicked nature of the problem addressed in this research it is not possible to determine and/or explicitly describe its relevant means, ends, or laws. This does not mean that design-science research for the problem is inappropriate, but that it provides a satisfactory solution. Iteration was central to this research. Available techniques, concepts, and researches were studied and newly introduced design perceptions were taken into consideration.</p>
<p>Guideline 7: Communication of research</p>	<p>Design-science research must be presented effectively both to technologically-oriented as well as management-oriented audiences.</p>	<p>This research presents a design-science artifact that addresses a heretofore poorly addressed problem dealing with the design of a process for tacit knowledge externalization and measurement among geographically distributed individuals. Based on a variety of current research and disciplines in IS, it introduced definitions and concepts in relation with asynchronous interactions among such individuals and proposed an artifact which presents the required steps to be followed for the externalization and measurement of categorized parts of tacit knowledge. The aim is to identify an opportunity process that forms the basis for tacit knowledge management in an innovative manner. The methodology can be adopted in an organization as a purposeful tool. The outcome from this research is a set of guidelines for organizations, businesses, and researchers which demonstrates to them how to run experiments on categorized parts of tacit knowledge and what type(s) of support tool they may require.</p>

Table 3.2: Application of Hevner’s Guidelines

## **CHAPTER FOUR– Definitions, theories and concepts**

This chapter introduces the thesis's definitions and concepts on knowledge, knowledge decomposition, and transformation for geographically distributed group members. It also introduces a model structure and a process for opinions and ideas externalization and a KM cycle. The chapter also introduces opinions and ideas as the parts or types of tacit knowledge which are easier to be transformed into explicit knowledge. It provides a comparative study between opinions, ideas, and tacit knowledge by presenting their common characteristics. The chapter proposes knowledge representation as an object as the basis for knowledge articulation, capture, and transformation.

### **4.1 Introduction**

Tacit knowledge externalization and measurement has gained momentum among researchers and within businesses because of its importance as a competitive edge. Its categorization into types appears to be a step in the right direction as managing knowledge in its entirety proved to be problematic, unsafe and less manageable.

This chapter introduces definitions and concepts about knowledge, its management and categorization into types, as well as how knowledge could be externalized. These definitions and concepts are integral parts for the methodology developed in chapter 3 as they support the claim that opinions and ideas are parts of tacit knowledge. It also introduces a KM cycle (figure 4.2) which adheres to the externalization process discussed in chapter 3 as the first phase of the developed methodology. The nurture process (figure 4.3) is also essential as it elaborates the categorization of knowledge into types.

Based on the previous arguments that some parts or instances of tacit knowledge could be easily externalized and transformed into explicit form, this chapter through the analysis of opinions and ideas demonstrates their links and correspondences to that knowledge. It also introduces the thesis's definitions of knowledge and KM.



4.2 Opinions and ideas as parts of knowledge

“A Clod can have the facts, having opinions is an art” (Charles McCabe)

This section builds on the earlier introduced literary definitions on opinions and tacit knowledge in establishing the links and correspondences between the two. This is important to demonstrate that the assumption that opinions are parts or types of tacit knowledge is logical.

Figure 4.1 is Wilsham’s basic communication diagram which shows the phases of the reflection/action among two individuals, persons A and B, who are engaged, for example, in the development of a joint document.

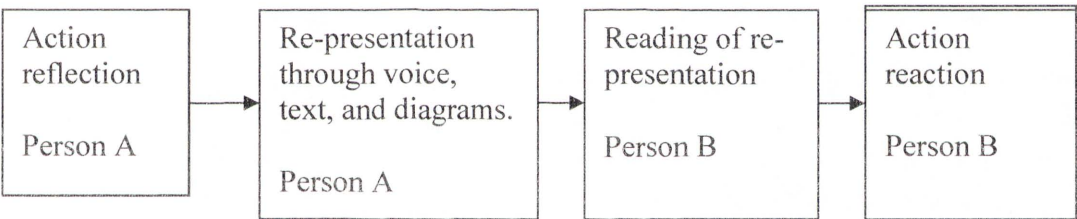
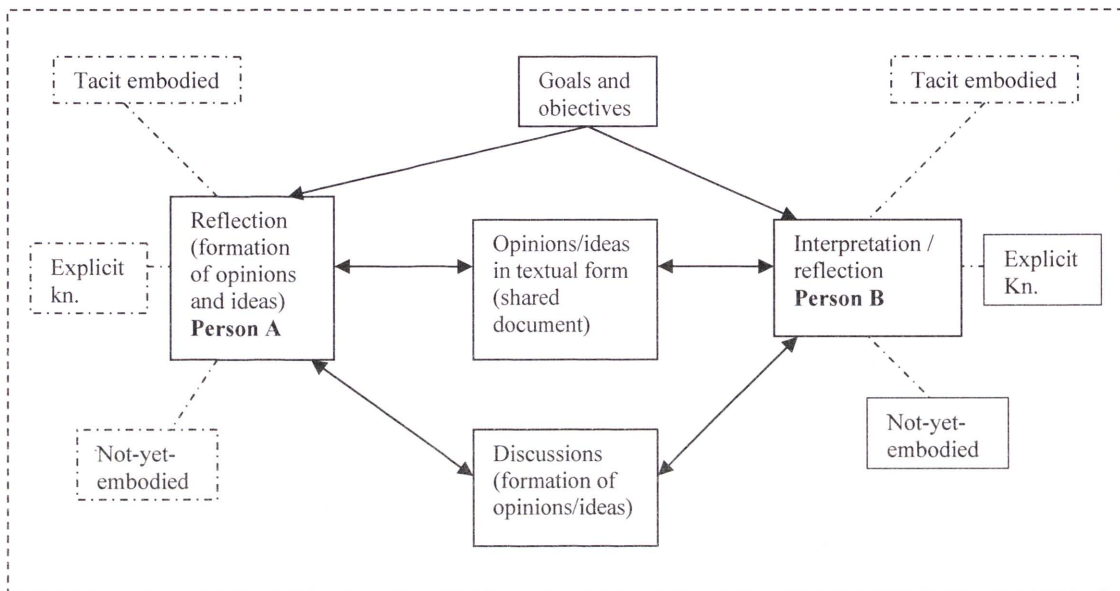


Figure 4.1: Welsham’s basic communication diagram

The thesis adopts and extends this diagram and proposes an articulation/reflection/interpretation model, (Figure 4.2), which presents how individuals nurture their released opinions and ideas. Figure 4.2 assumes that person A is reflecting on a problem, and given a pre-defined context and a set of goals and objectives articulates his/her perception of the problem into the shared document in the form of opinions/ideas. Other individuals, say Person B assume a state of interpretation-reflection-perception reflecting on Person A’s articulated knowledge. Accordingly, he/she might either engage in a discussion with Person A for more clarification on his/her intended meaning or contents of the idea, or, alternatively, might update the content of the document introducing his/her perception of the original content and release the document back into the system. Imbedded is his/her own interpretation, hence an idea.



**Figure 4.2: The proposed reflection-articulation-interpretation model**

This process takes into consideration the different types of knowledge released by the group members as well as the resources, both explicit and tacit. This knowledge could be simply explicit where there will be no need for further clarification by the other members, or it could be tacit embodied where little clarification is required, or not-yet-embodied released in the form of opinions and ideas where high level of message exchange or document's update is required in order for more of this knowledge to be released. This means bringing knowledge from the unconsciousness into the consciousness. This argument is made clearer in the Catholic Encyclopedia's (2008) discussion on the types of knowledge "it is impossible that all the knowledge a man has acquired should be at once present in the consciousness. The greater part, in fact all of it with the exception of the new thoughts actually present in the mind, is stored up in the form of latent dispositions which enables the mind to recall it when wanted".

There is a widespread agreement that personal contact with an observation of other's is a critical factor in knowledge acquisition (Collins 2001, Leonard & Sensiper 1998). In this research, the personal contact is defined as the exchange of messages and/or the document updated by the members. Cook & Brown (1999) and Collins (2001) have suggested an interactive process of acting on the material being transformed, working

with others more expert in the field, receiving their judgment on transformation efforts, attempting to meet their standards and see what they see, identifying critical factors, and so on.

Geyer (2001) argued that individuals generate knowledge as well as processing information. This knowledge generation occurs with numerous dimensions of representation, emerging as a result of multiple interactions and processes between individuals and groups. He continued by stating that the fundamental business activity within organizations is to organize individuals into group efforts that create, preserve, and then project knowledge into the marketplace, embodied in the form of services or products. Hawryszkiewicz (2008) argued that the requirements of a new product must be defined and refined as new ideas come up and feedback is received from potential users.

In general, knowledge is subjective in nature and intimately linked to individual and collective interpretations. Knowledge is considered as either easily articulated or difficult to articulate depending on its categorized types. Opinions and/or ideas refer to an individual's release and articulation of his/her understanding, perception, analytical thinking, and interpretation on a given problem and/or situation. The importance of the release of individuals' opinions/ideas lies in their influence on other individuals who might have an interest in a solution to a problem and in most circumstances might trigger the formation of more ideas generation among the individuals. Hawryszkiewicz (2004) stressed the importance of processes in group interactions for idea generation as well as conflict resolution among actors in group activities.

The importance of the release of opinions and ideas in remote group work interactions is inevitable for the success of the product being developed as it reflects the individual's analytical solution, perception, or know-how towards the solution of a problem. An individual's idea is the result of his/her accumulated experiences, work practices, and know-how. The value of such an idea resides in its distinguished way of providing a solution which might not be seen by others the same way. Opinions and ideas might also generate discussions and in most cases more input among the individuals. What



distinguishes an individual's opinions and ideas is that 'drop' of his/her hidden intelligence towards the solution of a problem which makes it possible for others to be exposed to possible solutions to a bottleneck, conflicting views or problems.

Conflict and differences among the individuals' articulated opinions and ideas and the subsequent possible discussions may result in the formation and release of more creative opinions/ideas within the individuals. In return, this may result in more articulation and constructive solutions. Novel ideas and constructive opinions arise among individuals from such articulation and acceptance of each other's mental contribution towards a product development.

Nonaka (1994), in his book "The Knowledge Creating Company" and based on John Loke's perspective argued about the importance of experiences in ideas generation and identified two types of experiences; namely, sensation and reflection.

It is important that individuals are encouraged and given incentives to articulate their hidden know-how in the form of opinions and ideas as this might result in further discussions and their development. Knowledge that is not articulated is obsolete and its value is only tangible when it is expressed and articulated. Jikoski and Kikoski (2004) added that what is unsaid and unexpressed could be the reservoir of tacit knowledge. This articulation is short in providing the full intended meaning by the originator of the opinions and ideas: "We can know more than we can tell", Polanyi (1965) and any knowledge that he/she has in regard to a particular context has to be subsequently discussed among the individuals. This process might trigger either clarification by the originator and/or the release of more of his/her knowledge, and its development and amplification by others. Turban (2001) asserted that individual creativity can be learned and improved through idea generation and nurture.

In order to share personal knowledge, individuals must rely on others to listen and react to their ideas. Constructive and helpful relations enable people to share their insight and freely discuss their concerns (Von Krogh, Ichijo & Nonaka 2000). Each employee should

maximize his contribution to the pool of ideas that provide competitive edge for the firm (Kikoski & Kikoski 2004).

Cook (1998) stated that tacit knowledge is “distributed in the totality of the individual’s action experience” (381-400) Furthermore, it relies on “tactile cues registered by the human body interacting with its environment”. The opinion of a person is closely related to the context in which it is released and nurtured as well as the series of events, circumstances, and interactions which lead the person to articulate it. A change in the events or circumstances during interaction or the emergence of a stimulus might trigger a change and or modification in the released opinion/idea of the individual the same way face-to-face discussions result in idea generation and learning. The key here is exposure to other’s thoughts, opinions, and ideas. There are two dimensions of tacit knowledge: the first is the technical dimension which encompasses the know-how; the second is the cognitive dimension which consists of beliefs, ideas and values which we often take for granted (Nonaka & Komo 1998).

Ideas, on the other hand, are more susceptible to changes or emergent situations within a given context especially in design environments where work depends on creativity. Ideas are not associated with reasoning and are altered easily by individuals, not always necessarily, to major events, circumstances, or social milieu.

The nurturing of ideas and opinions might follow either a manual method or be electronically induced. Marakas and Elam (1997) supported technology based idea generation when manual idea generation fails. Masetti (1996) demonstrated through experiments that computer-enabled people were more creative in problem solving. This is surely caused by the atmosphere of relaxation which remote interaction provides to the people working together.

Opinions and ideas are not personally subjective, but collectively subjective. However, despite the inevitable subjectivity, objectivity in the process of releasing opinions and ideas should be of paramount importance and all measures should be taken to ensure that.

The objective selection of opinions and ideas should be relevant to the goals and objectives of the group.

It is clear that the dissertation is aiming at better externalization of individual's opinions and ideas nurtured as a result of interactions and discussions among group members given a specific context, for example, developing a product and a set of predefined goals and objectives. An interactive environment ensures the nurturing of opinions and ideas based on the building up of sensory inputs between the members which represents a stimulus for the dormant parts of a members' not-yet-embodied knowledge. This calls for support for the individual's cooperation, communication, and fulfillment of the steps required in turning opinions/ideas into textual presentation.

Opinions are evidently more solid than ideas as they mainly rely on experiences, beliefs and expertise lived by humans. According to Maturama and Varela (1987), opinions may be based on people's perception during an observation and every time a person is confronted with new sensory input, that person reacts to the new stimulus with his/her experiences and beliefs.

Knowing, experiences, work practices and such are prerequisites to the formation of opinions by individuals. An individual has to possess a solid understanding, reasoning, and perception of a particular subject in order to be able to present a solid opinion in a given context. General knowledge is important to opinions, but the proper contextual opinions are justified with solid background, being knowledge, expertise, and experiences, on specific contexts. The ability of the individual to justify his/her released opinion/s surely strengthens his/her opinion. Consequently, an opinion is associated with two parts; namely, the actual opinion and its reasoning or justification.

Part of the individual's tacit knowledge is captured as a result of capturing and nurturing the opinions of that individual as indicated in (Figure 4.2), which sets for the overall implementation of the building of the opinions and ideas as a result of the progressive development of a product.



The opinion of a person has its grounds in what was accumulated and perceived during a long period of time as a result of observations, work practices, story telling, and experiences. The basis of a person's opinion has its grounds in past knowledge accumulated in his/her brain. The opinion of an individual is articulated 'now' but has its roots in 'past' in all what was learned, the experiences, the instincts, the creativity, and the intelligence of the individual. This interplay between present and past is important because it represents the originator's perception and comprehension of the 'present' and his/her ability to bring along knowledge from the 'past' to form opinions which might help in resolving present problems.

Opinions are verified based on prior knowledge, might have precedence, and are reproducible. In other words, opinions are normally substantiated with knowing, that is, one cannot state his/her opinion without a solid perception of a particular analysis of events that happened in the past or in a given context which lead to stating the opinion and in most cases standing firmly behind it. For example, the statement "I believe it is going to rain tomorrow", cannot be claimed without prior knowledge, observations, and analysis by the individual about certain events that might have lead to rain previously. At the end, it may or may not rain but the fact that on the one hand there are many black clouds and on the other hand the temperature has dropt low are the substances of the opinion.

An opinion has to have two parts; the actual opinion and the reasoning behind it. This changes the account about the rain to "I believe it is going to rain tomorrow, because there are many black clouds and the temperature has dropped". This statement is much stronger and more convincing than the original one because of the logicity of the reason behind the opinion. The subject's prior knowledge (black clouds and cold) and experiences (he/she had experienced rain as a result of black clouds and low temperature) lead to the creation of his/her opinion. This logic, in most cases, is shared among others easily because they may have had similar experiences and observations.

Opinions could be beliefs, thoughts, experiences, and observations that are shared by a group of people as well as individuals. In cooperative work, group members normally

have similar or very close prior knowledge, expertise, and backgrounds in order to be able to communicate, exchange, and capture each other's knowledge. Having these common features, the group member's opinions might be as close as they can be to one another.

An idea is defined as "the transcript, image, or picture of a visible object, that is formed by the mind; also, a similar image of any object whatever, whether sensible or spiritual" (Webster Revised Dictionary 2008). Empirical analysis, rather than solid analysis is the basis of ideas. They are usually dependent on one's imagination and level of intelligence, and based on what a person identifies as logical based on their perception to a given mental reasoning. When team members take a lenient and helping attitude towards one another, new ideas flow easily, and even radically different knowledge can be created (Van Krogh, Ichijo & Nonaka 2000).

Ideas are less solid and convincing than opinions because they cannot always be verified with reasoning. They are thoughts based mainly on intelligence that cannot be always verified with reason or logic. They are mostly irreducible and have no precedence. They are generally based on the individual's imagination and intelligence and not generally proven by scientific data.

Plato argued that, the physical world is a mere shadow of the perfect world of ideas. Human beings aspire toward the eternal, unchanging, and perfect ideas that cannot be known through sensory perception but only through reason. Aristotle criticized Plato and stressed the importance of observation and the clear verification of individual sensory perception. Csikszentmihalyi and Sawyer (1995) have tackled the issue from a different perspective stating that ideas are also a result of interaction and dialogue. People develop most of their ideas through dialogue. It is only by interacting with other people that one can get any thing interesting done, essentially a communal enterprise.

What is interesting about ideas is that they seem to point beyond nature to some transcendent realm. This might be problematic in group work because ideas cannot always be supported by strong arguments and logic. Intelligence plays a major role in the

formation of a person's ideas. Intelligence, which can be defined as the ability of a person to comprehend, to show creative behavior, and to acquire, retrieve, and use knowledge in a meaningful way in order to understand concrete and abstract ideas shapes an individual's formation of ideas. Ideas may generate discussions, which help in the process of attaining goals and objectives.

The main difference between opinions and ideas is that an opinion can be verified based on prior knowledge, whereas ideas are thoughts, which are based on intelligence that cannot always be verified with reason or logic. Opinions that cannot be supported by reasons or logic are to be regarded as ideas.

Both ideas and opinions are important for knowledge creation in a group setting. The main issue here is that the opinions and ideas are formed by and among group members in a contextual setting through a conversational process. This context is what the group members are trying to achieve based on predefined goals and objectives. Consequently, individuals and group's opinions and ideas are always expressed to verify the context in which the individual or the group members work. Ideas can be generated easily through interaction with objects of the world. Smith (1998) has gone further and related ideas to learning "our long term success requires total commitment to working together effectively and a willingness to embrace new ideas and learn continuously".

Idea and opinion generation should follow a process, which provides the group members with the platform on which the capture can occur. It is argued that ideas are about potentials and innovations are about results. This argument is important as the task of organizations should be in turning simple ideas into innovative ideas which will yield positive results for the organization. Dobni (2006) stated that innovation is important because it allows companies to create substantive customer value within a highly competitive environment. In fact, he asserts that leading-edge organizations wield innovation to take advantage of opportunities when they arise and outpace their competitors in the process. Dobni introduced an innovation model which organizations could follow to turn their individuals' ideas and opinions into beneficial results.



Leonard and Sensiper (1998) argued that creative ideas do not arise spontaneously from the air but are born out of conscious, semiconscious, and unconscious mental sorting, grouping, matching and modeling. Consequently, a process is indispensable for the group members to systematically release their opinions and ideas. Within this process the opinions and ideas gathered would be filtered from those that do not satisfy the goals and objectives. As a conclusion, thoughts, views, impressions, expertise, knowledge, concepts, beliefs and judgments, which are parts or instances of tacit knowledge, have equivalent parts or instances in opinions and ideas. Table 4.1 introduces the similar characteristics among these instances as well as the possible technologies for the articulation of the different types or instances of tacit knowledge.

Types of tacit knowledge (TKn)	Articulation of tacit knowledge	How they relate	Acquired from/by	Technologies for TKn types articulation
Subconsciously understood and applied (know-how, instinct, ideas)	An idea articulated and/or expressed as a result of accumulated empirical knowledge and individual intelligence and vision in the form of special concept and solutions to a problem which might point beyond expectations/nature and exchanged with others. It is accepted as a last resort because of lack of prior knowledge by others (*)	Link: some issues can not be explained but are still adopted when articulated. They point beyond novelists.	Experience, practice, research, intelligence	GSS, interactive systems, conversational systems (Blogs, Wikkis, LiveNet, Notes, VIPGSS)
Difficult to articulate/ to document (know-how, expertise, thoughts, instinct, analytical skills)	Experts' opinions articulated and expressed as judgment based on special knowledge accumulated through years of observations and mental analysis. Acceptance by less experienced people strengthen it (**)	Link: experts tend to stand after their articulated opinions and convince others of the validity of their problem solving analysis through work practice and group interaction and/or messaging	Work practice, group work, repetitive tasks, experience	GSS, Interactive systems, cooperative systems

Developed from direct experiences and actions (expertise, work engagement, practice, idea)	<p>Opinions articulated and/or expressed based on judgment or sentiment as a result of knowledge accumulation through learning by doing, repetitive tasks or formation of figures in the mind about a person or thing by recording own experiences (**)</p> <p>Ideas articulated as thoughts/concepts in mind as a result of products development and/or mental activity, conviction, or principle which might raise awareness in others (*)</p>	Link: impressions can only be established through experiences. Opinions and ideas are tried to convince others with their validity	Shared experiences, observations, work practices, reflections, learned by doing	Video/audio conferencing, GSS, Blogs, DSS
Shared through interactive conversations (know-how, view, idea, opinion)	<p>Opinions articulated or expressed in the form of beliefs shared by most people through direct group work discussions, joint formal decision on particular topics, expression of views backed by prior experiences (**)</p> <p>Ideas articulated/expressed in plan/suggestion forms based on views and know-how accumulated through exchange of knowledge with others. The individual might dictate what to do in particular situation (*)</p>	Link: sharing of opinions and ideas occurs in the form of group collaboration work and consequentially decisions will be taken/adopted	story telling, group work, interaction, opinions/ideas, Blogs, Wikkis	GSS, Blogs, Wikkies, face-to-face interactions, conversational systems, cooperative systems
Belief (culture, religion, exposure, habits)	<p>An opinion articulated and/or expressed as a message expressing acceptance to societal rules, regulations, and/or taboos. Listening and involvement strengthen the articulated opinion (**)</p> <p>Ideas articulated and expressed as a result of encouragement from others in similar situation or rituals and they are accepted by them as a result of prior success in innovative ideas</p>	Link: people can be encouraged through stories about prior success. Opinions and ideas can strongly be attached to belief and acceptance is easy especially for believers or experts.	Story telling, group work, work practice conversation, meetings	Blogs, Wikkis, emails, message systems, conversational systems

	(*)			
Common practice (belief, know-how expertise)	<p>An opinion articulated and/or expressed which is known and shared by most people in a workplace. The opinions might have hidden aspects from others which facilitate its acceptance. Group work facilitates its nurture (**)</p> <p>An idea articulated and/or expressed in the form of a plan/suggestion dictating to others what to do in an emergent situation to solve a problem (*)</p>	Link: Opinions and ideas are well accepted by people and encouraged through working together and repetitive group work.	story telling, conversation, practice, observations, documents, files, memory, communication, cooperation	emails, messages, conversational systems, cooperative systems
Informal/un-codified (concepts, logical analysis, intuitions, talents)	<p>An opinion articulated by a person as a result of mental analysis and analytical perception not founded on proof/certainty but open conversation and discussions with others (**)</p> <p>An idea in the form of concepts, philosophies, images, issues, based on psychological stimulus for problem adjustment and solving as in word of mouth (*)</p>	Link: the fact that it has not been found on proof or certainty renders opinions and ideas informal. Good communication make their verification and acceptance easy	experimentation, interactions, discussions, observation, creativity	Message systems, documents, emails, blogs, experimental systems
Ephemeral and transitory (thoughts, inceptions, view)	An idea articulated as a figure or expressed as impression in the mind of individuals. Persistence of the idea is not guaranteed until accepted by others and may vanish if not used properly (*)	Link: some things do not just last forever, and may come up again any time. Opinions and ideas are important at emergent situations and might not be adopted or valid later because they are based on need in particular situations	Imagination, reflection, engagement, discussion, trigger, group work	Emails, conversational systems



Formal/embodied (thoughts, views, belief)	<p>An opinion articulated as a fact accepted by most people. Its easy acceptance makes it a fact or a given (**)</p> <p>An idea expressed as a heart of message, content of piece, main theme and circulated among groups and communities. Discussions among individuals might guarantee its acceptance as a fact (*)</p>	<p>Link: some things are taken for granted. Opinions/ideas are in the mind of most people. Special circumstances trigger them in the heads of most people and are accepted without need for many discussions. Their articulation renders them valid</p>	<p>exposure, instinct, perception, rules, documents, files, memory</p>	<p>GSS, DSS, emails, Blogs, Notes, Wikkis, documents</p>
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**Table 4.1: Correspondences between tacit knowledge instances, opinions and ideas**

The table shows that instances of opinions (\*) and ideas (\*\*) have corresponding tacit knowledge instances and common features. It is worth mentioning here that the main difference between an opinion and an idea is that opinions are normally substantiated with facts and may be defended by the articulator whereas ideas are not. Consequently, the externalization of the individual’s opinions and ideas is an externalization of parts of his/her tacit knowledge. This externalization, and because of the varieties in the types of knowledge other than opinions and ideas, such as thoughts, beliefs, and expertise might require different, but also similar, types of technologies for their externalization. Different technologies, and in many cases combination of technologies, are required for additional individual’s knowledge to be acquired, accumulated, and/or nurtured, especially when they are exposed to new ideas, opinions, thoughts, views, expertise and know-how. Hawryszkiewicz (2008) stated that new product requirements are the results of new ideas collected from potential users.

As a result, the change of the requirements may affect the required knowledge for the process and the way a process is fulfilled, hence, the probable need for new and additional technologies.

Generally, the more dynamic a process is, the more the reliance on different technologies for the fulfillment of the imbedded tasks and activities. This dynamicity is integral in group work. It caters for dynamic technological support as the more knowledge is created and exchanged within groups and among groups, so the different and more technological support might be needed for externalization of the resulted knowledge. These technologies should cater for the increasing reliance on social relationships where there is greater emphasis on user analysis and communication (Hawryszkiewicz 2008), hence less and less reliance on emails to manage the dynamic changes in process development. An important impact of this new trend is the creation of different technical solutions that support user driven changes (Hawryszkiewicz 2008) and the emergent knowledge during the development of the process.

In addition, globalization and its associated new ways of remote cooperative work businesses are looking for additional technological supports as means to create, capture, and retain the resulted knowledge generated from different geographical locations. New ideas, opinions, thoughts etc are being constantly generated and exchanged within the different geographically distributed locations of the same organization as well as among organizations. Relying on emails and on face-to-face technologies and techniques is not sufficient for the externalization of today's organizational knowledge. Consequently, existing GSS, Blogs, Notes, Wikkis and such, as well as customized and/or newly developed technological supports are required to cater for the different types of knowledge within and among organizations. Special, and possibly new, technological support for tacit knowledge externalization must be developed as a result of the exponential increase in the amount of knowledge being created, generated, acquired and exchanged in today's emerging business competitiveness.

#### **4.3 Definitions**

The definitions presented in this section as well as the discussion which follows in the dissertation are rooted in the concepts and points of view addressed in previous sections as a basis for the comprehension of the two most prominent views on knowledge.

In the following sub-sections, the thesis' definitions and their explanations are introduced

#### **4.3.1 Knowledge Management Definition**

The thesis defines KM as follows:

“The set of activities which focus on the creation, capture, sharing, transformation, retention, and use (a process referred to as externalization) of ‘value’ and ‘transformed’ knowledge imbedded in the group’s memory (explicit knowledge) and intellect (categorized types of tacit knowledge) satisfying a set of predefined goals and objectives”

This definition suggests that the management of knowledge is the management of both explicit knowledge and ‘categorized parts’ of tacit knowledge. The definition distinguishes between value knowledge (both explicit and tacit embodied) and transformed knowledge (which is only tacit i.e. not-yet-embodied knowledge). Explicit knowledge is that which is captured and retained in accessible physical medium such as the group memory, whereas tacit knowledge is the unarticulated knowledge in the heads of the individuals, categorized as opinions and ideas in the thesis.

#### **4.3.2 Value Knowledge**

The thesis defines Value Knowledge as follows:

“Filtered knowledge, explicit and tacit captured and collected by individuals in groups, in the form of knowledge-documents objects, during a document development process satisfying the goals and objectives of the group in a given context.”

This definition presumes the progressive accumulation of knowledge documents (the document’s content could be of any form, e.g. a text, graphs, multimedia etc.) by the group members which may or may not satisfy the predefined goals and objectives and which is composed of both tacit and explicit knowledge.



Value knowledge is not personally subjective, but it is collectively subjective. However, despite the inevitable collective subjectivity, objectivity in the process should be of paramount importance and all measures should be taken to ensure it is implemented, i.e., the objective selection of value knowledge relevant to the goals and objectives of the group.

#### **4.3.3 Transformed Knowledge**

The thesis defines Transformed Knowledge as follows:

“It is the set of opinions and ideas released by individuals engaged in a distributed cooperative setting either directly or as the result of filtration from value knowledge document.”

This definition implies that this knowledge is the individuals’ released opinions and ideas. These opinions and ideas can be directly from the individuals or they can be a result of those individuals’ discussions on captured opinions and ideas from value knowledge.

The importance of these two definitions is their relationship to the Value and Transformed Knowledge documents discussed earlier.

#### **4.3.4 Group Memory**

The thesis defines Group Memory as follows:

“It is the repository of the captured value and transformed knowledge, in the form of knowledge-documents”

It is apparent from this definition that the group memory retains knowledge, explicit or tacit, as knowledge documents. It is also apparent that the set-up under which knowledge can be gathered is asynchronous where the individuals are dispersed over space and time.

The first idea introduced by the above definition is the retention of ‘value knowledge’, not just any knowledge, by the individuals.

### 4.4 The Model Structure

This section proposes a model for the progressive and consequential creation and development of documents among distributed individuals engaged in a cooperative setting (Figure 4.2). This model is part of the design rigor in chapter 3 and represents the walkthrough required for distributed individuals in their quest during product design development.

The shared document in the model is an object and is the means of interaction among the individuals. Knowledge is released into that shared document which will be consequently and progressively discussed, augmented, filtered, and retained among the members. The model also shows that the outcome from the development process is two documents, a Value Knowledge document (VKd) which is the developed product and a Transformed Knowledge document (TKd) which contains the released and/or filtered ‘tacit knowledge in the form of opinions and ideas’ of the individuals.

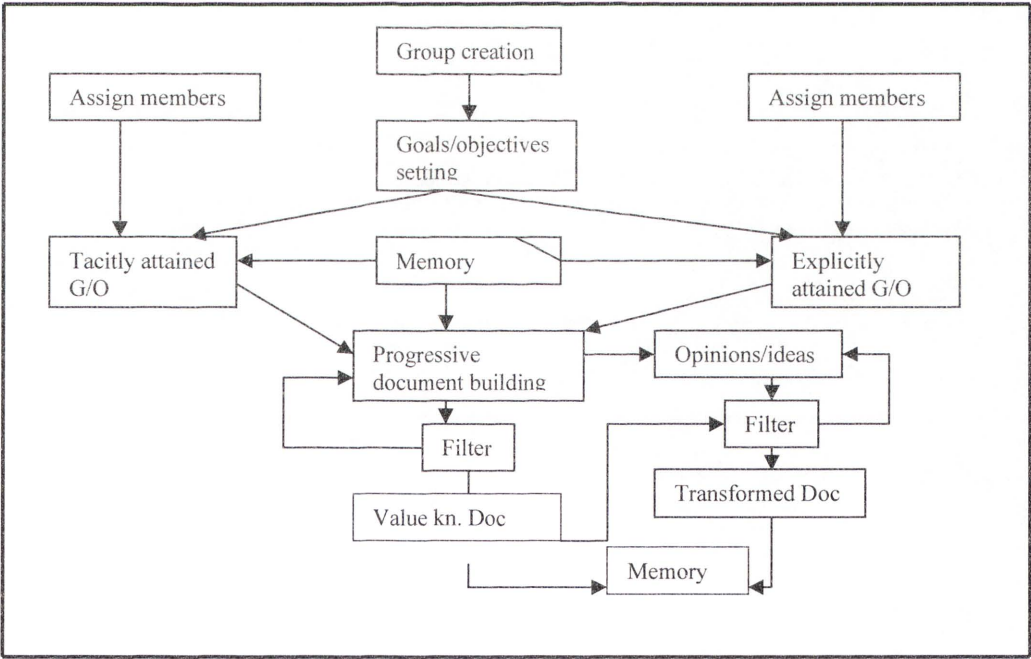


Figure 4.3: Model for knowledge creation in remote cooperative virtual settings

The VKd holds both explicit and tacit knowledge which are basically the individual's contributions to the development of the product. The TKd only holds the opinions and ideas of the group members during the development process, both tacit embodied and not-yet-embodied knowledge.

The former is the know-how, such as the experiences and problem solving processes of the individuals and the latter is the opinions and ideas which are the result of interactions, discussions, and filtration among the individuals on a particular issue during the project development process. It is also a filtered document from all the irrelevant opinions and ideas that do not fulfill the predefined goals and objectives or at least lead to that fulfillment.

The two filter processes in Figure 4.3 are important in resolving any conflict in the development process as well as knowledge that is not conforming to the goals and objectives. Organizing is directed towards removing equivocal information from the information environment (Weick 1969). Depending on whether the information is embedded in tangible raw materials, recalcitrant customers, assigned tasks, or union demands, there are many possibilities, or sets of outcomes that might occur.

There is a high level of interaction in the model among the individuals which requires a high level of control. Setting up the mode of interaction is vital for the success of the model. Weick (1969) declared that control in organizations is a result of relationships and not people. Group creation is an activity where the members set up the definition of the group and its type. Also included here is the assignment of the members to the group.

The next activity is the setting of goals and objectives which lays the ground of all subsequent activities. An organization is the rational coordination of the activities of a number of people for the achievement of some common, explicit purpose or goal, through division of labor and function via a hierarchy of authority and responsibility (Schein 1965). Goals and objectives setting is an activity that takes place among the members of a group through an embedded message system.



Among geographically dispersed individuals, the fulfillment of the progressive document building, the attainment of knowledge, the task assignment, and the filtration activities all depend on the decision taken by those individuals on whether or not their end products satisfy the goals and objectives. In the literature there is a common assumption that activities in organizations are performed to promote goal attainment (Etzioni 1964).

Once the goals and objectives are set, the next activity is to identify, define, and allocate the resources required during the project development process. The resources, here, are the contribution and knowledge required at each stage of the project development. The main resources are set cooperatively during the tacitly and explicitly attained goals and objectives, where discussions are held on what explicit resources are needed as well as which experts are available within the organization that might help in the attainment of the goals. The people involved in the process discuss what part of each other's know-how might be beneficial for the attainment of the objectives.

Conflict of opinions among the group members is a major issue in both face-to-face and remote settings. Any resolution needs to be mirrored to reflect the set of goals and objectives.

The explicitly and implicitly attained goals and objectives are two activities where individuals using the model interact in the quest to define what might be the explicit (resources) and tacit knowledge (know-how, expertise) required for the project development process. The members identify the explicit resources availability in past documents in the system's or organization's memory, the internet, or any external source of information. The tacitly attained goals and objectives, on the other hand, is an activity of identifying the know-how, expertise, and experiences among the members of the group. Both activities require cooperation among the members and conflict could be reduced as it is in the interest of the members to finish the design process. In this particular research, the assumption is that the students have the common interest of wanting to fulfill their term project. The overall assumption is that the group members comprise people with compatible expertise and common goals, which stimulate them to cooperate effectively and with minimal conflict towards attaining the result. This

argument is supported by Kankanhalli, Tan & Wei (2000), Kayworth and Leidner (2001), and Maznevski, and Chudoba (2000), who stated that team diversity creates obstacles to effective communication.

The research does not go into the philosophical debate on how conflict can be resolved in virtual group settings. Researchers (Souren, Pria, Samarah & Mykytyn 2005) believe that virtual teams are temporally and geographically dispersed groups, and may include members from varied cultures and backgrounds. Such diversity may cause intra-group conflicts in virtual teams. Many attempts has been directed towards examining different ways to address virtual team conflict, but research on what is conflict in virtual teams and its impact on team performance received very little attention. Souren, Pria, Samarah and Mykytyn (2005) stressed that only recently have researchers begun to address the role that conflict management styles play in tasks performed by virtual teams (Montoya-weiss, Massey, & Song 2001; Seetharaman, Samarah & Mykytyn 2004).

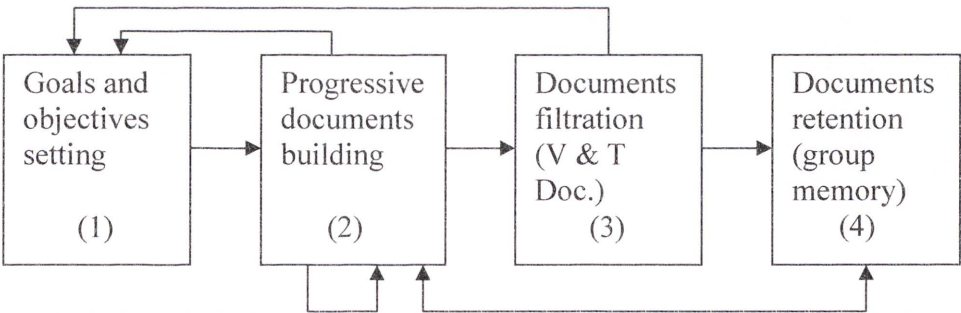
Mannix, Griffith and Neale (2002) proposed that conflict refers to awareness by various parties of their differences, discrepancies, incompatible wishes or irreconcilable desires. A more recent school of thought maintains that conflict is necessary for groups to perform effectively (Souren, Pria, Samarah & Mykytyn 2005). Cosier and Schwenk (1990) and Jehn (1995) argued that when used constructively, conflicts may cause a thorough evaluation of decision alternatives. This happens because each member brings unique perspectives and knowledge to the group discussion, which may question the assumptions made by the participants. On the other hand, groups using computer support are likely to have less affective conflict and more task conflict, as they are more focused in their discussions than the groups having no computer support (Jarvenpaa & Leidner 1998).

Souren, Pria, Samarah & Mykytyn (2005) stated that the anonymous interaction supported by group-support systems could be a major reason for low levels or absence of interpersonal conflict, because, anonymity allows greater freedom to participate openly, and hence it may encourage more productive conflict (Montoya-weiss, Massey, & Song 2001). The model's memory is essential in the fulfillment of the explicitly and tacitly

attained goals activities. This memory is accessible for documents that were retained as public, or legacy, documents. It holds knowledge of all the groups' documents, the organization's rules and procedures, member's personal documents and resources, and a list of experts and their expertise.

The next process is the assignment of members to the tacitly and explicitly attained goals activities. It is an activity where the group members expertise, know how, and previous similar design involvement is crucial. Cooperative agreement should be attained by the group members on individual's tasks during the design process. This activity does not imply that the assignment of a member to a particular task is definite because during the course of the design process, a situation might emerge causing modifications to then be necessary. The progressive document building is where the effective design process takes place. The progressive nature of this activity implies gradual building of both the Value Document and the Transformed Document. The members have constant access and awareness of all the work done by others on both documents as a result of retention of the different version by different members as well as their opinions and ideas. The filtration processes ensure the deletion from both documents of any knowledge which does not satisfy the goals and objectives or at least lead to their satisfaction.

It is to be noted that 'memory' in figure 4.3, is used in the tacitly and explicitly attained knowledge activities as well as in the progressive document building activities. The model in figure 4.3 can be summarized as shown in Figure 4.4.



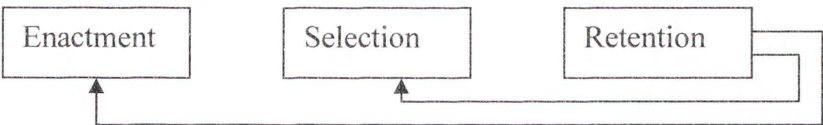
**Figure 4.4: Processes in remote knowledge transformation distributed environments**



Processes 2 & 3 in figure 4.3 are vital in shaping the final documents by the members. This argument has been stressed by Weick (1969), who stated that current system behaviors are a result of gradual shaping of an initial primitive form. He also asserts that the setting of goals and objectives is not a necessary process as he believed that we are conscious always of what we have done, never of doing it, and that actions are known only when they have been completed. He also argued that there are three organizing processes; namely, enactment, selection and retention, as shown in figure 4.4. The selection and retention processes are in accordance with the filtration and retention processes as shown in figure 4.3.

According to Weick (1969), the enactment process contradicts the two processes of goals setting and the progressive building of documents. He believes that action precedes thinking and that goals can not be set before hand as they are enacted.

The thesis argues differently as it stresses the importance of setting goals as a main activity in virtual cooperative work. Additional goals and objectives may be introduced during the interaction among the members and this might result in more release of such goals to accommodate for emergent situations. These additional goals should be introduced with much care because drastic changes to what the group's aims are might result in waste of time. This is similar to neglecting to define all problems in the initial problem definition phase of the waterfall model in systems development.



**Figure 4.5: Weick’s Organizing Processes**

**4.5 The dissertation’s management of knowledge cycle**

The KM cycle introduced in this section was developed to show the process required for the externalization of the opinions and/or ideas by the distributed individuals. The most important, debatable and critical questions being asked in KM today are as to which knowledge is to be managed, and whether or not individual knowledge can be captured and transformed. The management of knowledge has become of paramount importance, particularly tacit knowledge, as organizations are becoming more aware of the importance of the knowledge 'imbedded in the heads' of their employees, as well as the organization's explicit knowledge. They are also realizing that the success of their businesses depends on the proper management of both of these issues. There is always interplay in organizations between the saved knowledge in the organization's files and that in the heads of its employees. This interplay is integral in organizations because the knowledge retained in files and databases constitutes a base for inspiration and reflection for the employees. "The peculiar risk that we take in relying on any explicitly formulated knowledge is matched by a peculiar opportunity offered by explicit knowledge for reflecting on it critically" (Polanyi 1965). The existence of explicit sources of knowledge within the organization is vital as it constitutes its wealth, and because it provides employees with information that helps them in problem solving and in retention of information. What makes it difficult to manage knowledge in organizations and groups is the existence of these two types of knowledge. Managing only explicit is not enough because we then would be managing information only, and managing only tacit is also not enough because to be of value, tacit knowledge has to be transformed in one way or another to an explicit knowledge. This leads to the conclusion that KM should deal with both explicit and tacit types of knowledge. Nonaka & Takeouchi (1995) avowed that as a result of the dynamic interaction between tacit and explicit knowledge, personal knowledge is transformed into organizational knowledge. Jarvenpa and Eerikki (2004) stressed the business strategic importance of capturing the knowledge of the people in organizations. Consequently, the management of knowledge becomes the management of what people know.

KM aims at identifying the corporate knowledge in collective memories and facilitating communication and co-ordination between people who actually create it and people who

really need it (Wathne et. al. 1996). It is based on the realization that the preceding arguments are valid, and that the management of knowledge has to take into consideration aspects which surpass simply identifying knowledge and finding it. Knowledge has no value if it is not captured, retained, reused, and most importantly communicated among people.

The management of knowledge has to deal in the first place with deciding which knowledge is to be managed, whether explicit and/or tacit. Identifying the sources of knowledge is an important aspect, as it is a reflection of what knowledge needs to be managed, externalized and measured. Finding ways for this externalization and a technology, or a set of technologies, to this effect and for the retention and later access of the knowledge is also imperative. Finally, communication and accessibility of knowledge should be maintained and defined properly.

Explicit knowledge is collected from different sources:

- 1- previous documents
- 2- books/manuals
- 3- databases
- 4- Internet
- 5- messages
- 6- E-mails, and such.

The embodied knowledge (also called implicit) is the know-how of the individual and is manifested in the form of procedures, or 'how to do', based on expertise and practice of the individual. Examples of such knowledge:

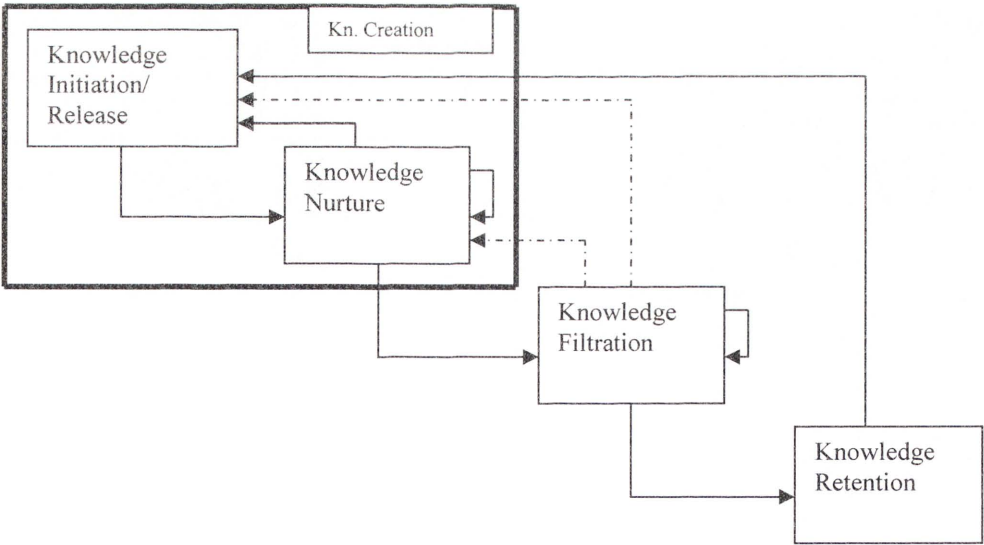
- 1- how to perform a particular task
- 2- how to do
- 3- what to do
- 4- why to do



The not-yet-embodied knowledge is by nature hard to capture and transform and is subject to the individual's perception and mental analysis presented in the form of opinions and ideas. The challenge with this knowledge is that the individual might not be aware of its existence. Stimulus may play an important role in the enactment of such knowledge. Situations that require reflection, thinking, and imagination facilitate, or at least might trigger, the awake-ness of such knowledge. This by itself may not be enough for the individual to formulate knowledge from his/her brain as intelligence is a determining factor here.

In the KM cycle presented in diagram 4.1, knowledge refers to the categorized types of tacit knowledge, which are opinions and ideas.

- 4- Knowledge creation
  - a. initiation/amplification
  - b. knowledge nurture
- 5- Knowledge filtration
- 6- Knowledge retention



**Diagram 4.1: The thesis' KM Cycle**

The group creation, assignment of members, goals setting, attainment of knowledge, as well as the progressive document building are mirrored by the knowledge (O/I) creation step in the cycle in Figure 4.3. Opinions and Ideas are initiated or released by members to be consequently nurtured based on a predefined set of objectives. Knowledge filtration is an activity mirrored by the filters in the model of Figure 3.2. This process in either of the models or the cycle is a repetitive process which is concluded as two documents.

### **Step 1: Knowledge Creation**

Knowledge is created by members who accumulate it by a process of initiation and release followed by development and amplification as a result of interaction through documentation. The creation of knowledge has to go through two important complementary steps; namely, knowledge initiation and knowledge nurture. In a similar argument, Nonaka and Horitaka (1991) stated "By organizational knowledge creation, we mean the capability of a company as a whole to create new knowledge, disseminate it throughout the organization, and embody it in products, services, and systems". To better understand the knowledge creation process, I present an example which compares the creation of the three different types of knowledge among members in a group to the historical process of creating fire.

#### **EXAMPLE:**

Creation of knowledge is similar to the ancient process of creating fire because of the similarities in the two processes as well as the similarities in the tools required. Basically, to create fire, one needs people, two pieces of solid wood, and a handful of dry grass. Likewise, to create knowledge, one needs people, a set of predefined goals and objectives, and an initial concept(s). Before making fire, wood must be collected as it is the resource for the sustainability of the fire once a spark is generated. Similarly, explicit knowledge is gathered from existing sources, for example, files, books, internet, once the group forms an understanding of the goals as well as the initial concept. An individual starts making fire by rubbing together the two pieces of wood to ignite the dry grass. It is a time consuming process which culminates in little sparks igniting the fire after adding grass. The rubbing of the two pieces of wood is comparable to the initial interaction

among members of a group when they are given a set of goals and ideas to form an initial concept of what is required. This is the enactment of knowledge, opinions/ideas in the heads of individuals. The rubbing of the wood and interaction are comparable. The latter requires interaction among people to create understanding and resulting in more knowledge being created given a context. The former necessitates friction to produce results.

Once fire is lit it can be nurtured by people around the fire adding more dry grass and wood. Likewise, once concepts are formed, more knowledge is initiated by the members. The sustainability of the burning of fire depends on the amount of wood added and the wind status. This is comparable to the nurture of knowledge among the members which is achieved by more personal knowledge initiation as well as explicit knowledge collected earlier and its adoption (books, manuals, databases, processes and procedures).

The nurture of knowledge depends highly on these explicit factors as the fire sustainability depends on the wind. Too much wind might extinguish the fire and too much reliance on external knowledge may negatively influence the nurture of knowledge by excluding new knowledge in the form of ideas and opinions, and by disrupting the knowledge creation process as a result of duplication and misunderstanding among the members. On the other hand too little wind might slow down the burning of the fire in the same way that lack of explicit knowledge might affect the creation of knowledge. Original knowledge should somehow be supported by existing knowledge and by reflection on existing knowledge. In short, the sustainability of the burning of fire is a result of a harmony between the amount of wood added as well as the state of the wind, the same way that the sustainability of the knowledge creation process is a factor of individual knowledge initiation, the effectiveness of external resources, the nurture of the knowledge initiated, the amplification of the explicit knowledge, and the proper interaction among the members.

### **Step 1.1      Knowledge initiation**



Knowledge initiation is based on the members' understanding of the context, as well as the availability of the goals and objectives. The initiation of an opinion or/and idea is a consequence of the group members' perception of the expected outcome from the development process. Action can either be

- 1- Initiation of new knowledge, that is, knowledge which is not based on the analysis of existing knowledge within the group. This new knowledge can be explicit, in the form of information collected from books, manuals, databases and such, tacit-embodied knowledge in the form of know-how, procedures, and processes, or not-yet-embodied knowledge such as ideas and opinions.

The initiated knowledge is based on the member's belief and interpretations of the context, and it provides the platform for discussions and individual interpretations among group members during the nurture process. It is a process where the members initiate/release new knowledge as a result of mental reflection which goes deep into the brain of the individual as his/her expertise, his/her perception towards the fulfillment of the goals and objectives, and his/her reflection on past experiences.

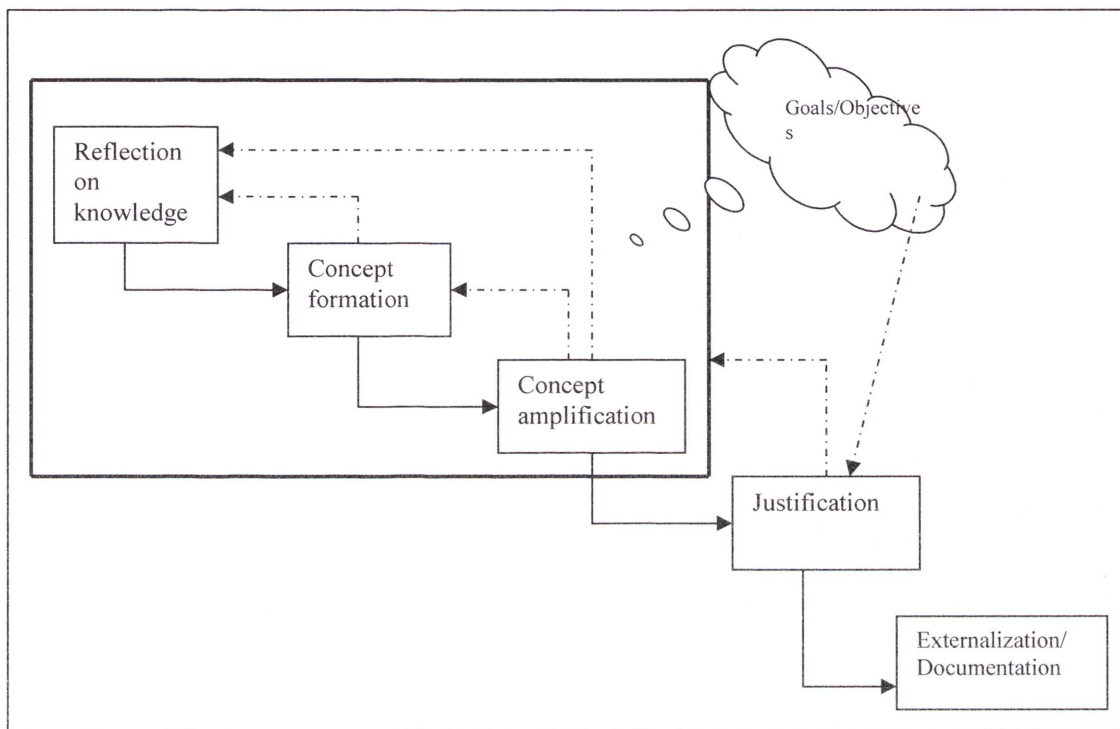
- 2- A process of an individual's releasing knowledge as a result of reflecting on existing knowledge released earlier by others. The individual amplifies and enlarges that knowledge by his/her reflection and perception on previously accumulated knowledge by the group. Also, the amplified knowledge is a result of the members' interaction with other members, accessibility to available knowledge, and his/her perception and reflection on that knowledge. Schon (1983) pointed out the importance of "reflection in action", that is, reflecting while experiencing. He added that individual knowledge is enlarged through this interaction between experience and rationality and crystallized into a unique perspective unique to the individual.

## **Step 1.2: Knowledge nurture**

Knowledge remains within the individual until it is articulated and amplified through interaction. The nurture of knowledge is a step where the members collaborate to amplify, adopt and create new knowledge or relinquish unwanted knowledge. At this step, initiated and/or amplified knowledge is available to the group members. The members 'fetch' this knowledge and form an understanding of its content. That is action reflection. The nurture of knowledge is a process through which existing knowledge is understood and new opinions and ideas may be formed based on it; in other words, the reflection process. This process requires a high level of interaction via messaging and/or document's augmentation among the members in order to nurture the knowledge initiated or amplified in the previous step. This process is an iterative process which results in the formation of new knowledge that contributes to the overall development process. Knowledge nurture is a process where knowledge members fetch available knowledge, reflect upon it, amplify it, and release it into the memory. The member's perspective on existing knowledge is brought upon by the availability of that knowledge to the members and the ease of its access. Knowledge nurture is a continuous process based on both individuals' and group's interpretation and perception of existing knowledge.

The nurture of knowledge should result in the emergence, formation, and creation of new concepts which is regarded as a necessary amplification of previously released knowledge by the members. It is an individual's process of reflection, concept formation, concept amplification, justification, externalization and documentation of new knowledge which is then integrated, that is, initiated and released, into the group's document (diagram 4.2).

The nurture of knowledge is also a cooperative process and requires high-level of interaction and discussions among the members particularly during the justification of the concepts. This interaction and the sharing of information between the members promote the sharing of member's experiences and know-how which might trigger the creation of new knowledge, hence the amplification of knowledge.



**Diagram 4.2: The nurture process**

The nurture of knowledge is the ability of interacting individuals to form new concepts by reflecting on existing knowledge, a process which might trigger past dormant expertise and/or knowledge in the unconsciousness of the individual. Reflection and expertise are complementary for the creation of new knowledge. The individual's past experiences as well as his/her reflection on others' released knowledge result in the formation of new concepts. These concepts are the result of a cognitive analysis based heavily on his/her intelligent, analytical and experimental abilities. They are also based on his/her ability to synthesize unrelated knowledge into new concepts. To make sense, ideas and opinions should be textually articulated. The individual's reflection on existing/released knowledge is a mental process of comprehension, conscious analysis, concepts understanding, and learning through exposure to other's know-how which might trigger dormant knowledge in the unconsciousness of the individual.



Face-to-face, creative ideas result at the conscious interaction level and do not simply come out of the air. Interactions among individuals are important factors for innovation. Leonard and Spensiper (1994) suggested that the essence of delivering new products, services, and organizational processes is social interaction among individuals. The dilemma here is that if such innovation lacks the face-to-face factor then what options are available as a medium for interaction. In other words, geographically located virtual teams working towards delivering a product or service should be provided with a support which simulates face-to-face interaction.

This thesis argues that the textual articulation of an individual's ideas into documents together with a powerful messaging system for their cooperation is integral among group members in asynchronous settings.

Remotely located members should be able to articulate their knowledge, both explicit and or tacit in textual form and make them available for others to reflect upon. This knowledge, which contributes to the overall product development could carry with it part of the not-yet-embodied knowledge. The nurture process provides the infrastructure for possible further articulation of this knowledge by members. Williams and O'Reillt (1998) argued about the importance of the members' diverse information in the creation of new knowledge. This argument is also supported by Janis (1982), who asserted that the overlapping experimental background of the individuals in groups leads to "close-mindedness" and pressure towards uniformity. For this reason, Diagram 3.3 shows that knowledge nurture is a repetitive process.

The success of the nurture of knowledge may be measured by how much of the contents of the released knowledge in the TKd can be matched to the VKd. The volume of opinions and ideas articulated in the TKd indicates the effectiveness of the nurture process. This is a result of the articulation of new knowledge, that is, tacit knowledge, by the members. This assumes that knowledge initiation is a result of a cognitive process of reflection on existing knowledge. It is also an indication of the successfulness of the interaction system which allowed the ideas exchange among the members.

## **Step 2: Knowledge filtration**

Filtration is a process through which the knowledge created via initiation and nurturing during the development process is tested to conform to the predefined goals and objectives. It is an important iterative process as it eliminates knowledge that does not fulfill the objectives, or lead to their achievement. This requires a high level of interaction among the members in order to discuss and agree on the relevance of the released knowledge.

## **Step 3: Knowledge retention**

This step is a simple but vital step which allows the saving of the final documents into the group's or system's memory and makes sure that accessibility is maintained. It is vital as it has two major functionalities; one is to retain knowledge and the other is to provide knowledge. The organization of knowledge plays an important role in this step because the retained knowledge forms the backbone of the group memory system. It is necessary to mention here that the word 'knowledge' used in the cycle refers to both the value-knowledge and transformed knowledge defined earlier in this chapter.

## **4.6 Knowledge transformation among geographically distributed virtual group members**

Knowledge is the nurture of opinions and ideas during individuals' interaction, conversations, and cooperation. Cooke (2003), Crowley (2001), Gourlay (2002) and McNerney (2002) stated that conversation and narrative are critical for tacit knowledge transformation into explicit knowledge. Similarly, Cooke (2003), Farrell (2001), Hager (2000) and Sveiby (1999) associated tacit knowledge with terms such as skills, know-how, working knowledge, and expertise, and that they are used to reflect knowledge which describes the ability of individuals to perform tasks. Gourlay (2002) identifies two issues associated with this knowledge. The first is whether it is an individual trait or a

trait that can be shared by both individuals and groups, and the second is whether it can be made explicit. This thesis suggests that extracting tacit knowledge from the members is a culture that encourages the release and nurture of their opinions and ideas through the progressive and consequential building of a shared document.

An individual’s knowledge is released into documents and becomes the source of knowledge for other members who nurture it by amplifying its contents into more knowledge as a result of transition of transformation from one type of knowledge to another.

Figure 4.6 introduces the dissertation’s views on the transformation of knowledge in a virtual setting and compares it to Nonaka and Takeouchi’s 1995 face-to-face knowledge transformation. The issues associated with knowledge transformation among remote group members is the lack or even impossibility, of direct physical interaction among the members and the reliance on IT tools for interaction and communication. The dissertation adopts a shared document structure as the basis for interaction among the members of groups together with facilities for ideas exchange and discussions. It also assumes that a member’s textual articulation of the opinions and ideas correspond to the verbal articulation in face-to-face interaction; hence, the reflection process is reflection on what has been released by individuals.

	Face-to-face interaction	Virtual interaction
Tacit-to-tacit	Socialization, interaction, verbal articulation, discussions, apprehension through experiences	Textual articulation, reflection on textually articulated/released knowledge, mental amplification, messaging
Tacit-to-explicit	Externalization, textual representation	Textual representation, textual amplification
Explicit-to-tacit	Internalization, comprehension	Access, comprehension, concepts formation, mental amplification
Explicit-to-explicit	Combination, linking information together	Access, editing, augmentation, documentation, textual amplification

**Figure 4.6: Spiral for knowledge transformation in virtual setting**



1- Tacit knowledge can be converted into tacit knowledge, through a process of reflection on documents contents released by group members in the form of opinions and ideas. In face-to-face interaction, tacit-to-tacit is a socialization process which converts tacit knowledge through interaction between individuals and relies on the experiences gained from the interaction. In remote interaction, this knowledge is converted, or transformed, through a mental reflection on textually available knowledge. The interaction is not physical but through documents. The result is a nurture of the individual's knowledge and possibly amplification of his/her tacit knowledge.

2- Tacit knowledge is transformed into explicit knowledge through the release and documentation of the member's opinions and ideas into shared documents. The identification of opinions and ideas is a process where the group members introduce them as individual's perception of how particular problems and solutions to the context might satisfy or lead to the satisfaction of the objectives and goals. The group support system that supports such transformation should allow group members to create a shared document for the task at hand, capture explicit knowledge, and capture their thoughts and expertise as opinions and ideas in an explicit form through the use of a group support system.

3- Explicit knowledge is transformed into tacit knowledge through a process of accessing and comprehending the contents of a document which holds the member's opinions and ideas. The group members should have reliable access to retained information or knowledge. The group support system supports this by providing a group memory, which easily facilitates the retrieval of knowledge.

4- Explicit knowledge can be transformed into explicit knowledge through augmenting and documenting the opinions and ideas in the shared document through the release of knowledge, as opinions and ideas by the members. The process here is retrieve, use, amend, and store any existing documents in the system.

The Yan Kee group in an article entitled “Communication, Collaboration, Coordination: The three C’s of work group,” (1995) introduced what it called “The Complete Infrastructure of Groupware as having three dimensions:

- 1- Communication (pushing and pulling of information and knowledge in and out of organizations.
- 2- Collaboration (shared information building on shared workspaces).
- 3- Coordination (delegation of tasks).”

Other project teams have attempted to capture their thinking by audio or videotaping their meetings and ended up with a staggering volume of tapes and files. While several others have tried to preserve tacit knowledge during face-to-face interactions as reports, meeting minutes, design documents, presentations, memos, and indeed practically anything that they wrote down. This group ended up with an office completely filled with stacks of papers, extending almost to the ceiling. Some even had the luxury of a project historian or librarian, whose job is to capture and organize the knowledge created in the course of the project. It also failed, because without a way to capture the informal knowledge as well, and without an organizational commitment to accessing and using this knowledge, it was just an expansive way of filling the attic.

On the other hand, as McInerney (2002) suggested, instead of “extract[ing] knowledge from within employees to create new explicit knowledge artifacts” (50-68), the focus in organizations should be on creating a ‘knowledge culture’ that encourages learning and the creation and sharing of knowledge. Mandviwalla et al. (1995) have addressed the issue of collaborative writing and suggested that it adds insights to the design of computer-based collaborative writing tools. They also argued that a group authored document is a common form of collective memory and that collaborative writing is a cognitive process in which a portion of group memory is formalized.

The problem of retrieval is addressed only after the problem of creating a group memory that identifies the ‘value knowledge’ needed by the group members is addressed. Creating such a memory requires capturing the knowledge and organizing it effectively.

Jeff Conklin (2002) stressed that transparent knowledge capture which preserves relevance and meaning is a major challenge. He added that the capture of informal knowledge is difficult and expensive but can be made easier by improving teamwork.

Because Sternberg (2000) and his colleagues view tacit knowledge as knowledge which has not been made explicit, they (Stenberg & Hedlund 2002; Sternberg & Horvath 1999; Sternberg et al. 2001; Gourlay 2002) have developed ways to measure tacit knowledge as have Richards and Busch (2000). In summary, if tacit is to be used in KM, it is imperative to make it explicit.

Discussions on retaining knowledge, in the literature, mostly addresses explicit knowledge as a process of searching and locating knowledge and tackles implicit knowledge as a process of searching for experts possessing this knowledge. There is hardly any effective attempt to retain tacit knowledge even though it is a treasure that contributes effectively to the competitive advantages of an organization if properly retained and accessed when it is needed. We have to understand the nature of such knowledge in order to understand why research on implicit knowledge is so poorly conducted. It is knowledge about mental models, skills, know-how, expertise, concepts and similar.

Vasconcelos (2000) in his taxonomy showed that explicit knowledge could be defined as structural knowledge about documents and explicit communication among individuals where the documents are accessed. The same does not apply to implicit knowledge and, in this author's opinion, that explains the taxonomy only listing the forms such knowledge take and not its structural form. Explicit knowledge is formal knowledge, that is, knowledge that can be described in forms, databases and documents, whereas implicit knowledge is less formal or informal.

In order to confirm the previous findings regarding the relationship between tacit knowledge transformation and opinions and ideas, the following example demonstrates how opinions and ideas transformation, and consequently tacit knowledge



transformation, can be established. The example will demonstrate how opinions and ideas are captured and transformed among individuals working cooperatively.

The example is based on the assumption that three geographically dispersed people, namely X, Y, and Z are working together to develop a design for a state of the art car. Presumably, their cooperation would be supported by a virtual cooperative group support system which possesses the functionalities introduced in chapter 5.

The example describes how the members' opinions and ideas during the design development of the car can be captured, transformed, and shared based on Table 3.1. Geyer (2001) supports this transition of knowledge transformation between tacit and explicit by stating that "it moves back and forth across explicit and tacit dimensions from individuals to collective knowledge groups and back again".

Tacit-to-tacit: One day 'person X' was reflecting on what 'person Y' had told him in regard to the design of the car and his/her analogy regarding the speed of the car as compared to the speed of the Stealth Bomber, a very high-tech airplane he had seen at an air show few days ago. After reflecting on 'person Y's' explanations about the advanced features of the Bomber, 'person X' started to form ideas about designing a car that is not only as fast as the Bomber but also inspired by its overall design as a state of the art piece of technology.

Tacit-to-explicit: Being so hyped up about this incredible idea 'person X' instantly sends a message to the 'group' (persons Y and Z) notifying them of his brilliant idea. He started to articulate his ideas and opinions regarding the design onto the transformed-knowledge-document, containing the opinions and ideas, as well as updating the Value-document, being the original document, of the group with a detailed description of the design specifications supported by extracts on similar design from the internet and research available in previous documents within the group and explaining some details he believes are not likely to be understood by the untrained eye.

Explicit-to-explicit: By accessing the documents and reflecting on 'person X's' ideas and new specification updates on the shared document, persons Y and Z communicate

through exchange of messages and update on the shared documents with feedback regarding the design and prototype suggesting some vital modifications where necessary. This modification may either be entered as opinions and ideas on the transformed knowledge document or as an update to the value knowledge.

Explicit-to-tacit: After finalizing all the specifications that were introduced and getting approval from higher authorities, assuming the group works in an organization adopting the group support system, they export the value document to the manufacturing team. Before beginning the manufacturing process, the manufacturing team has to check if their existing equipment fits the requirements of the new design. The manufacturing team now must think of the best possible way to manufacture the car to maximize profits while delivering the best quality. In short, the blue shared document provided by the design team (explicit knowledge) was given to the manufacturing team to work on and to develop their opinions and ideas (tacit knowledge) regarding the best possible way to build the car.

#### **4.7 Representation of knowledge as an object**

As discussed earlier, representation of knowledge as an object is the backbone of the knowledge externalization process in the thesis. The object's contents are the knowledge released by individuals in the virtual setting. Opinions and ideas are captured as objects in a document by individuals who access them and augment them as a result of nurturing and discussions.

This thesis differentiates between the structures of two objects:

- 1- Cognitive object, present in the brain of the knower (tacit)
- 2- Physical object (explicit)

Interaction and communication among members in a group is the basis for the transformation of the object from the cognitive state to the physical state as a result of the release of tacit knowledge into a document. The mapping between the two states cannot be a complete transformation of the 'content' of the cognitive to the physical. But

interaction and discussions on the contents among members nurtures further mapping, resulting in the transformation.

The knowledge-as-object approach is still influential (Walsham 2003), even though there has been increased emphasis in recent years on practice-based theories of knowing and learning (Blackler 1995, Blackler et al. 2000). The importance of context in designing and implementing knowledge management initiatives (Thompson & Walsham 2004) has also been acknowledged. This includes those involving information and communication technologies (McDermont 1999, Walsham 2001). Communities of practice were the platform for work among these approaches (Lave & Wenger 1991, Wegner 1998, Brown & Duguid 1998).

Knowledge is essentially objective. Such names as the 'given' or the 'content' of knowledge may be substitutes for that of 'object', but the fact remains that we know something external, which is not formed by, but offered to, the mind (Catholic Encyclopedia 2009).

The cognitive nature of an object was addressed in the literature. Cognition is brought about by the presence of the known object in the knowing mind. The object here is not a physical object like a picture, a duplicate, or a copy. It is a cognitive likeness. Knowledge can take many forms, hence the issue of where knowledge resides is a question that depends on a person's view of what knowledge is.

Therefore, to some, (Polanyi 1969) knowledge is with the individual and for some it is in groups or communities of practice (Nonaka Takeuchi 1995, 1996). Polanyi's theoretical ideas on explicit knowledge are worth noting. The ideal of a strictly explicit knowledge is indeed self-contradictory; deprived of their tacit coefficients, all spoken words, all formulae, all maps and graphs are strictly meaningless (Polanyi 1969). As discussed previously, Polanyi rejects the existence of explicit knowledge and claims that all knowledge is rooted in tacit knowledge. Consequently, he rejects the idea of representing knowledge as an object.



The conceptualization of knowledge as an object is effective for building applications because it allows for the transferability of the knowledge. Consequently, I argue with Polanyi's views that tacit knowledge cannot be made explicit on the basis that his books and research papers are a damning proof that tacit knowledge can be represented in textual form that can be understood by others. In his arguments, he contradicts himself by stating that there is always something missing in the articulated knowledge of an individual. If we accept this account to be true then all his writings overlook the valuable knowledge in one's consciousness.

Polanyi (1969) was clear in his statement which asserts that there is objective explicit knowledge independent of the individual's tacit knowing. I fully agree with this argument provided it was the final result of his ideas. I am in disagreement with his three triad definition of tacit knowing described earlier in this chapter. These ideas were further adopted by Welsham (2001) who devised a basic communication model to represent them.

Polanyi gave an example of a person who was traveling in a country which he has not visited before. The person reports his experience in the country at the end of the first day, in a letter to a friend. This example, according to Polanyi involves three integrations or the heuristic blending of experience through tacit power which he described as: "we may say that the triad of knowing consists of subsidiary things (B) bearing on a focus (C) by virtue of an integration performed by a person (A)" (Polanyi 1965).

My disagreement is with the "re-presentation" through voice, text, data, diagram or similar in Welsham's 2001 model (Figure 4.1) which corresponds to Polanyi's (1995) sense-giving argument. Polanyi ruled out the possibility of objective explicit knowledge in the sense-giving stage. My position is different, given the fact that person B (Figure 3.1) in the reading of representation stage reads and may comprehend the contents of the letter, one must question why the letter cannot be accepted as an object in textual form which is a representation of its cognitive likeness. In such a case, Polanyi would not, in my opinion, be contradicting himself. The 'subsidiary things' have been reflected upon by person A in the action reflection with his/her experiences and past knowledge of

similar context and the result is a textual form of person A's tacit power. Person A may have not articulated all of his/hers tacit knowledge in the letter and Polanyi's statement "we can know more than we can tell" still holds true, but the articulation of tacit knowledge into a readable form represents the first step in the transformation of an individual's tacit knowledge into explicit form.

This transformation may not be a complete representation of its cognitive likeness; however, it appears to be beyond any doubt that objectivity of the meaning of the subsidiary elements has been integrated, reflected upon and written. Hence it appears that some sort of transformation took place, even though it may not be a total reflection of the tacit power of person A.

In addition, more of the tacit power of person A could be fetched and nurtured and more transformation of his/her tacit knowledge regarding the subject could be articulated had person B asked for more details about person A's experience. Consequently, person A and person B nurture an existing opinion or idea resulting in the release of more tacit knowledge. The interaction and cooperation between an individual with others might trigger new or additional knowledge as a result of action reflection and consequently more of his/her tacit knowledge could be articulated. The re-presentation is augmented as a result of a deeper reflection about the new stimulus to the latent knowledge in the consciousness.

The interaction in this case is the exchange of letters between person A and person B. The same is true in a face-to-face interaction where people engage in conversation to discuss a topic which may utter additional opinions and ideas as a result of comments and clarification between each other. This process may also result in learning of a different sort by the interacting individuals; namely, learning about the analysis and problem solving techniques of others. Similarly, such learning is possible in a virtual group members interaction where the group member's released tacit knowledge may trigger the articulation and the leaning process found in face-to-face interaction.

Accessing the released knowledge results in group member's engagement in discussions about the contents of what has been articulated and released with the person who initially uttered the piece of knowledge, as well as among each other. This discussion might awaken dormant knowledge (not-yet-embodied knowledge) in the sub-consciousness of the person who initially articulated the knowledge. This environment of discussion may also affect other members by awakening their own not-yet-embodied knowledge.

The above arguments cannot be realized without an effective tool for cooperation made available to the group members in virtual setting. It is the effectiveness of the technology that is used by the group, I.e. the GSS which makes the interaction productive and the release, capture, nurture, transformation, and retention of knowledge possible. The cooperative system should provide an effective and dynamic group memory to accommodate for the progressive and consequential accumulation of the group's knowledge. This group memory system provides an easy access and retention of the contents of the objects within the group. It also provides a good messaging or conversational system for the overall effectiveness of the process of knowledge transformation.

The following example is an illustration of the above mentioned process:

**EXAMPLE:**

Assuming a tool or a group support system (GSS) is used as a platform for cooperation among geographically dispersed virtual group members; it allows remote interaction on a shared workspace between the members of a group of 4 students developing their semester's long term project. This idea of cooperative development of a term project in a workspace structure and the support and coordination of activities has been addressed by few researchers in the field. The members have set the general outlines of the project in the form of goals and objectives. The system allows the cooperative progressive and consequential building of documents based on the objectives and ideas.

The output from the overall development process is two documents. One is the project itself, containing both explicit knowledge and the group's opinions and ideas, while the



other contains, in versions, all the opinion and ideas released by the members during the development of the project. The tool also provides facilities for discussion, messaging and notification to be passed among the members.

The process starts by creating a common group document on which the members will accumulate their project. Let us assume that member 'A' devised two pages about the subject in question and saved them in a VKd. Member 'A' had also separately written his/her opinions and his/her own perception that he/she might have on the subject on TKd. The other members in the group are aware of the existence of member A's output on TKd and VKd. They can access both documents, although they cannot alter the TKd for reasons of originality. Member B, for example, may read the knowledge provided by member A in both documents, and notify him/her of any ideas either by using the massaging system or as an update of member A's TKd; namely, his ideas and opinions.

The other members by logging into the system become aware of what is happening between person 'A' and person 'B' and may simply engage in the process. The end product is the semester's project, being the last version of VKd, and all opinions and ideas of the group, being the last version of TKd. The overall process of developing the project presented in the example has the same characteristics as that of Polanyi's (year) ideas on tacit power and acts of communications as well as Walsham's model and his 'Compound UK' example.

This thesis distinguishes between tacit and explicit knowledge based on the assumption that tacit knowledge in the form of opinions and ideas resides in the heads of people and that its release and articulation allows the reader to be aware of the individual's opinions and ideas. This initial articulation of knowledge can subsequently be improved, or nurtured, through discussions and interaction between the knower and the reader.

This process might result in further articulation of additional insights by the individual because the discussion may trigger knowledge that might have been dormant in the individual consciousness at the time he/she articulated the initial opinions and ideas.

The opinions and ideas are the property of the consciousness of an individual as long as there is no trigger or need for articulation. The moment a person starts to articulate his/her opinions and ideas an initial mapping of the knowledge in the brain (embodied knowledge) is uttered and may be articulated as a textual form. More knowledge of the unconscious may be articulated as a result of interaction among individuals.

## **CHAPTER FIVE- Technologies for knowledge externalization: an example tool for categorized tacit knowledge types' externalization**

This chapter introduces the current technologies used by distributed individuals, groups, and communities for their communication, collaboration, and cooperation for managing and externalizing their knowledge. It also introduces an example tool 'Virtual-Interactive-Personalized Group-Support-System' (VIPGSS) which was developed as a possible technology to support geographically distributed individuals in their quest to cooperate and externalize categorized types of tacit knowledge, namely opinions and ideas. The chapter recognizes the lack of an integrated technology for remote interaction among individuals and stresses that an integrated tool is critical for the support of such interaction given the difficulties in the diversification of the use of technology in organizations, businesses and educational institutions. The introduced tool is developed taking into considerations aspects from Computer-Supported Cooperative-Work (CSCW) groupware and group memory.

### **5.1 Introduction**

Globalization compelled researchers and businesses to develop both theoretical and technological support for KM and distributed group work. The management of knowledge emerged as a vital theoretical discipline for the KM processes and the knowledge conversion activities. Moreover, this led to the development of various supporting tools for the associated processes and activities.

Current KM technologies intend to improve, enhance, and/or enable knowledge externalization contrary to the traditional fulfillment of activities in other disciplines through the use of technology. This is mainly due to the elusive nature of knowledge and the resulting diverse KM processes and knowledge conversion activities. The literature provides several categorizations of knowledge tools, often actually offering some classification or taxonomy of various relevant ICT technologies for supporting KM (Carlsen & Paulsen 1999) and knowledge conversion.



It was Polanyi's (1966) distinction between explicit and tacit knowledge which urged researchers to develop a set of management concepts, disciplines and definitions directed toward building a framework for the management of knowledge. Consequently, (Liao 2003), different KM working frameworks were developed; namely, definitions, paradigms, frameworks, concepts, objects, propositions, perspectives, measurements, and impacts. These have been detailed for the purpose of investigating the numerous questions about KM: What is knowledge management? What are its methods and techniques? What is its value? What are its functions for supporting individuals and organizations in managing their knowledge? And finally what technologies are required for its externalization? (Nonaka et al. 1996; Wilkins et al. 1997; Wiig et al. 1997; Heijst et al. 1997; Johannessen et al. 1999; Drew 1999; Liebowitz & Wright, 1999; Hendriks & Vriens 1999; Rubenshtein-Montano et al. 2001; Liebowitz 2001, and Liao, 2002).

The efficacy of transforming parts of tacit into explicit is in "enabling everyone in an organization to verbalize their tacit knowledge" (De Alwis & Hartman 2008). This tacit knowledge cannot be limited to the employees' know-how, but also their thoughts, opinions and ideas. The use of information and communication technologies can only partly help the externalization of tacit knowledge, as much of that knowledge is transformed by observations, skills, body language, physical demonstration, doing, and repetition.

Integral to such knowledge creation among distributed group members is an open culture where thoughts, know-how, opinions and ideas are freely articulated and captured. Importantly, individuals have to cultivate a commitment to articulate their knowledge and this can only be achieved if they share common interests in the process and activities development. In order to achieve successful and effective knowledge externalization among the individuals, an integrated tool (a GDSS) becomes a necessity. Such a tool narrows the gap between the distributed individuals, and facilitates their knowledge externalization by bringing them as close as possible to each other. The technological requirements of such a tool combine concepts and protocols from CSCW and groupware

and include functionalities mimicking the physical interactions found in face-to-face settings.

## **5.2 The Need for an Integrated Tool**

Table 4.1 clearly demonstrated two major facts. Firstly, it shows that instances of opinions and/or ideas are types of tacit knowledge. Secondly, it shows that for each of the identified tacit types there is one or more available piece of technology which can be adopted for the manipulation of the types. Given the current business situation which is characterized by the lack of an integrated tool, it is common for businesses to use different tools for the different activities associated with knowledge externalization. Depending on the associated functionalities in a business process, decisions are taken about which tool, available in the market, supports these functionalities. It is also common that more than one tool is used and possibly integrated in support for the fulfillment of the functionalities in the form of links to the tool. In today's organizations and businesses the use of different software, groupware and other cooperation, communication and KM technologies is becoming a by product. It would have been more practical, more effective, and easier, for those organizations if an integrated tool could be developed which encompasses the KM processes, consequently addressing the externalization of whichever type/s of knowledge these organizations categorize.

Despite the recent trend of technologies supporting the management of knowledge in distributed groups and Communities of Practice (CoP), significant shortcomings persist. These are in the availability of an integrated tool which facilitates interaction, communication, encompasses all the activities in the process, and accommodates the required support for the knowledge conversion process in general and particularly when it comes to tacit knowledge externalization.

The problems associated with recent Group Support Systems (GSS) and Distributed Group Support Systems (DGSS) and/or Groupware technologies support for the KM process are the result of the inevitable use of diverse technological tools for the coordination of work, processes, and tasks in distributed environments. Recent literature

(Samara et al. 2008), on knowledge conversion in GSS-aided virtual teams showed the necessity to use a variety of configured software among distributed group members, such as Lotus Same-time and IBM collaboration software.

Groupware emerged as a bland of synchronous (chat), asynchronous (e-mail) and community-focused tools (e-groups) where informal communications predominate and where participants freely collaborate and exchange their thoughts and feelings. Groupware systems are well suited to support CoP where specialists of a given domain of knowledge, who may be dispersed all over the world, exchange their expertise in finding a solution to a specific problem. The groupware utopia is to offer an interaction with quality near to face-to-face conversion of knowledge. Discussion groups and chats are common groupware applications which make possible the articulation of knowledge. However, writing is still the predominant way of communication in most, if not all, groupware; for example, Microsoft Exchange, lotus Notes, Blogs, and Wiki. There is no claim in the literature regarding the existence of an integrated technology which supports dispersed groups in managing the knowledge processes and in knowledge conversion and externalization activities. These technologies, on the other hand, allow for effective capture of knowledge/information among the participants, joint documents editing, distant conversation, and immediate messaging.

Table 5.1 presents current classes of KM software and their main contribution to Nonaka and Takeouchi’s (2001) knowledge conversion processes. It also shows the disciplinary origin of their main concepts.

Category	Dominating Knowledge Conversion Process	Origin of concepts	Example
Intranet-based systems	Combination	Computer networks (web technology)	Microsoft Internet Information Server, Blogs, Wiki's
Electronic Document Management	Combination	Information Science	Excalibur RetrievalWare and File Net, Blogs, Wiki's
Groupware	Externalization	CSCW (Computer Supported Cooperative	Notes (Lotus) and Exchange (Microsoft), Blogs, Wiki's



		Work)	
Workflow	Externalization	Organization & Methods	ARIS Toolset (IDS Scheer)
Knowledge Base Systems	Externalization	Artificial Intelligence	Neugents (Computer Associates)
Business Intelligence	Combination	Data Base Management	Business Objects
Knowledge Map	Socialization	Information Science and Human Resources Management	Gingo (Trivium) and Lotus Discovery Server
Innovation Support Tools	Internalization	Innovation and Technology Management	Invention Machine
Competitive Intelligence Tools	Combination	Strategic Management and Information Science	Knowledge. Works (Cipher Systems) and Vigipro (CRIQ/CGI)
Knowledge Portals	Socialization, Externalization and Combination	Computer Networks and Information Science	Digital Dashboard (Microsoft), Lotus k-station and Sopheon

**Table 5.1 Categories of KM software (Carvalho & Ferreira 2001)**

The utilization of existing software technologies which support Nonaka’s (year) conversion model mainly supports information access and retrieval. Not much has been done or said about knowledge externalization as well as coordination and cooperation support among distributed individuals. Increasingly KM software will be classified in more than one of the proposed categories, which can be alternatively considered as an array of KM features that can be integrated in software (Carralho & Ferreira 2001).

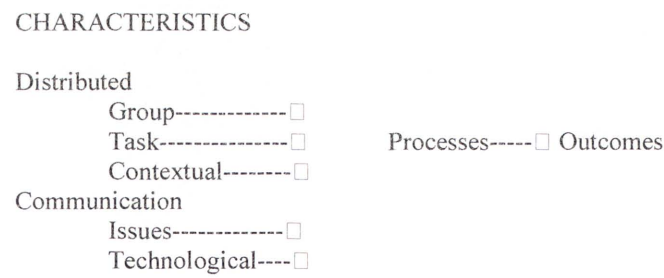
Recently, technologies such as GSS and DGSS for remote interactions among distributed individuals started to emerge. They support individuals in groups, teams, or CoPs “at different locations and possibly different times”, in their decision making, communication, and cooperation (Dase, Tung & Turban 1995). Their impact on the performance of distributed teams, team members, and communities was the subject of several studies but their impact on knowledge externalization in these environments has not been examined sufficiently (Majchrzak et al. 2000).

In the context of virtual teams, the willingness to share knowledge becomes critical because group members do not meet face-to-face and may not have a prior knowledge of

each other (Samarah et al. 2008). This lack of knowledge of each other looses importance where the members work in small groups with a predefined set of goals and objectives in a given context because of their mutual interest in accomplishing a specific task.

Additionally, because of the novelty of DGSS, there is little theoretical or empirical research on the topic. The traditional GSS framework; namely, supporting people working on a common task, in the same room at the same time, developed by McGrath (1994) is adapted by many researchers as a suitable framework for GSS research. The framework introduces four types of characteristics influencing the processes and outcomes of the group, namely, the group, the task, the context, and the technology (Dase, Tung, & Turban 1995).

The framework asserts that the outcome of interaction among individuals is dependent on the process which in turn is determined by the group, task, contextual and technological characteristics. DGSS require a different framework with a new set of issues and challenges because of its distributed nature. Figure 1 is a revised framework (Dase, Tung, & Turban 1995) for distributed research where technology becomes a factor. This framework can be used in applications where the group’s members are geographically distributed and are engaged in the development of a predefined set of tasks using technology for communication.



**Figure 5.1 Distributed GSS research framework**

With synchronous DGSS the participants are distributed across multiple sites linked by various communication technologies, such as screen sharing, and video-audio conferencing. With asynchronous DGSS, group members are to be linked via technologies in different places and different times, such as by e-mail, voice-mail, and

work-flow management systems like Lotus Notes. While there is a need to share information, there may be other critical issues such as schedule conflict, attention to ongoing task and process coordination, timely feedback, awareness, and access to information to be addressed by the DGSS.

The problems associated with DGSS and/or Groupware technologies support for the KM process are the result of the diversification in the available technological tools as well as the fact that these tools do not embed the proper coordination of work, processes, and tasks in the distributed groups. Recent literature (Samara et al. 2008), on knowledge conversion in GSS-aided virtual teams showed the necessity to use a variety of configured software among distributed group members, such as Lotus Sametime and IBM collaboration software.

Carvalho & Ferreira (2001) proposed that “If it is true that many KM tools address mainly the problem of knowledge transfer in order to promote its sharing; it is also true that we can already find software solutions that intend to support knowledge codification and even creation”. This can only be achieved through the development of a software tool which integrates available software systems and which accommodates for coordination. It is well supported in the literature that information technology is to extend, and enhance the knowledge conversion process, hence its externalization, in a spiral where knowledge changes constantly. Available technologies do not offer an integrated technological tool which supports all the functions associated with this process. Adding to that, despite the recent trend of technologies supporting the KM process, significant technological shortcomings are still encountered in supporting the tacit knowledge externalization.

In addition, the diversity in software categories supporting the knowledge conversion process among distributed individuals is becoming a major problem for asynchronous interaction and there is a need for the emergence of a new integrated type of software which allows users to perform most if not all of the externalization processes and activities. It should also facilitate document management tools, chatting, messaging as well as task coordination, communication and collaboration. The potential of the current



software to support the KM process is under-evaluated and under-explored. In fact, their actual utilization stresses mainly their support to information access and retrieval, while their communication and collaboration dimensions are yet to be discovered (Carvalho & Ferreira 2001).

The problems associated with existing technologies are the results of their support for specific processes and activities for KM process and knowledge conversion activities. The fact that researchers’ and developers’ acceptance of the statement “tacit knowledge is induced by dialog and collective reflection” (Nonaka & Takeuchi 1995) does not mean that building products, software and tools (Table 2), or their integration, which allow individuals, groups, and COPs to release their knowledge and discuss them will automatically ensure an effective KM and knowledge conversion processing. What is needed is DGSS which integrates different functionalities to ensure proper group work and effective knowledge management and externalization. The different products presented in Table 2 are currently used, among others, for synchronous and asynchronous group work. They offer advanced features which allow the communication among members and individuals but they lack the proper coordination which is vital for distributed group work. This explains the amount and speed among major developers (IBM, Microsoft) to provide an integrated product for the proper management and conversion of knowledge.

The lack of coordination structure in the available distributed support may also “contribute to group fragmentation, member withdrawal, unproductive communication, and failure to complete the group work and tasks” (Dufer, Kwon, Park & Peng 2002). Table 5.2 introduces commercially available group/communities’ support tools, their efficiencies and failures, and where they can be used.

Tool	How it works	Pros.	Contra-indications.	Appropriate usage	Tips
Instant Messaging	Sends/receives messages among users. Setting change to invisible.		Not good for in-depth conversations. Law security	Immediate feedback. Awareness.	Variety in the market. Trillian, Adium

Personal Digital Assistant	Bundles phone, email, calendar and others into one handheld device	Users always connected. Remote use.	Difficult typing features due to size.	Managers outside office.	They do not call it "crack berry" for nothing.
Tele-conferencing	Allows multiple users conversation through phones.	Simultaneous real time, inexpensive connection.	Synchronization. Time lags for concurrent talking. No visual support.	Small groups/teams familiar with each other. Short meeting.	Use only in very specific cases
Video-conferencing	Adds video to a conference. Voice activation allows focus on the speaker.	Alternative way to face-to-face. Can see gestures, expressions, and body language	Very expensive. Hard to set up. Awkward delays and poor sound and video. Need for high bandwidth for simultaneous videoconferencing	Schedule of formal meetings. Team building across locations. Job interviews.	Arrange for training classes and good communication and bandwidth.
Web-conferencing	Software, like NetMeeting. Allows on-line real time meetings. Featuring slides presentation, whiteboard animation, live video, chat, and real-time audio.	Documents sharing with textual presentation of thoughts	Hard to launch and set-up. Relies solely on documents. Collaborative feeling is low.	Presentation, sharing ideas. Complicated discussions. Troubleshooting.	You might lose your audience easily because of social problems.
Wiki or ftp site	Online archives for large files for access by others. Participants can add and update information over time.	Highly accessible. Interlinking of documents. Easy multiple editing by users. Ftp is better than email; it keeps messages outside users' servers.	Not much commitment. Difficult to learn. Requires lots of effort to update and maintain. Not real time. Open participation (anyone can contribute).	Gathering feedback or updates from lots of people. Project planning across multiple teams. Knowledge sharing for large communities.	To keep a wiki from becoming too long, break sections into separate pages and link them. Designate one person to update a Wiki. Set rules for update (Jot.com & Typepad.com).
Blogs	Website offers frequently updated observations, news, headlines and such, on a particular subject.	Cheap easy to use strategy. Helps groups by exchanging ideas anywhere. Possible transfer of people's knowledge. Help individuals to gather certain communities around them (groups,	Lack of interest to join. Ideas are not always easy to write. Lack motivational support. Expertise may easily be put off for lack of contribution. Require time and	Education (Edublog). "Project Blog" built to promote tacit knowledge sharing. Project management. Knowledge sharing among Blog	Managers can benefit from it. Use it for link with friends and discuss issues with them.

		CoPs). Better informed groups. Development of strong relationships. Support feedback. Profile building in groups. Reduce unproductive email and meeting volume.	dedication. Open participation.	participants.	
Lotus Notes	Application suit that includes: e-mail, discussion forums, documents repository, expense approval system, web-based request system. Support for knowledge capture and conversion. Used as a knowledge map system (Lotus discovery), knowledge portals (Lotus K-station)	A groupware system. Integrates few products. Effective database system. Document management system. Interaction with other DB systems and other web technologies. Ease-of-use, document-based architecture, sophisticated security structures, and integration with Notes, e-mail and the Domino Web engine.	Too many products. Lotus Notes is a technology that has to be seen to be understood and widely used.	Secure working. Ideal for building web-based document-management, contact-management, and workflow applications, all of which can take advantage of Lotus Notes' e-mail capabilities and the Domino Web engine.	Look for the best product or product's set for your environment.

**Table 5.2 Summary of few existing groupware technologies and their features**

Tables 5.1 and 5.2 show that users engaged in the knowledge sharing and conversion activities are forced to alternate between different categories of software and that each category has some favorable and non-favorable features. Some of these activities might benefit from integrating more than one category. Samara et al. (2008) suggested a back-to-roots solution by proposing future studies in collaborative technologies to be based on different technologies for knowledge conversion among distributed teams. This might seem a proper solution given the lack of integrated support but one is reminded of the old saying: “to confuse someone, provide him/her with too many good choices.” The fact of the matter is that issues and problems for KM and knowledge conversion support will remain as long as the diversification of supporting tools persists.

Based on these certainties, an example tool was developed as part of this thesis as a possible technology for distributed small groups of individuals’ cooperation and for the



externalization of their opinions and ideas. It is a possible alternative to current diverse technologies in organizations, businesses and educational institutions which supports the management of knowledge. Additionally, it supports the processes associated with knowledge externalization (articulation, creation, sharing, transforming, nurture, and retention) among distributed individuals.

Tables 4.1 and 5.2 demonstrate that businesses and organizations, depending on the extent of dynamicity of the process they perform, rely on a different technological tool for the knowledge externalization process as described in Nonaka and Takeouchi's (1995, 2001) knowledge conversion process introduced earlier. Table 5.3, which combines some entries from both table 4.1 and 5.2, shows that for the fulfillment of the conversion processes (externalization, socialization, combination, internalization), different tools already available in the market might be used. It also shows that different technological tools might be used for the same conversion process. Hence, in order to overcome some of the difficulties in the choice and implementation of different technologies the introduced example tool in this research provides possible solution as an integrated tool which businesses may rely on without the need for alternation between available supportive tools.

Tacit knowledge articulation	Source	Technological Category	Knowledge conversion process	Example tool
Empirical knowledge in the form of ideas	Experiences, practice, research, intelligence	Intranet-Based Systems	Combination	Internet information server, Blogs, Wikis
Judgment based on knowledge accumulation in the form of opinions	Work practices, group work, task fulfillment, experiences	Electronic document management	Combination	Interactive systems, ERWF, Blogs, Wikis
Shared through interactive conversation in the form of ideas and opinions	Messages, conversations, cooperation	Groupware, workflow, knowledge portals	Externalization, socialization, combination	Lotus Notes, Aris Toolset, Digital Dashboard
Based on judgment, sentiment, thoughts, concepts as opinions and ideas	Shared experiences, observations, reflections, learned by doing	Knowledge portals and knowledge maps	Socialization	Gingo, lotus discovery, digital dashboard

Beliefs shared through interaction as opinions and ideas	Group work discussions, joint formal decisions, views, know-how	Groupware, workflow	Externalization	GSS, DGSS, Lotus Notes
Concepts, logical analysis, intuitions, talents as opinions and ideas	Mental analysis, concepts, issues, philosophies	Innovation support tools	internalization	Invention machines, experimental systems

**Table 5.3 Example of some current tools for the knowledge conversion process**

**5.3 The Developed tool as an integrated tool for the knowledge Externalization Process**

Current technologies such as e-mail, groupware packages, Blogs, Wikkis, hypertext systems, and intranets/extranets are on the list of technologies that have been developed for knowledge externalization in its entirety (Andrew & Ciborra, 1998). They also hold promising support for individuals’ knowledge. This is in line with the efforts that we have seen regarding groupware support for the concepts of KM (Orlikowski 1992; Alavi 1997; Conklin 1998; Robertson, Sorensen & Swan, 1998). Knowledge externalization and the fulfillment of its associated activities is a group effort, hence, the development of software to support it should cater for the group work as individuals alone cannot fulfill certain tasks in complex situations (Wathne et al. 1996). Kirn (1997) added that although each individual might have his/her own area of expertise and responsibility, it is mainly through joint coordinated efforts that they could create knowledge and perform their work. Drucker (1994) stressed that she/he must also be able to collaborate with other knowledge workers, and Shum (1996) characterized knowledge work as interdisciplinary and recognized it as a collaborative process aimed at a common goal to learn about the problem and its alternative solutions.

Few technologies have been developed to specifically address the management and externalization of types of tacit knowledge such as opinions, ideas, thoughts and emotions, among distributed individuals in groups and CoPs. Because of the difficulties associated with alternating in the usage of different technologies for such support, an integrated example tool was developed. The aim was to provide small group members

with support for managing and externalizing their opinions and ideas. The framework was based on the concepts and theories of chapter 4's KM cycle's processes, tacit knowledge conversion components, as well as members' coordination, cooperation and process/task coordination. The tool was originally developed to support two categorized types of tacit knowledge, that is, opinions and ideas. It is possible to use the tool for other categorized types as long as the correspondence to tacit knowledge is established.

The tool has a workspace structure at the group level, a 'Ba', where all interactions, document development, knowledge conversion, experts identification, awareness, capture of opinions and ideas, goals setting, multi-functionalities, group formation and knowledge sharing take place. It also has a document-based structure at the user level.

It requires users' registration via a simple one page registration form which captures not only the traditional user-name, password, name, and such, but also the user is asked to provide information about his/her qualification, expertise, and interests. This information is required, and can be updated at any time by users, for the search for experts. A visitor, who is a user with no membership in groups, can only access public documents and use the 'Help' option to learn about the system.

The workspace is the highest level of interaction, a space or a 'room with no walls', where interactions among members in a group or between members of groups are maintained. The tool creates a main workspace every time a group is created and/or accessed which holds the group work together in terms of documents' building, documents' accessibility, and knowledge development process. Sub-workspaces are created for multi-functional work on the same document by a member or among members. There is no limit to the number of such work-spaces: it depends on the current documents the user or users are working on at the time. At the individual level, a user working on editing a document, for example, may create a sub-workspace and edit another part of the same document and so on. This concurrent work on the same document on different workspaces is captured when the user saves the document. At the group level, members of a group work on the same workspace. The system creates



versions of that workspace and users, while having the feeling that they are working individually, are in fact working on the same space concurrently. The system allows members of a group to work on versions of the same document as well as more than one document at the same time; this is possible through the sub-workspace structure. In addition, members may perform multiple tasks on the same document or on different documents concurrently. Monitoring the multi-functionality is automatically handled by the system. Awareness at the workspace level is strongly maintained as members are regularly aware of others' existence on the workspace and more importantly the work they are currently undertaking on the workspace or what they did previously.

While the workspace structure provides interactions as of who is doing what and when they're doing it, the document provides interaction of 'on what' a member or members are working. Users release their knowledge onto the document, access others' work on the documents, discuss a document's contents through messaging, and update contents. Multi-functionality can be performed on the same document by a member and/or members and on different documents. Similarly to the workspace level, awareness is vital at the document's level. Members are always aware of who is doing what on a document and or documents in the group.

The tool was developed to support group work tasks by facilitating:

- 1- Group formation and member's assignment to activities
- 2- Progressive shared document's building
- 3- Knowledge release
- 4- Knowledge exchange
- 5- Discussions/conversation among members on their released opinions and ideas
- 6- Concurrent updating/editing of documents (TKd and VKd documents)
- 7- Knowledge capture
- 8- Retention of documents
- 9- Search for documents
- 10- Experts search
- 11- Awareness at different levels

12- Individual multi-functionalities on a document or a set of documents in the same or different workspaces

13- Group multi-functionalities on a common document or a set of common documents in the same or different workspaces

## **5.4 Summary of the tool's activities**

The following provides the tool's main activities summary:

1. Multi-functionality. This is the ability of a member and/or members to simultaneously perform more than one function on a given document or to simultaneously perform more than one function on different documents. A member might be working on a document in a group and he/she can alternate between workspaces and can open a new group and work on a document with that group. This is achieved through the creation of a different workspace for versions of the same document and at the same time establishes the link between all these workspaces. The simultaneous work on the same document in different workspaces caters for different manipulation on the document's contents, including editing and deletion.

Multi-functionality at the group level is the ability of more than one member to access a group's shared document and work on it simultaneously. This is a feature which is vital for cooperation and the progressive and consequential building of a shared document.

Group members can perform any of the functionalities supported by the tool simultaneously on the same document. The document is the space or the 'Ba' where all interactions occur and where opinions and ideas are released and captured. It is important to emphasize that all members who are simultaneously accessing the same document are working in the same workspace.

2. Members' awareness of all work by others on the shared document. This means that a member's manipulation of a shared document propagates to all other members. For example, a member might be editing his version of the document while another member might be saving his version. This is made possible as the tool automatically saves

members' versions and includes them within the shared workspace making all other members aware of the saved version.

Consequently, members in a group, accessing the same document are aware of the simultaneous access as well as manipulation of that shared document by all other members who are working on it simultaneously.

3. Members cooperation to build a product design document (PDD). PDD is a shared document containing the design of a product as a result of progressive virtual cooperation among group members, to build it. This dissertation assumes that the product development is the development of a term paper/project by a group of students. Consequently, the product design is able to be submitted by a group of students as a term project document, which facilitates knowledge sharing and knowledge transfer through the amplification of its content as well as discussions through an effective messaging system. The overall product design document process is asynchronous and no face-to-face meetings among members are necessary. The imbedded message feature caters for communication among the members.

4. Catering for two types of memories. These are the tool level memory and the groups' level memory. The former is all saved 'public' documents from all groups and the latter is the memories of individual groups. After discussions among the members about the captured knowledge, the knowledge is filtered and retained. Retention may be a temporary retention while the documents are being developed, in other words, progressive building of documents. On the other hand, there may be a permanent retention at the end of the design process, manifesting as final versions of VKd and TKds. The reuse of the knowledge is also dependent on whether the documents are temporarily or permanently retained.

The member's work at a particular time is captured, retained, and made available to other members whenever they access the group's workspace. The tool facilitates constant awareness of the goal, awareness of member's contribution to the design, awareness of



availabilities of members, awareness of the opinions and ideas of others, and awareness of the expertise within the group.

5. Facilitates members' engagement in a conversation using the messaging system to build the goals and objectives at the beginning of the development of the product. If necessary, the group might build a document that captures all interactions among the members during the setting of the goals and objectives. The members build the set of goals and objectives which becomes their context during the design process. Reference to the set is imperative during the building of the VKd and the TKd as it sets the direction to the relevance of the knowledge being retained. The set acts like the driving reference for the members where they 'discuss' the relevance of any member's contribution in regard to whether it satisfies the set or leads to the satisfaction of the set.

6. Facilitates expert search which is integral as it allows members to look for experts in a particular field or topic at the system (tool) level as well as a specified group level. This function locates experts and allows the members of a group to have discussions or ask questions of knowledgeable people. An expert does not have to belong to the group.

In addition, these activities require the set up of:

#### 1 A context

This sets the environment within which the cooperative work takes place and which is different from one application to another as the environment changes. It includes the circumstances and conditions surrounding the cooperation. The context is important as it gives meaning to the cooperation among the members. Any perception which might be associated with the cooperation is also set within the context. It is for the interest of the members of the group to cultivate a commitment to articulate their knowledge and this can only be achieved if they share common interest in the development of the product.

#### 2 The type of work

This identifies whether the work is cooperative, collaborative, individual, virtual, synchronous, asynchronous, and/or remote.

3 The type of users

User's identification is very important in any collaborative work. The groupware depends highly on who is going to use it. Experts in a given set up or context will be interested in support which is characteristically different from systems for less expert users. Groupware is built to accommodate user friendliness as well as the technical abilities of the users.

4 The type of users' interaction

The way people interact and their expected objectives from the groupware are dependent on the context within which the groupware is built. The design of the groupware should mirror the fulfillment of the objectives. It should also provide interactive support which maintains awareness of these objectives, thus eliminating any deviation from the objectives regardless of the interaction mode, whether it is virtual, remote, synchronous, or asynchronous.

5 The types of facilities required for individuals' interaction

Interaction is made possible by the infrastructure of communication provided to the users. Facilities should include a platform for message exchange, email, and hypertext. Documents also provide facilities for interaction among users in situations where development is accomplished through the release of know-how and expertise into the documents.

6 The type of infrastructure for the capture of the results of interaction

The infrastructure should provide the user with a means by which knowledge is identified. This infrastructure is dependent on the type of work being performed. Different work requires different infrastructure set ups. Whether knowledge is

captured on documents as a result of transforming it or not should be considered when building the infrastructure.

7 Facilities for individual and group multi-functionalities

Multi-functionality is integral for people working together in a virtual remote environment as it coordinates the individual's as well as the group's simultaneous work on different activities. Developing a product necessitates multiple accesses to resources in relation to the product.

8 Facilities for the retention and access of retained knowledge

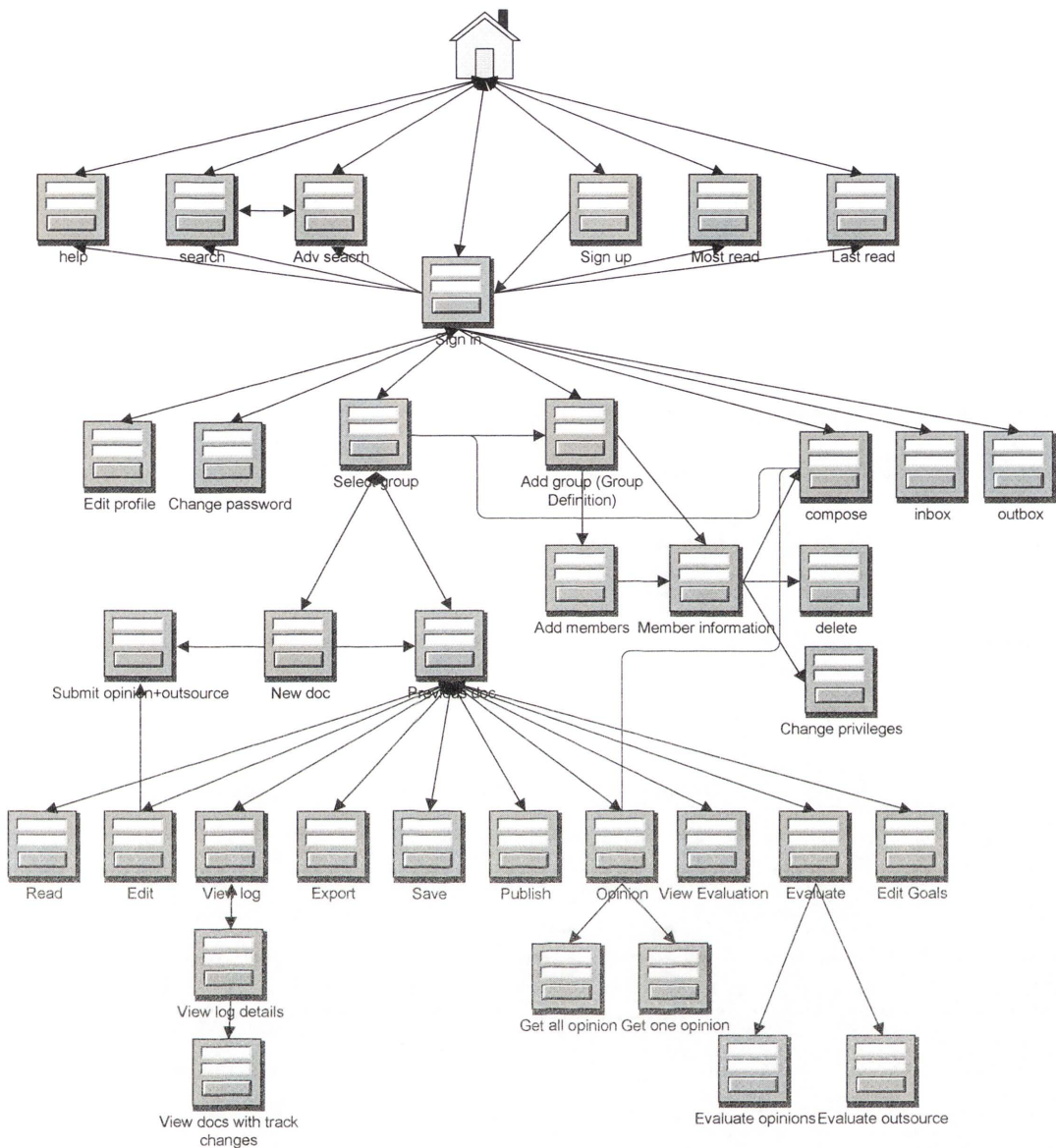
The captured knowledge should be retained to be accessed later. A group memory system should be built to accommodate retention and accessibility.

#### **5.4.1 Support for KM cycle and knowledge externalization**

This section shows how the developed tool supports the following:

- 1- The KM cycle (chapter 4)
- 2- The knowledge transformation table (chapter 4)
- 3- The coordination of multiple functions as:
  - a- Multi-access to a document
  - b- Multi-access to more than one document
  - c- Multi-workspace access
  - d- Multi-functionality on a workspace in a document (individually or by more than one member)
  - e- Multi-functionality on a workspace on different documents (individually or by more than one member)





**Figure-5.2: Navigation design in VIPGSS**

### 5.4.2 KM cycle support

The KM cycle introduced in chapter 4 is different from that of the literature’s KM cycles in Awad and Ghaziri (2004), Tiwana (2000), Dixon (2000), Liebiwitz and Wilcox (1997) and Davenport (2000), as it addresses the management of knowledge among distributed individuals. The management of knowledge proposed is the management of the group

member's contributions towards the progressive and consequential building of the product captured as the VKd and TKd. During their interaction, group member's release, capture, nurture, filter, and retain the different types of knowledge which constitute the final product of the development process.

The tool provides support for the members to interactively and asynchronously build the goals and objectives. In fact, the set up of the goals and objectives takes into consideration many factors.

In the case where the management of an organization calls for a group of people to develop a product, the goals and objectives are traditionally known or set before-hand and the members of the group accommodate them into their workspace after creating the group. These goals become constantly available to the members and the VIPGSS supports any amendments to them by the members during the life time of the product development.

In the case where the members of a group have to set the goals, as for example, students developing a term paper, the tool provides the necessary functionalities to do so through conversation using the messaging system or using a document as the means of developing the goals. This process, in most cases, is an iterative process where any update on the goals is made available to all members of the group. This is important as objectives are not constant and may change as the environment, the project's specifications, and the technology change.

In either of the two cases, the objectives become available to the group members every time a document is accessed, remembering that every document has its own goals and objectives. This is very important as the document(s) produced by a group should fulfill its goals and objectives.

The basis for the KM cycle is the document structure and a messaging structure which together provide the cooperative aspects of the tool.

#### **5.4.2.1 Support for knowledge transformation**

Based on the discussion introduced in chapter 4, the basis for knowledge transformation is a document structure. The two types of documents introduced, VKd and TKd are important for the transformation of knowledge as the former is a textual representation of the overall development of a product by the members. The latter, however, is a textual representation of the members' opinions and ideas. Members may create the former and it automatically creates the latter, both being in dynamic object's form. In other words the TKd is a subset of the VKd.

The literature does not provide answers to the puzzle of how knowledge is transformed in remote settings. Nonaka and Takeouchi's (1995), work addresses transforming or converting knowledge from one type to another in face-to-face interaction where knowledge is first created within individuals and then shared through discussions, interactions, observations, and experiences. Table 4.2 compares the activities needed for knowledge conversion in both face-to-face (Nonaka & Takeuchi 1995) and virtual interactions (El-Den 2006). It is apparent from the table that in virtual remote interaction, document(s) as well as a messaging system are essential for both as a means of communication and for the success of knowledge transformation.

The tool also facilitates the creation of group knowledge as a result of individual member's perception and amplification of released knowledge by the members onto the knowledge and transformed documents. The overall process of knowledge transformation is a process of nurturing both explicit and/or tacit knowledge.

#### **5.4.2.2 Support for knowledge creation**

The first phase of the proposed KM cycle is the creation of knowledge by members of the group. This knowledge could be either:

- 1- Explicit, collected from resources available to the member such as versions of the developed document by the group, books, papers, past documents retained



by the system, files, databases, and such. This knowledge is more information than knowledge. The tool, through its group memory, provides the infrastructure for the accessibility to this type of knowledge as a VKd.

- 2- Tacit-embodied, where the members release their know-how, expertise, work practices, known procedures and known processes as opinions and ideas. This knowledge is the members' knowledge regarding the context which constitutes their contribution to the final development document. The tool accommodates this type of knowledge by allowing its release into the TKd as well as the VKd.
- 3- Not-yet-embodied, where the member introduces his/her thoughts as opinions and ideas. This is a mental process which adds value to the development of the final product or document. This knowledge is included as part of the TKd as well as in the VKd as opinions and ideas.

Knowledge creation is the process which encompasses knowledge initiation and knowledge nurture. Knowledge is created as either an initiation of new knowledge or an amplification of existing knowledge as a result of knowledge nurture. In either of the two cases, the existence of two structures is imperative; on one hand a document structure and on the other hand a messaging structure to support the creation process.

The document structure provides the medium where knowledge is released or accessed by members and the messaging structure is vital for interaction among the members in their quest to develop the document(s) by discussing the released knowledge. It is also vital for the exchange of their thoughts, opinions, and ideas on their released or initiated knowledge.

#### **5.4.2.3 Support for knowledge initiation**

Knowledge initiation is a process of augmenting the contents of document members by introducing new knowledge in the form of opinions and ideas. This knowledge could be of any type and the process requires the ease of accessibility of the existing document, the availability of awareness of the specific content which each member released in the existing document. Members must also be aware of what editing was done by others. The document structure allows members to elicit their knowledge. This knowledge is represented as a text in the document. The document is a word document which contains the actual developed text by all the members. When accessed, this document presents the members with all relevant information regarding the history to-date of all the work on it in regard to who accessed it, edited it, knowledge released into it and by whom.

Associated with the VKd document is another document which is created automatically by the VIPGSS, namely, the TKd. This document is a corner-stone as it holds the opinions and ideas introduced by the members. It is structured by member's names. Each member's opinions and ideas are captured by this document. Based on the assumption that these are the components of tacit knowledge that are easier to be transformed into explicit knowledge, this document holds the transformed tacit knowledge, or more properly, the not-yet-embodied knowledge of the group. Users of the VIPGSS are made aware that the knowledge introduced into this document should be original and represents their opinions and ideas.

#### **5.4.2.4 Support for knowledge nurture**

Knowledge nurture is an individual process, whereby a member reflects on available knowledge and augments or deletes it, as well as a cooperative process which requires interaction among the members in regard to knowledge and information contained in the VKd and TKds. The tool provides support for this phase in the form of:

- a- prompt accessibility to the documents

- b- a messaging system for discussions on knowledge released by members
- c- member's awareness of each other's availability

Basically, the nurture of knowledge is a result of member's reflection on existing knowledge released earlier by other members. This necessitates the prompt availability and accessibility to knowledge released and concepts formed by the members. This is supported through members' ease in accessing the documents. This mental process may result in the amplification of existing knowledge provided that the member through his/her mental analysis, expertise and know-how forms new concepts and/or additional knowledge to introduce. This amplification is introduced in the VKd and TKd in the form of knowledge added which augments the contents of both documents. The reflection on knowledge, concept formation, and concept amplification instigates the nurture process which is mental steps by individuals and results in the release of knowledge that is to be justified by the group members. This means that the justification process is a cooperative process which requires interaction and discussions among the members. The tool supports these steps through documents and by the availability of the messaging system. The externalization step is basically the documentation of the justified knowledge. This step requires an effective memory system.

### **5.4.3 Supporting and coordinating multiple-functionalities**

The tool has features which help members of a group to progressively and consequentially develop a common shared document. It is not a document support system in the traditional sense but a tool which was built to answer a critical literary question of how a group of people, remotely located, engage in cooperative work to jointly develop a product. This product can be of any form; for example, a term project or a program design, and such.

The four multi-functional supports allow:

- 1- individuals to perform multiple functionalities on a given document



- 2- more than one individual to perform multiple functionalities on the same document
- 3- individuals to perform multiple functionalities on different documents
- 4- more than one individual to perform multiple functionalities on different documents

In order to accommodate the above features, the workspace infrastructure was developed to allow distributed individuals in a group to concurrently develop a common product be it a document or a design of any kind by automatically creating a 'main common' workspace for each group. This workspace becomes the place of work where all interactions among the members in that group take place. A member may create sub-workspaces from this main workspace. The power of the sub-workspaces is that it allows the user to perform multi-functionalities on a given document by alternating between the main workspace and any sub-workspace. For example, a user might be editing VKd-1 on one workspace and at the same time entering his/her opinions and ideas on the same document. It is also possible that a user might be working on one document in a given group and on a given workspace while, he/she is exporting a document in different group and on a different workspace. Creating sub-workspaces accommodates the individual's needs to perform a different functionality on a given document and/or functionalities on a different document, hence, allowing an individual's concurrent work on the same or different documents. The sub-workspace structure on the individual level works for both the multiple access of the same document as well as different documents. The user does not have to open a new window to perform multiple functionalities in both places as the workspace structure allows for containment of information on the workspace of the same document as well as different documents. A workspace allows for:

- 1- the formation of any number of groups within it,
- 2- groups to have their own members and documents,
- 3- members to be in any number of groups,
- 4- documents to have any number of versions,

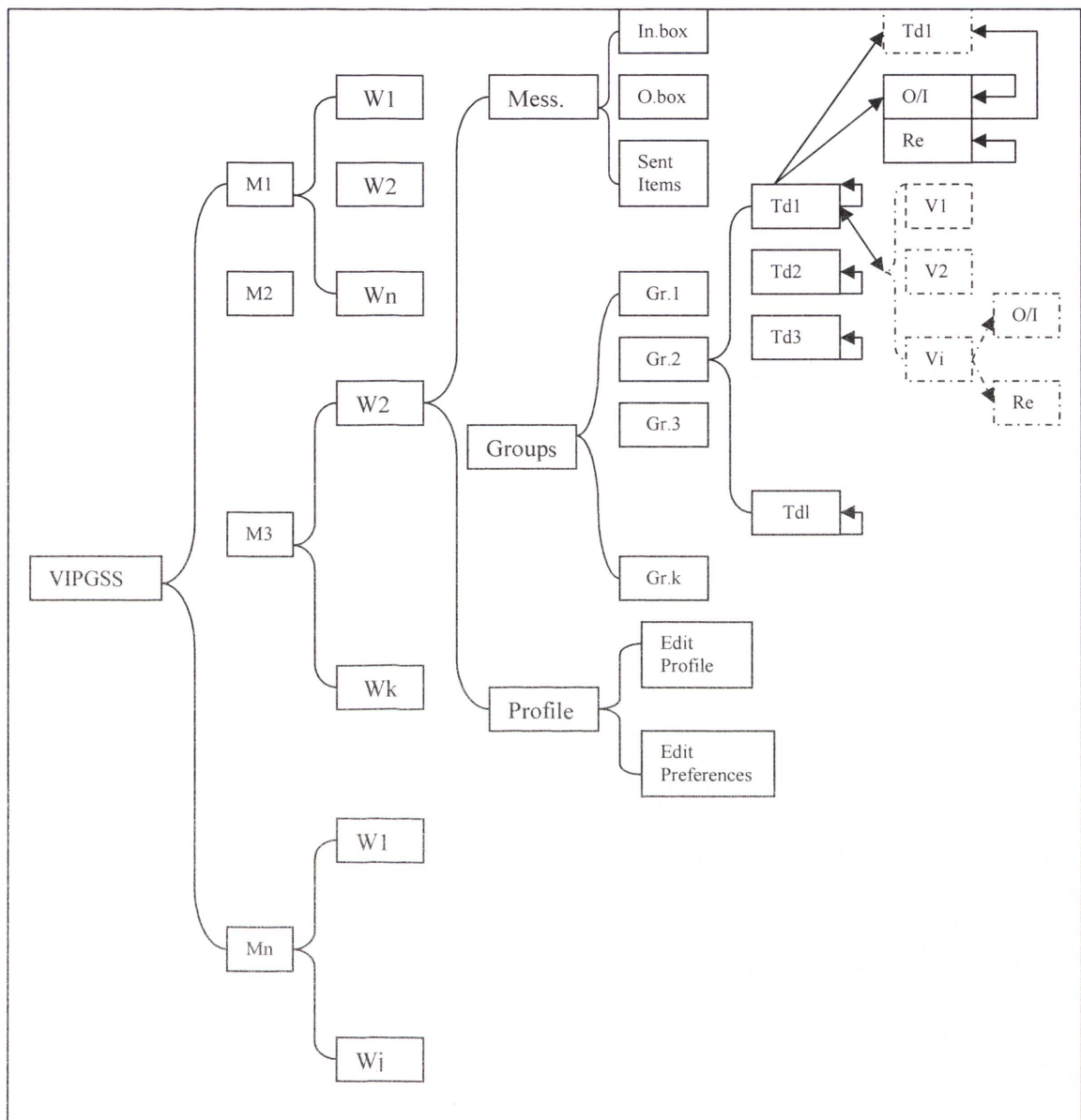
- 5- versions of a document to have their associated opinions/ideas and resources documentation.

The tool's documentation structure is made possible by the support and coordination of multi-functionalities made possible by the use of workspace structure at all levels of work. Figure- 5.3 shows the access structure of documents.

VIPGSS was developed to cater for multiple functionalities by and among group members in the development of the KM functions as well as the transformation of knowledge introduced earlier. These multiple functionalities help in coordinating the work at the individual, group, and document levels. Multi-functionality is defined as the ability of a member or members to perform different functions in the same session of work as well as the ability to perform multiple functionalities during the fulfillment of a particular activity or activities in the same workspace. In addition these multi-functionalities are performed on a single document or more than one document.

It should be made clear at this point that there are few types of functionalities that are to be supported among group members working towards the development of a product:

- 1- Cooperative multi-workspace functionalities which allow members to cooperatively perform a task or varieties of tasks
- 2- Individual multi-workspace functionalities which allow individual member's task fulfillment



**Figure-5.3: The workspace access structure in VIPGSS**

The development of a product, as in a term paper in the research, is a cooperative virtual process among geographically distributed group members as described earlier. The progressive nature of the development process means that the term paper is developed in a period of time with set deadline, in this case, the end of the semester. The members should be able to access the shared document (VKd) and amplify its content by nurturing the knowledge or information retained in it. They can also amplify the contents of the



opinions and ideas document (TKd) by releasing their concepts to be available to others. This progressive and consequential nature of work requires the availability of multiple functionalities to be coordinated in order for proper control on the development of the document.

What distinguishes group work presented in this thesis is the progressive building of documents by group members which requires remote virtual cooperation among the members and their guests to gradually develop the document(s). This progressive build of the document may only be accomplished through high levels of interaction among the members which is the result of knowledge availability within the documents as well as the exchange of messages among the members of the group.

All work related groups are maintained through a workspace which is created for a group. A workspace allows the formation of any number of groups within it, each with its own members and documents. Each member can be in any number of groups, a document can have any number of versions, and each version accommodates its own opinions/ideas and resources. The tool is structured for the manipulation of TKd and VKds. This structure represents the support and coordination of multi-functionalities at the workspace level as well as for creating sub-workspaces from within a workspace.

Access to a VKd is effectively an access to its last edited version. The last edited version of the document by a member is automatically saved. There could be more than one member editing a document. In order to resolve conflict, the system notifies the member(s) trying to concurrently edit the same document that another member(s) is also currently editing it. The last version edited remains the current one for the group. Reading a document does not make a new version of it. The access to older versions of a document, that is, not the current one, is an access to already existing explicit knowledge released or amplified by the members and this allows such versions to be a 'read-only' document without a possibility of altering its content. This is very important as these old versions represent individual contribution during the development process hence they represent explicit sources for the members.

#### **5.4.4 Support for awareness**

Awareness has been discussed in the literature to mean many things to many people (Jang, Streinfield & Pfaff (2000). This is why its definitions were introduced. They reflect the type and level of awareness required by the system being built.

Awareness among group members has been recognized within the CSCW community as one of the most important components of collaborative work (Tollmar, Sandor & Schomer 1996). According to Dourish and Bly (1992), it is important that awareness provides knowledge of individuals' availability, current activities, and communicating individuals. Awareness might lead to informal interaction, spontaneous connections, and the development of shared cultures. Dourish and Bellotti (1992) have defined awareness as "an understanding of the activities of others, which provides a context for your own activity" (107-114).

Through their studies, Jang, Streinfield and Pfaff (2000), have identified four specific types of awareness deficit suffered by virtual teams:

- 1- Awareness about others' activities
- 2- Awareness about member's availability
- 3- Awareness about the process performed by the members
- 4- Awareness about the lack of discussions among members (perspective awareness)

Hawryszkiewicz (2003) stated that services for group support are different and must emphasize coordination of activities supported by communication services to maintain awareness. The close correspondence and link between activities within groups should always be maintained. Any group-support system must cater for high level awareness especially for the coordination of multiple activities in a given context.

Designers of collaborative writing systems, such as Quilt, PREP and GROVE have stressed the importance of issues related to information sharing and coordination as well

as mechanisms for their support. Dourish and Bellotti (1992) have argued that the approaches followed resulted in problems for the groups in these systems.

Based on the above discussions, this thesis introduces awareness at the following levels:

- 1- User level awareness, which administers awareness regarding the member's identification and personal information.
- 2- Group level awareness, which administers awareness related to the group's formation, belonging, documents and membership
- 3- Document level awareness, which administers awareness related to a document during its development.
- 4- Productivity level awareness, which administers awareness regarding the work performed on a document, progressive opinions and ideas, progressive results, progressive views, log and view details.

The subjects administer awareness as a necessary component for the progressive building of the document. This argument is central as the task of maintaining high level of awareness of the context (the document in the research) as well as the individual member's intelligence and know-how in the form of opinions and ideas at all levels of the design is integral. This is due to the progressive nature of building the document and the release of opinions and ideas.

The tool provides the user with awareness of his/her environment by turning his/her attention to the group he/she is working within, remembering that a user might have many groups' memberships. As well, the awareness extends to the documents in a particular group, the status of the members in a given group and a given document, and on the progress made by him/her and others regarding the update of the document(s) and the opinions and ideas.

The context within which group members collaborate is comprised of both the subject which is the member, and the object which is the document and the associated opinions



and ideas. This is the case where the workspace provides the infrastructure between the subject and the object. Awareness at the group and document levels was built to accommodate these two factors because it is only by providing awareness of both that the group members can effectively contribute to the development of the document.

At the group level, the tool maintains awareness by providing the member with knowledge about the project he/she is working on as well as the identity of the other members who are working on the documents at that time. It also provides an option to contact those members who are online if discussions on the documents or the progress are needed. This is achieved through the use of the message system while still on the workspace. By choosing a document from the 'previous documents' option, the system provides a list of all the documents in the group with information for each regarding title, version, author, type, language, date inserted, public, keywords, and select. With these options the member is presented with general knowledge about the documents in the group. The select option transfers the member to the document level, where he/she is presented with knowledge pertaining to the selected documents, i.e. the last edited version by a member of the group who edited the version.

The knowledge presented to the member regarding the documents can be listed as: read, edit, export, delete, save, unsave, publish/unpublish (for public documents), view log, opinions, evaluate, results, document goals, and change external evaluator. The 'delete' option allows a member to export a document to another group provided he/she is a member in both the sender and receiver groups. Besides that, the member is also aware of the current document's identification information described previously.

The productivity level awareness provides the necessary support for the members regarding the progressive collaborative work on the document. The system, through its memory structure provides accessibility to all the work done so far, by all members on the document. This access makes the members aware of others' work on the document. The member may access:

- a- The last updated version of the documents
- b- All previous versions of the documents updated at different times
- c- All changes made to documents by all users
- d- A view log diagram showing the 'read' and 'edit' status of the documents by all members
- e- A detailed view of the work done on the document in a textual form comprising the following entries:
  - (i) member, the person who performed the activity on the document,
  - (ii) action, what the activity was, possibly read, edit, or save,
  - (iii) date, the time and date the activity was performed,
  - (iv) comments submitted by members on the progress of the document,
  - (v) view opinions and ideas, which provides to the member a textual view of the opinions and
  - (vi) ideas inserted by a given member on a given date and at a given version of the document
- f- The main evaluator's results of evaluation on the current version of the document as well as the opinions and ideas. This is a very important step as it may trigger changes to be made by the group members on the document and their opinions and ideas.
- g- The external evaluator's results of evaluation. Even though this activity does not affect the results of the progress of work by the groups on the document, it is an important activity for an external expert's judgment on the progress of building the document.

## 5.5 Coding

Coding was supported by using the following Technologies:

- frm\_XXXXXX.php: These are visual design files. They are a mix of HTML/DHTML and PHP

- `cls_XXXXXX.php`: These are PHP libraries and classes. They do not have any attached visual design.
- `inc_XXX.php`: Files containing constants and other necessary files
- `fnc_XXXX.php`: PHP files with utility functions
- `[functions]`: It is a folder with helper and other functions used in the project
- `[admin]`: folder holding the administration panel of the system
- `[upload_docs]`: Uploaded documents are stored here. This folder must have 0777 attributes.

PHP: PHP, server side technology, mainly used because it is free and widely supported. The language has lots of features and is powerful for web scripting.

- MySQL: The DBMS used is MySQL. It combines well with PHP. MySQL is free and has numerous noteworthy features
- DHTML: Dynamic HTML and JavaScript were used on the Client side to make some visual changes on the fly. An example of that are the tree and the main menu.
- CSS: Used with the HTML to add visual design to the pages

### Sources

[http://www.unix1.com/information\\_technology/programming/php](http://www.unix1.com/information_technology/programming/php)  
[http://media.wiley.com/product\\_data/excerpt/67/0764557467.pdf](http://media.wiley.com/product_data/excerpt/67/0764557467.pdf)

Appendix B, presents the main coding of VIPGSS. Not all coding is included in Appendix B for reasons of simplicity and/or space.

## **5.6 VIPGSS and Existent Group-Support Systems**

In the literature, most KM systems are supported by technologies in which their platform for managing knowledge is based on one or more of the following:



1. Document based, that is, a technology that permits creation/management/sharing of formatted documents such as Lotus Notes, web, and distributed databases.
2. Ontology based, that is, similar to document technologies in the sense that a system of terminologies (i.e. ontology) are used to summarize the document. For example, Author, Subject and Organization as in DAML & other XML based anthologies
3. AI based. That is, AI technologies which use a customized representation scheme to represent the problem domain.
4. As network maps of the organization showing the flow of communication between entities and individuals
5. Social computing tools are being deployed to provide a more organic approach to creation of a KM system
6. Web-Page Based, where knowledge is shared through its release into common web-pages.

The example tool is document based and caters for most of the functionalities found in similar groupware such as:

- 1- Sharing of valuable organizational information.
- 2- Avoid re-inventing the wheel, reducing redundant work.
- 3- Reducing training time for new employees
- 4- Retention of Intellectual Property after the employee leaves if such knowledge can be codified

Currently, there are few group-support systems which are considered to be useful as KM systems or at least helpful in supporting some of the KM functionalities. Blogs, WIKI, lotus notes, Google Groups etc. are examples of such systems. The following table provides some similarities and differences between the developed tool (VIPGSS) and two commercially available tools, namely, Wikkis and Blogs. It also includes some examples about Google Groups. Table 5.4 introduces some of the similarities and differences between the developed tool and Wiki and Blogs. It also shows examples of some other available technologies for group work.

<b>VIPGSS</b>	<b>Wiki</b>	<b>Blogs</b>
Available servers, WWW	World Wide Web	World Wide Web
Document-Based	Web-Based	Web-template-Based
PHP Server (possibly other servers)	Any server	Any server
DHTML and Java Scripts	Database – Http Protocol	HTTP protocol
Document creation/editing	Page creation/editing	Blog editing
Users must be registered	Unregistered users are allowed	Unregistered users are allowed
Group/individual based (Lotus Notes, IBM Collaborative software)	Community based (low individual use)	Individual/community based (low individual use)
Link between Workspaces and between documents	Link between Wiki pages	Link to other blogs
Documents edited and changed on users' needs (Lotus Notes)	Wiki pages changes continuously without restrictions (unsolicited access)	Blogs change constantly with as comments and feedbacks are added (unsolicited access)
Specific for tacit knowledge externalization	General knowledge creation and sharing support	General knowledge creation and sharing support
Supports groups' categorized types of tacit knowledge creation, sharing, and transformation	Supports communities knowledge sharing and transformation	Supports individuals' and communities' knowledge sharing and transformation
Supports high level of discussions among group members for knowledge sharing	Supports continuous discussions among users in communities for pages growth	Supports discussions and enables bloggers to link users
Members editing review is essential for categorized knowledge nurture and creation	No editing review is essential. Users can write whatever in their mind	No editing review is essential. Blogs are enlarged constantly with thoughts and points of view
Editing is cooperative and close to the group members	Open philosophy for editing pages	Open philosophy for editing blogs
Document search	Full text search	Blog search and text search
Experts search (Lotus Notes, IBM collaborative software)	No defined	Not defined
No email required as it embeds a message system for conversation and messaging	Email for messaging (as in Google Groups) and distant conversation	Email for messaging (as in Google Groups) and distant conversation
Document's version control	Recent pages control	Blog control and instant commenting

Low vandalism (membership is essential)	Vandalism is high due to unrestricted as well as unsolicited access	Vandalism is high due to unsolicited access
Articulation of opinions and ideas	Exchange of thoughts, ideas, opinions and feelings (discussion groups, chats)	Exchange of thoughts, ideas, opinions and feelings (discussion groups, chat)
Documents writing for knowledge articulation	Wiki pages development (writing) for articulation (Microsoft Exchange, lotus Notes)	Blogs and text development (writing) for articulation (Microsoft Exchange, lotus Notes)
Joint document editing	Joint pages editing (also in groupware systems)	Joint Blogs editing (also in group systems)
Private groups	Private and public communities and groups	Mostly public groups
Private documents with possibility of turning them public	Mostly public pages	Mostly public blogs
Specific for group work (might be used by individuals)	Communities and groups use	Communities, groups, and individual use
High individual support	Moderate individual support	Moderate individual support
Group creation is predetermined	Group creation by invitation (as in Google Groups)	Group creation by invitation (as in Google Groups)
Members contribution to documents building is essential	Encourages people to contribute upon interest in the topic/subject. Higher within individuals	Encourages people to contribute to individual blogs upon interest in the topic/subject
Supports individual's multi-functionality on the same document	Not Defined	Not Defined
Supports individual's multi-functionality on different documents	Supports multi-access to different Wiki pages	Supports multi-access to different blogs
Supports more than one users' multi-functionality on the same document	Supports access to a Wiki page by many individuals	Supports access to a blogs by many individuals
Supports more than one user' multi-functionality on different documents	Supports users access to different Wiki pages and text simultaneously	Supports users access to different blogs simultaneously
High level of awareness at the individual, groups, documents,	Low awareness	Low awareness



and workspace levels		
Formal communication (groupware systems)	Informal communication (also in chat, email, e-groups)	Informal communication (also in chat, email, e-groups)
Categorized types of knowledge access, retention, and retrieval	Mainly Information access, retention, and retrieval	Mainly Information access, retention, and retrieval

**Table 5.4:     VIPGSS as compared to Wiki and Blogs**

## **CHAPTER SIX – Experiment, analysis and results**

This chapter introduces the thesis' experiment which was conducted on small groups of students during the development of their semester long term projects. It also presents the results of analyzing the data collected from the questionnaire which was administered at the end of the semester. The aim was to find out whether, following the methodology presented in chapter 3 and using the developed tool, the categorization of tacit knowledge into opinions and ideas ensures its externalization given the concepts presented in chapter 4. The questionnaire formed the basis to achieve these tasks as well as eliciting the data required for the analysis and measurements of the transfer of knowledge among the members. Different analytical methods were used, such as statistical analysis, reliability analysis, correlation analysis, cross tabulation analysis, regression analysis, and "t" test analysis, in order to ensure consistency in the results of the analysis. The data collected from the questionnaire provided the platform for measuring the success in knowledge externalization/transformation. The analysis of the results was based on the 4C platform introduced by Sarker (2006), where the introduced hypotheses and assumptions were used as references for the measurement of the extent of the categorized types of knowledge transformation.

### **6.1 - Introduction**

Globalization has changed the way organizations conduct business. Today's organizations rely heavily on performing most of their work and business activities globally. Employees, partners, customers, suppliers, stakeholders, and other businesses are more and more co-located and geographically distributed. They are becoming heavily dependent on extensive distributed group work, for communication and cooperation as well as for problems solving and products development. The quest to support such new environment of distributed groups and communities interactions implicated an urgent need for computer based technologies to facilitate "doing work together, BUT apart". KM and its externalization presented unexpected challenges to organizations because of

the ambiguities of the term knowledge as well as the dominant information based culture. Lately, organizations have realized that the knowledge of their individuals and groups is the most valuable asset for competitiveness and started the task of finding ways, setting concepts, and building software for the management of knowledge as a different and non-information based discipline.

The extent of both explicit and tacit knowledge created, shared and exchanged as a result of this new way of doing business increased exponentially as “natural boundaries of companies have changed, joint ventures, outsourcing, economical partnership, and professional networks have been developed and places where knowledge could be created have increased” (Boughzala, Dudezert & Heibult 2006). Managing and later measuring such knowledge became an extremely urgent task for groups and communities, as they were forced to cooperate, communicate, and manage their knowledge using available inadequate information-based technologies to develop products, exchange ideas, solve problems, externalize and measure knowledge. This inadequacy is attributed to the realization by researchers that knowledge is not information or a form of it and, in addition its processing, management and measurement require a whole set of technologies drastically different from those used in information processing, management and measurement. They lack the proper technological support for the externalization and measurement of knowledge as well as the needed support for the interaction among originators and receivers of such knowledge. Consequently, developing a methodology and building software to support such tasks emerged as new challenges within businesses, organizations and software developers in order to overcome the inefficiency in using information-based technologies for the fulfillment of such tasks.

The critical issue in the above arguments is the level of success in the knowledge transfer among the members of groups and communities. Knowledge transfer among groups and members of groups had been extensively addressed in the literature by many researchers on Information Systems Development (ISD) teams (Carmel 1999, Curtis et al 1988). They argued that ISD projects involve activities that require participation and contribution of all team members. These activities require continuous learning among the



members of the group. This learning is attributed to the success in the externalization of knowledge among individuals, especially in its creation, capture, and transfer. Sarker (2006) argued that current KM research has placed too much attention on the transfer of knowledge among individuals. Others have highlighted the importance of knowledge transfer by suggesting that for superior performance of a social entity, knowledge generation and its successful transfer needs to take place (Alavi 2000).

## **6.2- Thesis' experiment and analysis method**

The chapter introduces an experiment which was conducted among small groups of students using the developed tool for their distributed communication and cooperation during the development of their term projects in different subjects. The results of the analysis of the data gathered from the questionnaire were essential for the analysis of the categorized types of tacit knowledge as well as for the measurement of the externalization of the types. The chapter also introduces the analysis of the results of the data collected from the questionnaire in order to find whether the externalization (mainly the transfer) of the categorized opinions and ideas was successful or not.

The aim was to find out whether, while working on their projects using the developed tool, distributed members were able to effectively and successfully cooperate and externalize their opinions and ideas. The analysis of the questionnaire was based on verifying whether the two introduced hypotheses were true or not. The hypotheses proffers two important assumptions; first, the importance of categorizing tacit knowledge and second that this categorization helps in better externalization of types of tacit knowledge with a proper cooperative tool. The eight assumptions introduced earlier helped in the verification of the truthfulness of the hypotheses. The transfer of knowledge (as an integral factor in knowledge externalization) was chosen as the dependent variable during the analysis of the questionnaire, and independent variables were introduced as a basis for the verification of the hypotheses.

The experiment was administered to several groups, where students from different disciplines in the same classes, were asked, as part of their assessment, to use the tool. Three or four members were randomly selected for each group. For each subject, the students were given a list of topics from which to choose their projects. 54 groups were involved in the study each with 3 to 4 students, with a total of 154 students in the different subjects and from different disciplines and departments within the university.

After the groups' formation, the students were given few tutorials on the tool's functionalities in order to help them learn how to interact within groups as well as how they build, develop, and work on shared documents. The students were also made aware of the importance of individual contribution of opinions and ideas to the building of the shared document. During the two semesters, the students' work was monitored by the evaluator, who was the lecturer in this case, where comments and progressive marks were administered.

The students were not co-located as they are at the same university and have taken the same subjects. In order to ensure that the students relied only on the tool for their work on the project, development of their work was constantly monitored by the professor. The tool allowed the lecturer to monitor who did what and when, by capturing all work related to a document by all members of a group and recording the time and the amount of time spent by each of them. As well, the tool monitored the creation, sharing, and transfers of their opinions and ideas. It was not really possible to prevent any face-to-face interaction among the students during the development of the term project but, in my opinion, their work and use of the system was enough to assume that their work was as close as possible to collocated work. The students were notified at the beginning of the semester that their use of the tool would be constantly monitored and that a considerable percentage of their mark would be given for their contribution on the externalization of their opinions and ideas.

In my opinion, the student's co-located work was apparent in most cases through the monitoring of their discussions, opinions/ideas release, and contribution to nurturing

these opinions/ideas. It was also apparent through the lecturer's checking of the versions of the documents edited by the members. These versions could only be developed as a result of access by the members to each other's work.

### **6.3 - Development of the questionnaire**

The questionnaire (Appendix A) was distributed to the students at the end of the semester. The questionnaire was developed to verify whether knowledge externalization among the students in groups was successful and whether this externalization was affected by:

- 1- interaction among the members
- 2- the evaluator's contribution to the members introduced knowledge
- 3- the seniority and experiences of the members
- 4- the prior knowledge, class, and the major of the students

The analysis of the questionnaire was conducted using the SPSS software to answer the research hypotheses against the introduced assumptions. As stated before, it is assumed that the dependent variable is the externalization of knowledge and the independent variables are the members prior knowledge, major, class, seniority, evaluator's contribution, group interaction, knowledge nurture, and experiences.

### **6.4 - Analysis method**

The analysis of the questionnaire is based on Sarker's (2006) introduced 4Cs framework: capability, credibility, extent of communication, and culture. Sarker suggested that these four factors affect the extent to which an individual's knowledge can be transferred from within distributed small groups. Sarker conducted two experiments based on these factors. One was conducted on students in the same country (the USA) and the second between groups in different countries. She assessed the transfer of knowledge among these members based on the use of emails for their interactions. The factors of the 4Cs framework are:



- 1- The capability of the members, which is defined as the member's know-how, both hard and soft. This was also proposed in Davenport & Prusak (1998).
- 2- The member's credibility, which is defined as his/her trustworthiness and reliability. This was also discussed in Szulanski (2000) and Szulanski et al (2004).
- 3- The member's extent of communication with remote team members. This was also stated in Bresman, Birkinsham and Nobel (1999)
- 4- The member's culture, also noted in Davenport and Prusak (1998), and Yoo and Torrey (2002)

The thesis adopts these factors for the analysis of the questionnaire. Culture was not considered an important factor during the analysis as the students involved are from the same culture, namely, English speaking Lebanese, and from close cultures, namely, neighboring Arab countries.

#### **6.4.1 - Capability**

The study of capability in this research concentrates on two main assumptions. The first focus is the study of a member's contribution, regarded as a sign of capability to introduce new effective opinions and ideas during the project development. And the second focal point is whether or not such capable members affect the knowledge transfer of less capable members within the group.

The know-how of a member is a combination of his/her prior knowledge, seniority, experiences, class, and major. All of these factors affect a member's capability if he/she is able to demonstrate to his peers that he/she is capable of releasing valuable knowledge during the term project development. Consequently, his peers regard him/her as capable. It is assumed that know-how is another factor affecting the capability of a member. Know-where is the ability of the individual to be able to locate valuable knowledge vital to the development process. Another factor is know-what, which deals with the capability of the member to know what of the knowledge he/she releases or is released by other members is valuable and should be retained. Such members will have a major influence during the nurture process introduced earlier.

The members of a group accept that a member is capable if he/she constantly contributes to the creation and release of valuable opinions and ideas during the development of the project. Another assumption is that a member is regarded as capable by his/her peers based on the comments by the evaluator on his/her progressive work on the project.

A capable member is an individual who is able to professionally and constructively contribute to the overall knowledge externalization and the development of the term project. The member releases opinions and ideas which add value to the developed project, based on his/her know-how. The capability of the member is a factor directly affected by:

- 1- The “class” of the members, for example, freshman, sophomore, Junior, and Senior. Students in senior classes are supposed to be more capable than those in junior classes because of prior knowledge and experiences accumulated during years of study.
- 2- The “major” of the members, such as Business major or others. Students in majors with directly related topics to the context of the project are supposed to be more capable than others in constructive contribution to the development of the project. They do this by releasing more O/I.
- 3- The “prior knowledge” of the members on any of, or combination of the following topics: KM, Group-Support Systems, Tacit/Explicit Knowledge, Virtual Interaction, Virtual systems). Prior knowledge of these key concepts raises the capability of the members with such knowledge.
- 4- The “seniority/experience” on key concepts. It is assumed that seniority together with general experiences plays an important role as a factor affecting the capability of the members.

- 5- The “evaluator’s” contribution, assessments and discussions on a member’s released knowledge

Knowledge transfer increases in groups where members have higher class, major, seniority/experiences, and prior knowledge because such members are considered as having acquired know-how during their previous years and subjects taken. It also increases as a result of constructive comments and discussions by the evaluator.

A member (or members) in a group having any or all of the above factors is supposed to contribute more in releasing his/her opinions and ideas during the development of the term project, hence the increase or decrease of his/her capability. On the other hand, such members also affect the release and transfer of knowledge among members with lower class, major, and prior knowledge by increasing the overall opinions and ideas release in the group.

The capability factor was addressed in the questionnaire by the first 7 questions. These questions studied the effects of the knowledge released by members on other members of the group. The intention was to find out whether or not member’s released knowledge triggered others in the group to increase their contribution to the term project development through learning, being aware of others’ capabilities, ways of analysis and problems solving techniques, and to reflect on the released knowledge. These questions also checked whether the transfer of knowledge in groups with high capabilities is higher than with groups where the members have similar or fewer capabilities, that is, in class, major, prior knowledge, and seniority/experiences).

The main question to be answered by the questionnaire is whether or not, based on the above arguments, a capable member is one who releases considerable and valuable knowledge and who is appraised by the evaluator through recognition of his/her work and his/her good grades.



#### **6.4.2 - Credibility**

The credibility of the members is also considered as a measure of the volume of opinions and ideas released by members and how this affects the level of credibility of the member in the perception of others in the group. It is assumed that members who notice that others in the group constantly contribute to the development process by releasing their opinions and ideas regularly conclude that these members are credible.

Another very important factor which affected the credibility of the members was the evaluator's contribution to the work released by the members. In each group, in all subjects, the professor was added as a special member as an evaluator. His/her role was to check on the up-to-date work in each of the groups on both the T-document and the V-Document. The evaluator has access to the work of each of the groups, being a member in it. He/she can communicate with the members and comment on their released knowledge via the actual documents or by sending messages to the member which can be seen by all other members in the group. It is a reasonable assumption that members who notice that the evaluator's comments on other members released work are generally positive and encouraging, consider those members as reliable and credible. Another important evaluator's role which affects the credibility among the members is his/her constant marking of the work in progress on both the T-document and the V-Document of the members.

The main question which the questionnaire tries to answer is whether the productivity and contribution of members decreases or increases when the group member's credibility is being compared within the group: in other words the effects on the members, of those who are considered credible.

#### **6.4.3 Extent of Communication**

Excess in discussions, in opinions and ideas release, and in their progressive nurture was facilitated by the example tool's ability to allow members to communicate using the imbedded discussion feature. The release, creation, nurture and capture of the members' opinions and ideas require high level of interaction among the members in order to be

able to reflect on released work by others, a vital activity in virtual group work in general. As discussed in earlier chapters, more communication among the members is an integral activity in the process of nurturing released opinions and ideas, as it allows the members to be provided with a context for reflection on these opinions and ideas. Many researchers believe that communication is the key for success in the transfer of knowledge. Davenport and Prusak (1998) argued that the formation of individual's ideas, opinions, thoughts, and beliefs are only possible through extended discussions. Sarker and Sahay (2003) agreed, and posited that social action is integral to computer-mediated communication in ICT-mediated distributed teams. Consequently, increase of knowledge transfer is integral to increase of communication. Questions 12 – 16 in the questionnaire address the extent of interaction among the group members on the transfer of knowledge within a group.

## **6.5 - Questionnaire's statistics, analysis, discussions, and results**

### **6.5.1 - Statistics**

The following tables show some statistics regarding queries in the questionnaire in relation to the dependent variable, transfer of knowledge (7 questions), and the independent variables: Major (1 question), Class (1 question), Time-spent (1 question), Prior Knowledge (1 question), Evaluator' Contribution (4 questions), Group Interaction (5 questions), and Seniority/Experiences (2 questions). For each of these questions a separate table shows the following main statistics:

- 1- total number of students who contributed to the questionnaire
- 2- the number of students who choose to answer the question
- 3- the mean
- 4- standard deviation
- 5- the values of the variable: maximum and minimum numbers of possible answers to the question.

The tables also show the frequency and percentage of the answers by each member in all groups.

1- Major [Business, Others]

	F	%	Valid %	Cumulative %
Business	118	79.7	79.7	79.7
Others	30	20.3	20.3	100.0
Total	148	100.0	100.0	
Mean	1.2027	Min.	1.00	
Std Dev.	.40338	Max.	3.00	

A total of 148 students answered this question: 118 Business degree students on various tracks in the business school, and 30 other students, from engineering, computer science, biology, communications, and others.

1.2- Majorless-1

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid business	118	79.7	79.7	79.7
Eng. + Comp. Sc	18	12.2	12.2	91.9
Others	12	8.1	8.1	100.0
Total	148	100.0	100.0	

1.4- Majorless-2

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid Business	118	79.7	79.7	79.7
Eng. + Comp. Sc	18	12.2	12.2	91.9
Others	12	8.1	8.1	100.0
Total	148	100.0	100.0	

2- Class [senior (1), sophomore (2), junior (3), freshman (4)]

	F	%	Valid %	Cumulative %
Senior(1)	3	2.0	2.0	2.0
Sophomore(2)	45	30.4	30.4	32.4
Junior(3)	82	55.4	55.4	87.8
Freshman(4)	18	12.2	12.2	100.0
Total	148	100.0	100.0	
Mean	1.2027	Min.	1.00	
Std. Dev.	.40338	Max.	4.00	



A total of 148 students answered this question: 3 seniors, 45 sophomores, 82 junior, 18 freshmen

3- Prior-Knowledge [Yes (1), No (2)]

	F	%	Valid %	Cumulative %
Yes(1)	54	36.5	37.2	37.2
No(2)	91	61.5	62.8	100.0
Total	145	98.0	100.0	
Missing	3	2.0		
Total	148	100.0		
Mean	1.6276	Minimum	1.00	
Std. Deviation	.48512	Maximum	2.00	

4- Time-Spent [1-year, 2-years, 3-years, 4-years]

	F	%	Valid %	Cumulative %
Valid 1 year	37	25.0	39.4	39.4
2 years	36	24.3	38.3	77.7
3 years	15	10.1	16.0	93.6
4 years	6	4.1	6.4	100.0
Total	94	63.5	100.0	
Missing System	54	36.5		
Total	148	100.0		
Mean	1.8936	Minimum	1.00	
Std. Deviation	.89764	Maximum	4.00	

A total of 94 students answered this question: 37 said they spent 1 year, 36 said 2 years, 15 said 3 years, 6 said 4 years

5- Knowledge Transfer [7 High, 1 V Low]

5.1- KnowTra-1

	F	%	Valid %	Cumulative %
Valid 2 (low)	3	2.0	2.0	2.0
3.00	4	2.7	2.7	4.8
4.00	13	8.8	8.8	13.6
5.00	31	20.9	21.1	34.7
	81	54.7	55.1	89.8

6.00				
7 (v.high)	15	10.1	10.2	100.0
Total	147	99.3	100.0	
Missing System	1	.7		
Total	148	100.0		
Mean	5.5510	Minimum	2.00	
Std. Deviation	1.02157	Maximum	7.00	

**5.2- KnowTra-2**

	F	%	Valid %	Cumulative %
Valid 2 (low)	1	.7	.7	.7
3.00	7	4.7	4.7	5.4
4.00	23	15.5	15.5	20.9
5.00	39	26.4	26.4	47.3
6.00	63	42.6	42.6	89.9
7 (v.high)	15	10.1	10.1	100.0
Total	148	100.0	100.0	
Mean	5.3581	Minimum	2.00	
Std. Dev.	1.05631	Maximum	7.00	

**5.3- KnowTra-3**

	F	%	Valid %	Cumulative %
Valid 2 (low)	2	1.4	1.4	1.4
3.00	5	3.4	3.4	4.7
4.00	21	14.2	14.2	18.9
5.00	47	31.8	31.8	50.7
6.00	54	36.5	36.5	87.2
7 (v.high)	19	12.8	12.8	100.0

Total	148	100.0	100.0
Mean	5.3716	Minimum	2.00
Std. Dev.	1.07083	Maximum	7.00

5.4- KnowTra-4

	F	%	Valid %	Cumulative %
Valid 2 (low)	1	.7	.7	.7
3.00	10	6.8	6.8	7.4
4.00	28	18.9	18.9	26.4
5.00	43	29.1	29.1	55.4
6.00	45	30.4	30.4	85.8
7 (v.high)	21	14.2	14.2	100.0
Total	148	100.0	100.0	
Mean	5.2432	Minimum	2.00	
Std. Dev	1.15836	Maximum	7.00	

5.5- KnowTra-5

	F	%	Valid %	Cumulative %
Valid 2 (low)	1	.7	.7	.7
3.00	5	3.4	3.4	4.1
4.00	32	21.6	21.6	25.7
5.00	55	37.2	37.2	62.8
6.00	42	28.4	28.4	91.2
7 (v.high)	13	8.8	8.8	100.0
Total	148	100.0	100.0	
Mean	5.1554	Minimum	2.00	
Std. Dev.	1.01494	Maximum	7.00	

5.6- KnowTra-6

	F	%	Valid %	Cumulative %
Valid 2 (low)	1	.7	.7	.7
3.00	9	6.1	6.1	6.8



	4.00	22	14.9	15.0	21.8
	5.00	59	39.9	40.1	61.9
	6.00	40	27.0	27.2	89.1
	7 (v.high)	16	10.8	10.9	100.0
	Total	147	99.3	100.0	
Missing	System	1	.7		
Total		148	100.0		
Mean		5.1973	Minimum	2.00	
Std. Deviation		1.06398	Maximum	7.00	

**5.7- KnowTra-7**

		F	%	Valid %	Cumulative %
Valid	2 (low)	1	.7	.7	.7
	3.00	12	8.1	8.2	8.8
	4.00	24	16.2	16.3	25.2
	5.00	56	37.8	38.1	63.3
	6.00	44	29.7	29.9	93.2
	7 (v.high)	10	6.8	6.8	100.0
	Total	147	99.3	100.0	
Missing	System	1	.7		
Total		148	100.0		
Mean		5.0884	Minimum	2.00	
Std. Deviation		1.05937	Maximum	7.00	

**6- Evaluator's Contribution [7 high, 1 V. low]**

**6.1- EvaCont-1**

		F	%	Valid %	Cumulative %
Valid	2 (low)	2	1.4	1.4	1.4
	3.00	9	6.1	6.1	7.5

	4.00	37	25.0	25.2	32.7
	5.00	42	28.4	28.6	61.2
	6.00	43	29.1	29.3	90.5
	7 (v.high)	14	9.5	9.5	100.0
	Total	147	99.3	100.0	
Missing	System	1	.7		
Total		148	100.0		
Mean		5.0680	Minimum	2.00	
Std. Deviation		1.13873	Maximum	7.00	

**6.2- EvaCont-2**

	F	%	Valid %	Cumulative %
Valid 2 (low)	3	2.0	2.1	2.1
	12	8.1	8.2	10.3
3.00				
4.00	30	20.3	20.5	30.8
	44	29.7	30.1	61.0
5.00				
6.00	42	28.4	28.8	89.7
	15	10.1	10.3	100.0
7 (v.high)				
Total	146	98.6	100.0	
Missing System	2	1.4		
Total	148	100.0		
Mean	5.0616	Minimum	2.00	
Std. Deviation	1.19321	Maximum	7.00	

**6.3- EvaCont-3**

	F	%	Valid %	Cumulative %
Valid 2 (low)	2	1.4	1.4	1.4
	12	8.1	8.2	9.5
3.00				
4.00	29	19.6	19.7	29.3
	45	30.4	30.6	59.9

	5.00				
	6.00	41	27.7	27.9	87.8
	7 (v.high)	18	12.2	12.2	100.0
	Total	147	99.3	100.0	
Missing	System	1	.7		
Total		148	100.0		
Mean		5.1224	Minimum	2.00	
Std. Deviation		1.18725	Maximum	7.00	

**6.4- EvaCont-4**

		F	%	Valid %	Cumulative %
Valid	3.00	20	13.5	13.6	13.6
	4.00	39	26.4	26.5	40.1
	5.00	38	25.7	25.9	66.0
	6.00	36	24.3	24.5	90.5
	7 (v.high)	14	9.5	9.5	100.0
	Total	147	99.3	100.0	
Missing	System	1	.7		
Total		148	100.0		
Mean		4.8980	Minimum	3.00	
Std. Deviation		1.19780	Maximum	7.00	

**7- Group Interaction [7 high, 1 V. low]**

**7.1- GrInter-1**

		F	%	Valid %	Cumulative %
Valid	2 (low)	2	1.4	1.4	1.4
	3.00	22	14.9	15.2	16.6
	4.00	45	30.4	31.0	47.6
	5.00	35	23.6	24.1	71.7
	6.00	30	20.3	20.7	92.4
		11	7.4	7.6	100.0



7 (v.high)				
Total	145	98.0	100.0	
Missing System	3	2.0		
Total	148	100.0		
Mean	4.7034	Minimum	2.00	
Std. Deviation	1.21406	Maximum	7.00	

### 7.2- GrInter-2

	F	%	Valid %	Cumulative %
Valid 2 (low)	6	4.1	4.2	4.2
3.00	27	18.2	19.0	23.2
4.00	41	27.7	28.9	51.4
5.00	36	24.3	25.4	77.5
6.00	20	13.5	14.1	91.5
7 (v.high)	12	8.1	8.5	100.0
Total	142	95.9	100.0	
Missing System	6	4.1		
Total	148	100.0		
Mean	4.7958	Minimum	2.00	
Std. Deviation	3.55811	Maximum	7.00	

### 7.3- GrInter-3

	F	%	Valid %	Cumulative %
Valid 1 (v. low)	1	.7	.7	.7
2.00	3	2.0	2.1	2.8
3.00	26	17.6	18.1	20.8
4.00	45	30.4	31.3	52.1
5.00	45	30.4	31.3	83.3
6.00	18	12.2	12.5	95.8
7	6	4.1	4.2	100.0

	(v.high)			
Total		144	97.3	100.0
Missing System		4	2.7	
Total		148	100.0	
Mean		4.4444	Minimum	1.00
Std. Deviation		1.15133	Maximum	7.00

#### 7.4- GrInter-4

		F	%	Valid %	Cumulative %
Valid	2 (low)	8	5.4	5.4	5.4
	3.00	27	18.2	18.4	23.8
	4.00	42	28.4	28.6	52.4
	5.00	44	29.7	29.9	82.3
	6.00	19	12.8	12.9	95.2
	7 (v.high)	7	4.7	4.8	100.0
Total		147	99.3	100.0	
Missing System		1	.7		
Total		148	100.0		
Mean		4.4082	Minimum	2.00	
Std. Deviation		1.22057	Maximum	7.00	

#### 7.5- GrInter-5

		F	%	Valid %	Cumulative %
	2 (low)	9	6.1	6.3	6.3
	3.00	23	15.5	16.1	22.4
	4.00	35	23.6	24.5	46.9
	5.00	36	24.3	25.2	72.0
	6.00	30	20.3	21.0	93.0
	7 (v.high)	10	6.8	7.0	100.0
Total		143	96.6	100.0	
Missing		5	3.4		
Total		148	100.0		
Mean		4.5944	Minimum	2.00	
Std. Deviation		1.33869	Maximum	7.00	

#### 8- Seniority and Experiences [7 high, 1 low]

8.1- SenExp-1

	F	%	Valid %	Cumulative %
2 (low)	1	.7	.7	.7
3.00	19	12.8	12.8	13.5
4.009	29	19.6	19.6	33.1
5.00	34	23.0	23.0	56.1
6.00	52	35.1	35.1	91.2
7 (v.high)	13	8.8	8.8	100.0
Total	148	100.0	100.0	
Mean	5.0541	Minimum	2.00	
Std. Deviation	1.21657	Maximum	7.00	

8.2- SenExp-2

	F	%	Valid %	Cumulative %
Valid 2 (low)	3	2.0	2.0	2.0
3.00	8	5.4	5.4	7.5
4.00	22	14.9	15.0	22.4
5.00	40	27.0	27.2	49.7
6.00	43	29.1	29.3	78.9
7 (v.high)	31	20.9	21.1	100.0
Total	147	99.3	100.0	
Missing System	1	.7		
Total	148	100.0		
Mean	5.3946	Minimum	2.00	
Std. Deviation	1.24173	Maximum	7.00	

6.5.2 - Reliability analysis

The following Tables show the reliability analysis of the questions in the questionnaire. The questions in the analysis are the sets 6 – 12 (Knowledge Transfer), 13 – 16 (Evaluator’s Contribution), 17 – 21 (Group Interaction), and 22 – 23 (Seniority and Experiences) respectively.



The Tables show that all questions are reliable in terms of the number of items in each set of questions. They also show the reliability in terms of the number of students who answered the questions, disregarding those that have not answered a particular question(s). They demonstrate that all questions in the analysis are reliable. It is important to perform the reliability analysis because it represents the reliability of the answers of the samples involved in the study in terms of their contribution in the frequency of answering questions in the questionnaire.

### 1      Knowledge Transfer Q6-Q12

#### Case Processing Summary

		N	%
Cases	Valid	145	98.0
	Excluded(a)	3	2.0
	Total	148	100.0

A Likewise deletion based on all variables in the procedure.

#### Reliability Statistics

Cronbach's Alpha	N of Items
.823	7

145 students answered all questions in this set of 7 questions. 3 students left some questions unanswered.

### 2      Evaluators Contribution Q13-Q16

#### Case Processing Summary

		N	%
Cases	Valid	144	97.3
	Excluded(a)	4	2.7
	Total	148	100.0

a Listwise deletion based on all variables in the procedure.

#### Reliability Statistics

Cronbach's Alpha	N of Items
.776	4

144 students answered all questions in this set of 7 questions. 4 students left some questions unanswered

3-      **Group Interactions Q17-Q21**

**Case Processing Summary**

		N	%
Cases	Valid	132	89.2
	Excluded(a)	16	10.8
	Total	148	100.0

a Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

Cronbach's Alpha	N of Items
.754	5

132 students answered all questions in this set of 7 questions. 16 students left some questions unanswered

4-      **Seniority/Experience Q22-Q23**

**Case Processing Summary**

		N	%
Cases	Valid	147	99.3
	Excluded(a)	1	.7
	Total	148	100.0

a Listwise deletion based on all variables in the procedure.

**Reliability Statistics**

Cronbach's Alpha	N of Items
.838	2

147 students answered all questions in this set of 7 questions. Only 1 student left some questions unanswered

6.5.3 - Correlation analysis

The Pearson correlation measures the degree of linear association between two variables. According to this measure, the coefficient varies between -1.00 and 1.00, with 0 representing absolutely no association between any two variables, and -1.00 or 1.00 representing a perfect link between two variables. This analysis suggests that the higher the correlation coefficient, the stronger the level of association between the two variables. If there is a negative correlation coefficient between two variables, then increases in the value of one are associated with decreases in the value of the other and vice versa. It is very important to check for the association between the variables because the aim is to study the effects of the independent variables on the transfer of knowledge (dependent variable) among group members. Table 5.1 answers the following questions on the association among the variables:

- a- Does a relationship exist between two variables?
- b- If there is a relationship between any two variables, how strong is it?
- c- What is the best way to describe this relationship?

The Table describes the relationships between the variables. It shows the correlation coefficients between the dependent variable (Knowledge Transfer) and the independent variables (evaluator’s contribution, group interaction, seniority/experiences, class, and time, major). It also shows the relationships between the independent variables

		Ave-kn- tra	Re- prior-kn	ReL- time	Class	Av-ev- cont	Ave- gr-int	Av-sen- ex
Ave-kn- tra	Pearson Correlation	1						
	Sig. (2-tailed)							
	N	148						
Re- prior- kn	Pearson Correlation	.359(**)	1					
	Sig. (2-tailed)	.000						
	N	145	145					
ReL- time	Pearson Correlation	.403(**)	.(a)	1				
	Sig. (2-tailed)	.000	.000					
	N	94	91	94				
Class	Pearson Correlation	.349(**)	.405(**)	.579(**)	1			
	Sig. (2-tailed)	.000	.000	.000				



<b>Av-ev-cont</b>	N	148	145	94	148			
	Pearson Correlation	.520(**)	.186(*)	.408(**)	.184(*)	1		
	Sig. (2-tailed)	.000	.025	.000	.025			
<b>Ave-gr-int</b>	N	148	145	94	148	148		
	Pearson Correlation	.295(**)	-.032	.361(**)	-.032	.222(**)	1	
	Sig. (2-tailed)	.000	.699	.000	.697	.007		
<b>Av-sen-ex</b>	N	148	145	94	148	148	148	
	Pearson Correlation	.309(**)	.107	.269(**)	.070	.172(*)	.377(**)	1
	Sig. (2-tailed)	.000	.201	.009	.397	.037	.000	
	N	148	145	94	148	148	148	148

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

a Cannot be computed because at least one of the variables is constant.

**Table-6.1: Correlation among dependent/independent variables**

*Note: The major was not included in the correlation table above because it represents categorical variables. This is why two dummy variables (majorless-1 and majorless-2) were created in order to include the major into regression analysis*

In summary, according to Table 6.1, there are positive and significant associations between the dependent variable (transfer of knowledge) and all other independent variables.

### 6.5.4 Cross-tabulation Analysis: Analysis and Knowledge Externalization Measurement

The cross-tabulation analysis shows the frequency of the answers by students in each group, for each of the questions. Each question is rated 1(very low) – 7 (very High). The groups are divided into two types. One is where all students in groups are from the Business Department and the other is of students from different departments; mixed groups, which might also include business students. The questionnaire’s questions have been divided into four categories:

- a- questions related to The Transfer of Knowledge (1 – 7)

- b- questions related to Group Interaction (8 – 11)
- c- questions related to The Evaluator Contribution (12 – 16)
- d- questions related to the students' Seniority and Experiences (17 – 18)

The aim of this analysis is to find out whether the transfer of knowledge increases in mixed groups as a result of the evaluator's contribution, group interaction, and seniority and experiences. The diversity of know-how among the members in mixed groups, in comparison to groups of only business students, should increase the transfer of knowledge among the members. Also, group interaction among the members of mixed groups should be higher than the other groups. On the other hand, the members in mixed groups adhere and accept the role of the evaluator as a trigger for an increase of knowledge transfer more than those in other groups. Finally, the member's seniorities and experiences in mixed groups increase the transfer of knowledge more than the other groups.

The questions in the questionnaire were devised in the indirect mode. The students were not asked directly whether or not there was knowledge transfer within their groups. The same indirect types of questions were asked for group interaction, evaluator's contribution, and seniority/experiences. The following is a description of each of the questions and how each of the four categories questions reached its aim.

#### **(A)- Transfer of knowledge**

##### **Q1- to what extent were your opinions/ideas affected by other's opinions/ideas in your group?**

The availability of member's opinions and ideas is knowledge transferred within the group. A member's opinions and ideas were affected as a result of this availability, and reflect success in the knowledge transfer

**Q2- to what extent have you learnt about other's analytical skills by being exposed to their problem solving activities?**

Exposure to member's problem solving activities is a consequence of knowledge transferred by those members, hence the transfer of knowledge.

**Q3- to what extent have you learnt about other's ways of thinking by being exposed to their individualistic solutions?**

Member's exposure to others ways of thinking through access to their solutions to problems is a consequence to transfer of knowledge

**Q4- to what extent were your opinions/ideas affected by the explicit knowledge available in your group's memory?**

The availability of member's contribution through their release of explicit knowledge is considered as knowledge transferred within groups

**Q5- to what extent were your opinions/ideas affected by the tacit knowledge released by members of your group?**

The availability of member's contribution through their release of tacit knowledge is considered as knowledge transferred within groups

**Q6- to what extent were your opinions/ideas affected by discussions/feedback to your queries by experts in the system?**

Discussion and feedback on released knowledge is considered to be a trigger for knowledge transfer among members in groups as a result of constructive responses by experts (evaluators) responses



**Q7- to what extent have the exchange of messages within your group influenced your opinions/ideas?**

Exchange of messages is also considered to be a trigger for knowledge transfer among members in groups

**(B)- Evaluator's Contribution**

**Q1- to what extent have the evaluator's comments acted as enablers for additional opinions/ideas creation in your group?**

The comments by the evaluator on members released work acts as a trigger for transfer of knowledge among the members of groups

**Q2- to what extent has the evaluator's constant assessment on member's released knowledge helped them come up with additional knowledge?**

The evaluator's assessment of released work by members acts as an incentive for other members to review their peers work in order to see why it was praised by the evaluator hence acts as a trigger for more knowledge formation and transfer

**Q3- to what extent have the evaluator's comments on individual's work within your group reduced conflict among them?**

The evaluator's comments on released work acts as mediator between the members and resolves misunderstanding on each other's work

**Q4- to what extent has the availability of the evaluator's comments on individual work improved your overall contribution of knowledge?**

Overall the contribution of the evaluator was a source of generating more knowledge among the members of groups. The evaluator praises the good work, contribution, originality, and knowledge release of the members. These issues act as enablers for more knowledge transfer within the groups

### **(C)- Group Interaction**

**Q1- to what extent is the nurture of opinions/ideas close to the mental idea development in face-to-face interaction?**

The nurture of released knowledge is a process where members engage in extensive interaction in order to build on a piece of knowledge, opinion and/or idea, they agreed upon its relevance to the term projects. This increase of interaction results in more knowledge initiation and release by the members

**Q2- to what extent has messaging among members in your group helped in nurturing opinions/ideas?**

Communication through messaging results in discussions and exchange of opinions and ideas among the members. This process increases the group interaction and hence the transfer of knowledge among the members

**Q3- to what extent has the release/capture of knowledge helped in nurturing your group's opinion/ideas?**

The release and retention/capture of knowledge within a group is maintained through increase in interaction among the members which results in increase in the transfer of knowledge.

**Q4- to what extent was filtration of released knowledge affected by constant exposure to the group's goals/objectives?**

The filtration process requires increase of member’s interaction in order to purify the released knowledge from any undesired knowledge, i.e. knowledge which does not satisfy the goals/objectives of the group. This process results in the formation of valuable knowledge, hence the transfer of knowledge

**Q5- to what extent has the process of filtration resulted in conflict among your group members?**

Conflict results from the inability of the members to reach a solution on released knowledge. Increase of interaction might lead to resolving it.

**(D)- Seniority and Experiences**

**Q1- to what extent has the seniority of the members in your group affected the transfer of knowledge?**

Senior students may affect the group’s overall knowledge transfer as a result of their know-how accumulated during their years of study

**Q2- to what extent has personal expertise on key concepts by members affected the transfer of knowledge within your group?**

The experiences of an individual play an integral role in transferring knowledge within groups. These experiences act as an incentive for others to learn from them, hence initiate more knowledge within their groups.

**Tabular Results**

**A- Transfer of Knowledge**

**KnowTra1 \* VAR00001 Cross-tabulation**

Count		
	VAR00001	Total



		1.00	2.00	
KnowTra1	2.00	2	1	3
	3.00	1	3	4
	4.00	9	4	13
	5.00	21	10	31
	6.00	58	23	81
	7.00	7	8	15
Total		98	49	147

**KnowTra2 \* VAR00001 Cross-tabulation**

Count

		VAR00001		Total
		1.00	2.00	
KnowTra2	2.00	1	0	1
	3.00	4	3	7
	4.00	12	11	23
	5.00	25	14	39
	6.00	43	20	63
	7.00	13	2	15
Total		98	50	148

**KnowTra3 \* VAR00001 Cross--tabulation**

Count

		VAR00001		Total
		1.00	2.00	
KnowTra3	2.00	2	0	2
	3.00	4	1	5
	4.00	16	5	21
	5.00	27	20	47
	6.00	34	20	54
	7.00	15	4	19
Total		98	50	148

**KnowTra4 \* VAR00001 Cross-tabulation**

Count

		VAR00001		Total
		1.00	2.00	
KnowTra4	2.00	1	0	1
	3.00	8	2	10
	4.00	18	10	28
	5.00	23	20	43
	6.00	32	13	45
	7.00	16	5	21
Total		98	50	148

**KnowTra5 \* VAR00001 Cross-tabulation**

Count

		VAR00001		Total
		1.00	2.00	
KnowTra5	2.00	1	0	1
	3.00	3	2	5
	4.00	28	4	32
	5.00	31	24	55
	6.00	27	15	42
	7.00	8	5	13
Total		98	50	148

**KnowTra6 \* VAR00001 Cross-tabulation**

Count

		VAR00001		Total
		1.00	2.00	
KnowTra6	2.00	0	1	1
	3.00	6	3	9
	4.00	16	6	22
	5.00	34	25	59
	6.00	29	11	40
	7.00	12	4	16
Total		97	50	147

**KnowTra7 \* VAR00001 Cross-tabulation**

Count

		VAR00001		Total
		1.00	2.00	
KnowTra7	2.00	0	1	1
	3.00	9	3	12
	4.00	17	7	24
	5.00	32	24	56
	6.00	30	14	44
	7.00	9	1	10
Total		97	50	147

**B- Evaluator Contribution**

**EvaCont1 \* VAR00001 Cross-tabulation**

Count

	VAR00001	Total
--	----------	-------

		1.00	2.00	
EvaCont1	2.00	1	1	2
	3.00	8	1	9
	4.00	24	13	37
	5.00	26	16	42
	6.00	30	13	43
	7.00	9	5	14
Total		98	49	147

EvaCont2 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
EvaCont2	2.00	2	1	3
	3.00	11	1	12
	4.00	16	14	30
	5.00	25	19	44
	6.00	33	9	42
	7.00	10	5	15
Total		97	49	146

EvaCont3 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
EvaCont3	2.00	2	0	2
	3.00	9	3	12
	4.00	17	12	29
	5.00	32	13	45
	6.00	24	17	41
	7.00	14	4	18
Total		98	49	147

EvaCont4 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
EvaCont4	3.00	12	8	20
	4.00	25	14	39
	5.00	29	9	38
	6.00	21	15	36
	7.00	10	4	14
Total		97	50	147



C- Group Interaction

GrInter1 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
GrInter1	2.00	2	0	2
	3.00	14	8	22
	4.00	36	9	45
	5.00	21	14	35
	6.00	14	16	30
	7.00	9	2	11
Total		96	49	145

GrInter2 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
GrInter2	2.00	5	1	6
	3.00	22	5	27
	4.00	29	11	40
	5.00	21	15	36
	6.00	8	12	20
	7.00	7	5	12
	44.00	1	0	1
Total		93	49	142

GrInter3 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
GrInter3	1.00	1	0	1
	2.00	2	1	3
	3.00	20	6	26
	4.00	34	11	45
	5.00	28	17	45
	6.00	8	10	18
	7.00	3	3	6
Total		96	48	144

GrInter4 \* VAR00001 Cross-tabulation

Count

		VAR00001	Total
--	--	----------	-------

		1.00	2.00	
GrInter4	2.00	5	3	8
	3.00	19	8	27
	4.00	30	12	42
	5.00	26	18	44
	6.00	14	5	19
	7.00	3	4	7
Total		97	50	147

GrInter5 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
GrInter5	2.00	5	4	9
	3.00	17	6	23
	4.00	22	13	35
	5.00	22	14	36
	6.00	23	7	30
	7.00	6	4	10
Total		95	48	143

D- Seniority and Experiences

SenExp1 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
SenExp1	2.00	1	0	1
	3.00	15	4	19
	4.00	21	8	29
	5.00	23	11	34
	6.00	29	23	52
	7.00	9	4	13
Total		98	50	148

SenExp2 \* VAR00001 Cross-tabulation

Count

		VAR00001		Total
		1.00	2.00	
SenExp2	2.00	3	0	3
	3.00	6	2	8
	4.00	17	5	22

5.00	26	14	40
6.00	24	19	43
7.00	21	10	31
Total	97	50	147

	Question-1	Question-2	Question-3	Question-4	Question-5	Question-6	Question7
<b>Kn. Trans.</b>	86/98----- 41/49	81/98----- 36/50	76/98----- 44/590	71/98----- 38/50	66/98----- 44/50	75/97----- 40/50	71/97----- 39/50
<b>Gr. Intera.</b>	44/96----- 32/49	36/93----- 32/49	39/96----- 30/48	43/97----- 27/50	51/95----- 25/48		
<b>Ev. Contr.</b>	65/98----- 34/49	68/98----- 33/49	70/98----- 34/49	60/97----- 28/50			
<b>Se &amp; Exper</b>	61/98----- 38/50	71/97----- 43/50					

**Table 6.2: Summary of Cross Tabulation Analysis**

The table above shows four categories for each question; namely, transfer of knowledge, group interaction, evaluator contribution, and seniority/ experiences. It also shows the frequencies of the answers within the two types of groups. Only answers with responses have been shown: 7(high), 6, and 5.

*Note: The combination aa/bb-----dd/ee, means the number of answers on a particular question (aa) over the total number of students (bb) in the groups with only business students and the number of answers on the same question (dd) over the total number of students (ee) in mixed groups.*

**Measurement:** The table demonstrates that the majority of the students in both types of groups have answered very high when it comes to knowledge transfer, evaluator contribution, and seniority/experiences. Group interaction was considerably low compared to the others. Students, regardless of their departments, have answered positively that there was considerable knowledge transfer within their groups. The high answers were in regard to the evaluator contribution. This demonstrates the important



role the evaluator plays in ideas and opinions formation as well as being a trigger for more ideas generation on the members. The evaluator's contribution increased the transfer of knowledge within the groups. The regression analysis, below, also demonstrated this. Results for seniority/experiences also demonstrated that it plays an important role and that the students have found that it contributes to increase in knowledge transfer among the members of the groups.

### 6.5.5 -Regression Analysis: Analysis and Measurement

Regression analysis studies details the relationships between the dependent variable and the independent variables. The aim of this analysis is to make predictions on the effects of the independent variables, on the dependent variable, and to measure the extent of the externalization of members' opinions and ideas as a result. This means to measure the effect of members' prior knowledge, seniority and experiences, group interaction, class, major, and evaluator's contribution to the transfer of knowledge within groups. On the other hand, regression analysis measures the effect of combinations of the independent variables on the transfer of knowledge within the groups.

*Note: In the regression analysis Tables the following legends apply:*

#### *1- independent variables*

- e- Ave-prior-kn - stands for average prior knowledge*
- f- Ave-sen-exp - stands for average seniority and experiences*
- g- Ave-ev-cont - stands for average evaluator's contribution*
- h- Ave-gr-int - stands for average group interaction*
- i- Class - refers to the class a students is currently in*
- j- Major – refers to the major of the student*

#### *2- dependent variable*

*k- Ave-kn-tran - stands for average knowledge transfer*

### 6.5.5.1 – Analysis and Measurement

*Note: In the following regression analysis, the transfer of knowledge is the dependent variable and all other variables are independent.*

1. The effect of the member’s seniority & experiences, class, evaluator’s contribution, and the length of time of the acquired prior knowledge on the transfer of knowledge within groups.

**(Seniority & experiences + Class+ Evaluator’s contribution + time)**

**Knowledge transfer**

#### Variables Entered/Removed(b)

Model	Variables entered	Variables removed	Method
1	Ave-sen-exp, Class, Ave-ev-cont, ReLtime(a)		Enter

a All requested variables entered.b Dependent Variable: Ave-kn-tran

#### Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.601(a)	.361	.332	.59096

a Predictors: (Constant), Ave-sen-exp, Class, Ave-ev-cont, ReLtime

#### ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	17.547	4	4.387	<b>12.562</b>	<b>.000(a)</b>
	Residual	31.081	89	.349		
	Total	48.629	93			

a Predictors: (Constant), Ave-sen-exp, Class, Ave-ev-cont, ReLtime

b Dependent Variable: Ave-kn-tran

**Coefficients(a)**

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.642	.518		5.100	.000
	Class	.051	.131	.041	.393	.695
	ReLtime	.130	.090	.161	1.449	.151
	Ave-ev-cont	.339	.079	.404	4.273	.000
	Ave-sen-exp	.129	.058	.198	2.212	.030

a Dependent Variable: Ave-kn-tran

**Discussion:**

**Analysis:** In the regression model R2, value is .33, indicating that 33 percent of the variation in the knowledge transfer is explained by the variation in the four independent variables (class, time, seniority/experiences, and evaluator’s contribution). Evaluator’s contribution has a greater effect on the transfer of knowledge (sig : .000) within the groups. Seniority/experiences has the second greatest effect (sig: .03), followed by time (sig: .151, and the least is class (sig: .695).

**Measurement:** This analysis demonstrates the vital role of the evaluator on the comments and discussions of the group members. He/she gave incentives and directions to the members resulting in more transfer of knowledge among them. The seniority and experiences of the groups is also significant as a factor which increases the transfer of knowledge in groups. The class and the time have little effect on knowledge transfer in comparison to the other two independent variables. This means that regardless of the class and the number of years spent in the class, the evaluator interference raises the member’s contribution by releasing more of their know-how, expertise, and experiences than the other factors.

**Assumption satisfaction/dissatisfaction**

The results of this analysis satisfy assumption 7 and 8 **(A7 & A8)**. The evaluator contribution is vital for the increase of knowledge transfer within groups. In this analysis,



even though the evaluator contribution is considered with other independent variables, nonetheless, the results demonstrated its effect on the transfer of knowledge.

2 - The effect of the member’s major and seniority and experiences on the transfer of knowledge within groups.

(Major + seniority and experiences > < knowledge transfer)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.342(a)	.117	.099	.70611

a Predictors: (Constant), Ave-sen-exp, Majorless1, Majorless2

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.519	3	3.173	6.364	.000(a)
	Residual	71.798	144	.499		
	Total	81.316	147			

a Predictors: (Constant), Ave-sen-exp, Majorless1, Majorless2

b Dependent Variable: Ave-kn-tran

Coefficients (a)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.492	.340		13.214	.000
	Majorless1	-.288	.214	-.156	-1.347	.480
	Majorless2	-.497	.263	-.219	-1.887	.361
	Ave-sen-exp	.206	.051	.316	4.012	.000

a Dependent Variable: Ave-kn-tran

Discussion:

**Analysis:** In the regression model R2 value is .099, indicating that 10 percent of the variation in the knowledge transfer is explained by the variation in the independent variables (seniority/experiences and Major). Seniority/Experiences has a greater effect

(sig: .000) on the transfer of knowledge within the groups. The major practically has no effect on the transfer of knowledge (sig: .361 & 480).

**Measurement:** This demonstrates that the seniority and experiences of the members increases the transfer of knowledge within groups regardless of their major. Senior students who have prior general experiences influence the transfer of knowledge in groups through the release of their know-how.

**Assumption satisfaction/dissatisfaction**

Assumption 2 (A2) is tested in this analysis. The analysis shows that this assumption is partially satisfied as the major has very minimal contribution on the transfer of knowledge. Seniority and experiences have practically the main effect on the transfer of knowledge when it is combined with the major. The results here clarify that the seniority and the general knowledge of the students is much more important than his/her major. This can be explained by the context of the term projects developed by the students which do not necessarily have direct relationships with their major and rely more on the member’s know-how and expertise.

**3 - The effects of the member’s interactions, seniority and experiences, and prior knowledge on the transfer of knowledge within groups:**  
**(group interaction + seniority & experiences + prior knowledge > < knowledge transfer)**

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.489(a)	.239	.223	.64847

a Predictors: (Constant), Ave-prior-kn, Ave-gr-int, Ave-sen-exp

**ANOVA(b)**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.639	3	6.213	14.774	.000(a)
	Residual	59.293	141	.421		
	Total	77.931	144			

a Predictors: (Constant), Ave-prior-kn, Ave-gr-int, Ave-sen-exp  
 b Dependent Variable: Ave-kn-tran

**Coefficients(a)**

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.131	.334		9.360	.000
	Ave-sen-exp	.113	.051	.175	2.203	.029
	Ave-gr-int	.149	.052	.226	2.858	.005
	Ave-prior-kn	.527	.112	.348	4.692	.000

a Dependent Variable: Ave-kn-tran

**Discussion:**

**Analysis:** In the regression model, R2 value is .223, indicating that 22 percent of the variation in the knowledge transfer is explained by the variation in the three independent variables (seniority/experiences, prior knowledge, and group interaction). Prior knowledge has a greatest effect (sig: .000) on the transfer of knowledge within the groups. Group interaction is the second (sig: .005), and seniority/experiences is the third important (sig: .29).

**Measurement:** This analysis demonstrates that seniority and experiences are a significant factor affecting transfer of knowledge within groups. However, if taken with group interactions and prior knowledge, then its effects decrease with an increase in interaction among the members and with members with high prior knowledge on key topics related to the context of work. The prior knowledge of the members on key topics directly related to the context of their term project is a factor which increases the interaction among the members as a result of increase in the release of their know-how. Those with less knowledge in the group are affected by this release and consequently engage more and release more of their own know-how.

**Assumption satisfaction/dissatisfaction**

Assumption 2 (A2) is tested here. It is tested indirectly. H2 argues that member’s released knowledge allows others in the group to learn about their ways of thinking and analysis.



This could only be a result of the member’s interactions, seniority/experiences, and prior knowledge. A2 is satisfied by these results.

**4 - The effects of the prior knowledge and seniority & experiences on the transfer of knowledge within groups**  
**(Prior knowledge + seniority & experiences > < knowledge transfer)**

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.442(a)	.195	.184	.66464

a Predictors: (Constant), Ave-prior-kn, Ave-sen-exp

**ANOVA(b)**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.203	2	7.601	17.208	.000(a)
	Residual	62.728	142	.442		
	Total	77.931	144			

a Predictors: (Constant), Ave-prior-kn, Ave-sen-exp

b Dependent Variable: Ave-kn-tran

**Coefficients (a)**

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.570	.305		11.722	.000
	Ave-sen-exp	.167	.049	.259	3.417	.001
	Ave-prior-knkn	.503	.115	.331	4.376	.000

a Dependent Variable: Ave-kn-tran

**Discussion:**

**Analysis:** In the regression model, R2 value is .184, indicating that 18 percent of the variation in the knowledge transfer is explained by the variation in the two independent variables (seniority/experiences, and prior knowledge). Prior knowledge has a greater effect (sig: .000) on the transfer of knowledge within the groups. Group interaction is the

second effect (sig: .001). The results in this analysis highlight the very close effect of both independent variables on the transfer of knowledge within groups.

**Measurement:** This analysis demonstrates that both independent variables (prior knowledge and seniority and experience) have a major effect on the transfer of knowledge within groups but prior knowledge of related topics on the context of work creates slightly more opportunities for knowledge release and transfer than seniority and experiences. Compared to other combinations of independent variables, the combination seniority/experience and prior knowledge are both significant in the transfer of knowledge. Consequently, although the results here could be interpreted as significantly affecting knowledge transfer within groups, I strongly believe that this increase of transfer of member’s knowledge due to this combination can be seen more at the later stages of the term project development and not at earlier stages.

**Assumption satisfaction/dissatisfaction**

Assumption 4 and 5 (A4 & A5) are being tested here. The results demonstrated that these assumptions are valid, as the results of the regression analysis of both show a good rating. Also indirectly, A1 is being verified to be true here as the transfer of knowledge always relies on the know-how of the individuals.

**5 - The effects of group interaction on the transfer of knowledge within groups**  
**(group interaction > < knowledge transfer)**

**Variables Entered/Removed(b)**

Model	Variables Entered	Variables Removed	Method
1	Ave-gr-int(a)	.	Enter

- a All requested variables entered.
- b Dependent Variable: Ave-kn-tran

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
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1	.295(a)	.087	.081	.71306
---	---------	------	------	--------

a Predictors: (Constant), Ave-gr-int

**ANOVA(b)**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.081	1	7.081	<b>13.927</b>	<b>.000(a)</b>
	Residual	74.235	146	.508		
	Total	81.316	147			

a Predictors: (Constant), Ave-gr-int

b Dependent Variable: Ave-kn-tran

**Coefficients(a)**

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.378	.249		17.604	.000
	Ave-gr-int	.196	.053	.295	<b>3.732</b>	<b>.000</b>

a Dependent Variable: Ave-kn-tran

**Discussion:**

**Analysis:** In the regression model, R2 value is .081, indicating that 8 percent of the variation in the knowledge transfer is explained by the variation in the independent variable. Group interaction was significant at sig: 000. This means that more interaction within the groups had resulted in an increase of the transfer of knowledge.

**Measurement:** This analysis shows that group interaction alone does not significantly increase the transfer of knowledge within groups in this research. The reason could well be a consequence of the culture in Lebanon which does not appreciate group work. It is an individualistic society wherein an individual strives to raise his/her social status (Le Moi, in French). This fact influences group work in general and in this research it was obvious that the students interacted and appreciated group work only as a result of competing in gaining the attention of the evaluator on their individual contribution. There appear to be other factors which should be present to trigger the members’ incentives to cooperate; hence the need for more group interaction to identify considerable increase in



the transfer of knowledge within groups and this was noticeable only after the evaluator started reading and commenting on the group’s work as well as individual work.

**Assumption satisfaction/dissatisfaction**

Assumption 1 (AI) is being indirectly tested here. To prove the validity of this assumption, high levels of interaction among the members are required. The results prove this claim.

**6 - The effects of seniority & experiences on the transfer of knowledge within groups (Seniority & experiences > < knowledge transfer)**

**Variables Entered/Removed(b)**

Model	Variables Entered	Variables Removed	Method
1	Ave-sen-exp(a)	.	Enter

- a All requested variables entered.
- b Dependent Variable: Ave-kn-tran

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.309(a)	.095	.089	.70989

- a Predictors: (Constant), Ave-sen-exp

**ANOVA(b)**

Mode		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.741	1	7.741	<b>15.362</b>	<b>.000(a)</b>
	Residual	73.575	146	.504		
	Total	81.316	147			

- a Predictors: (Constant), Ave-sen-exp
- b Dependent Variable: Ave-kn-tran

**Coefficients(a)**

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	4.227	.275		15.372	.000
Ave-sen-exp	.201	.051	.309	<b>3.919</b>	<b>.000</b>

a Dependent Variable: Ave-kn-tran

**Discussion:**

**Analysis:** In the regression model, R2 value is .089, indicating that 9 percent of the variation in the knowledge transfer is explained by the independent variable (seniority/experiences). The coefficient (a) table shows a sig: 000 which explains that seniority/experiences have an effect on the transfer of knowledge within groups.

**Measurement:** This analysis implies that seniority/experiences alone are not enough for major increase in knowledge transformation within groups. This is mainly due to the limitations in the knowledge release by individuals if there is no incentive. They may well leave others to do the work, and not effectively contribute to the development of the term project. Previous analysis have shown that when combined with prior knowledge and evaluator contribution, seniority/experiences increase in the sense that more valuable release of know-how was noted.

**Assumption satisfaction/dissatisfaction**

Assumption 3 (A3) is being tested here. The results support the validity of the assumption as the results show that seniority/experiences influence the transfer of knowledge within groups. Assumption 1 (A1) is also verified to be true.

**7 - The effects of the evaluator’s contribution on the transfer of knowledge within groups**

**(evaluator’s contribution > < knowledge transfer)**

Variables Entered/Removed(b)			
Model	Variables Entered	Variables Removed	Method

1	Ave-ev-cont(a)	.	Enter
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- a All requested variables entered.
- b Dependent Variable: Ave-kn-tran

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.520(a)	.271	.266	.63738

- a Predictors: (Constant), Ave-ev-cont

ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	22.004	1	22.004	<b>54.163</b>	<b>.000(a)</b>
	Residual	59.313	146	.406		
	Total	81.316	147			

- a Predictors: (Constant), Ave-ev-cont
- b Dependent Variable: Ave-kn-tra

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.136	.296		10.598	.000
	Ave-ev-cont	.425	.058	.520	<b>7.360</b>	<b>.000</b>

- a Dependent Variable: Ave-kn-tran

Discussion:

**Analysis:** In the regression model, R2 value is .266, indicating that 27 percent of the variation in knowledge transfer is explained by the variation in the independent variable (evaluator’s contribution). This independent variable showed a sig: .000 which explains the major effect of the evaluator’s contribution on the transfer of knowledge within groups.

**Measurement:** This analysis implies that the contribution of the evaluator on the group work is vital for the transfer of knowledge within groups. The regression analysis’s results have shown that, with the exception of the major, all independent variables



indicated an increase of their percentages of variation as a result of including the evaluator’s contribution. This can easily be related, again, to the Lebanese culture where individuals mainly show more involvement in their work if they are watched by their supervisors. It is likely that they were promised promotions or bonuses, and were in fear of loosing face or their jobs. In the research, this is demonstrated by an increase of knowledge release and transfer whenever the evaluator was included as a factor among the independent variables

**Assumption satisfaction/dissatisfaction**

Assumptions 7 and 8 (A7 & A8) are being tested here. The analysis demonstrates that both assumptions are true. The evaluator’s contribution is vital for the transfer of knowledge within groups.

**8 - The effects of evaluator’s contribution and group interaction on transfer of knowledge within groups**

**(Evaluator’s contribution + group interaction > < knowledge transfer)**

**Variables Entered/Removed (b)**

Model	Variables Entered	Variables Removed	Method
1	Ave-giecon(a)	.	Enter

- a All requested variables entered.
- b Dependent Variable: Ave-kn-tran

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.505(a)	.255	.250	.64415

- a Predictors: (Constant), Ave-gi-econ

**ANOVA(b)**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20.737	1	20.737	49.978	.000(a)
	Residual	60.579	146	.415		
	Total	81.316	147			

a Predictors: (Constant), Ave-gi-econ  
 b Dependent Variable: Ave-kn-tran

Coefficients(a)

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
1 (Constant)	3.004	.326		9.211	.000
Ave-gi-econ	.472	.067	.505	7.070	.000

a Dependent Variable: Ave-kn-tran

Discussion:

**Analysis:** In the regression model, R2 value is .25, indicating that 25 percent of the variation in the knowledge transfer is explained by the variation in the two independent variables (evaluator’s contribution, and group interaction). Group interaction and evaluator’s contribution have a sig: .000 which explains that together they significantly increase the transfer of knowledge within groups.

**Measurements:** The analysis explains that the evaluator’s contribution has a major effect not only on the transfer of knowledge but also on group interaction since when comparing the results of this analysis with the one in ‘group interaction = transfer knowledge’ we notice that group interaction is more significant in this case. This explains that the members interact more as a result of increase in evaluator’s contribution and hence increase in the knowledge transferred within groups, as explained earlier.

Assumption satisfaction/dissatisfaction

Assumptions 6, 7, and 8 (A6, A7, A8) are being tested here. The analysis demonstrates that these assumptions are true. A6 is true as the nurture of knowledge by the members is a process which relies heavily on interaction among the members. The results show that group interaction is significant. A7 and A8 are also verified to be true as the results here show that the contribution of the evaluator is significant for the transfer of knowledge.

9 - The effects of the Major on the transfer of knowledge within groups.

(Major > < knowledge transfer )

Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	Majorless2, Majorless1(a)	.	Enter

- a All requested variables entered.  
b Dependent Variable: Ave-kn-tran

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.136(a)	.018	.005	.74196

- a Predictors: (Constant), Majorless2, Majorless1

ANOVA(b)

Mode		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.493	2	.746	1.356	.261(a)
	Residual	79.823	145	.551		
	Total	81.316	147			

- a Predictors: (Constant), Majorless2, Majorless1  
b Dependent Variable: Ave-kn-tran

Coefficients(a)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	5.583	.214		26.068	.000
	Majorless1	-.313	.225	-.170	-1.390	.167
	Majorless2	-.448	.277	-.198	-1.622	.107

- a Dependent Variable: Ave-kn-tran

Discussion:

**Analysis and Measurement:** In the regression model, R2 value is .005, indicating a very small percentage of variation in knowledge transfer which indicates close to no effect of



the members' Major on knowledge transfer. This result is in accordance with previous results which showed negligible effect of the major to the knowledge transfer even when it was combined with other independent variables. If compared with the class results below, we notice that the class is more effective with transferring knowledge among members. This can be explained by the fact that members within the groups had high regard for those in higher classes.

### Assumption satisfaction/dissatisfaction

No assumption is being tested here. The results of the analysis in this theses demonstrated that the Major has no effect on the transfer of knowledge within the groups.

### 10 - The effect of class on the transfer of knowledge within groups.

(class > < knowledge transfer )

#### Variables Entered/Removed(b)

Model	Variables Entered	Variables Removed	Method
1	Class(a)	.	Enter

a All requested variables entered.

b Dependent Variable: Ave-kn-tran

#### Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.349(a)	.122	.116	.69934

a Predictors: (Constant), Class

#### ANOVA(b)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.912	1	9.912	20.267	.000(a)
	Residual	71.404	146	.489		
	Total	81.316	147			

a Predictors: (Constant), Class

b Dependent Variable: Ave-kn-tran

#### Coefficients(a)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	4.217	.243		17.350	.000
Class	.383	.085	.349	4.502	.000

a Dependent Variable: Ave-kn-tran

**Discussion:**

**Analysis and Measurement:** In the regression model, R2 value is .116, indicating that 12 percent of the variation in knowledge transfer is explained by the variation in this independent variable. The coefficient (a) Table shows that this independent variable has some effects on the transfer of knowledge within groups.

**Assumption satisfaction/dissatisfaction**

No assumption is being tested here. Class has an indirect effect on the transfer of knowledge within the groups as know-how and expertise might have been accumulated during the member’s years at the university which consequently affects the transfer of knowledge within the groups.

**11 - The effects of Major and class on the transfer of knowledge within groups  
(Major, class > < knowledge transfer )**

**Variables Entered/Removed(b)**

Model	Variables Entered	Variables Removed	Method
1	Class, Majorless2, Majorless1 (a)		Enter

a All requested variables entered.  
b Dependent Variable: Ave-kn-tran

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.364(a)	.132	.114	.70000

a Predictors: (Constant), Class, Majorless2, Majorless1

**ANOVA(b)**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	10.757	3	3.586	7.318	.000(a)
	Residual	70.560	144	.490		
	Total	81.316	147			

a Predictors: (Constant), Class, Majorless2, Majorless1

b Dependent Variable: Ave-kn-tran

**Coefficients(a)**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.349	.348		12.482	.000
	Majorless1	-.108	.217	-.059	-.498	.619
	Majorless2	-.311	.263	-.137	-1.185	.238
	Class	.380	.087	.346	4.348	.000

a Dependent Variable: Ave-kn-tran

**Discussion:**

**Analysis:** In the regression model, R2 value is .114, indicating that 11 percent of the variation in knowledge transfer is explained by the variation in the two independent variables (Major and class). The coefficient (a) Table shows that when taken together, these independent variables have little effect on the transfer of knowledge. The results here demonstrate that the transfer of knowledge is affected by the class rather than the Major.

**Measurement:** Again this analysis shows the minor effects the Major and class of the members within groups has on the transfer of knowledge when considered with other variables such as seniority/experiences and prior knowledge.



**12 - The effects of prior knowledge, Major, class, and seniority & experiences on the transfer of knowledge within groups.**

**(prior knowledge + seniority & experiences + major + class > < knowledge transfer)**

**Variables Entered/Removed(b)**

Model	Variables Entered	Variables Removed	Method
1	Ave-prior-kn, Ave-sen-exp, Major, Class(a)	.	Enter

a All requested variables entered.

b Dependent Variable: Ave-kn-tran

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.489(a)	.239	.217	.65080

a Predictors: (Constant), Ave-prior-kn, Ave-sen-exp, Major, Class

**ANOVA(b)**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.636	4	4.659	11.000	.000(a)
	Residual	59.295	140	.424		
	Total	77.931	144			

a Predictors: (Constant), Ave-prior-kn, Ave-sen-exp, Major, Class

b Dependent Variable: Ave-kn-tran

**Coefficients(a)**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	3.121	.340		9.169	.000
	Major	-.038	.051	-.057	-.744	.458
	Class	.251	.089	.229	2.816	.006
	Ave-sen-exp	.168	.048	.260	3.507	.001
	Ave-prior-kn	.384	.125	.253	3.067	.003

a Dependent Variable: Ave-kn-tran

**Discussion:**

**Analysis:** In the regression model, R2 value is .217, indicating that 21 percent of variation in knowledge transfer is explained by the variation in the four independent variables. The coefficient (a) Table shows that when taken together, these independent variables have a similar effect on the transfer of knowledge with prior knowledge, seniority/experiences, and class (sig: .003, .001, .006). On the other hand, it has least effect on Major (sig: .458).

**Measurement:** As in the previous regression analysis the member’s major within groups has practically no effects on the transfer of knowledge in comparison to other variables such as seniority/experiences, prior knowledge, and class. The class in this analysis shows a good effect on the transfer of knowledge when combined with prior knowledge and seniority/experiences.

**Assumption satisfaction/dissatisfaction**

No assumption is being tested here. This analysis was conducted in order to find out whether the major and class have any effect on the transfer of knowledge. The results demonstrate that the class, with accumulated know-how over the years, has an effect, but not the Major.

**13 - The effects of prior knowledge, evaluator’s contribution, group interaction, Major, class, and seniority & experiences on the transfer of knowledge within groups.**

**(Prior knowledge + evaluator’s contribution + group interaction + seniority & experiences + major + time + class > < knowledge transfer)**

**Variables Entered/Removed(b)**

Model	Variables Entered	Variables Removed	Method
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1	Ave-gr-int, Majorless2, Class, Ave-ev-cont, Ave-sen-exp, ReLtime, Majorless1(a)	.	Enter
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- a All requested variables entered.  
b Dependent Variable: Ave-kn-tran

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.624(a)	.389	.340	.58757

- a Predictors: (Constant), Ave-gr-int, Majorless2, Class, Ave-ev-cont, Ave-sen-exp, ReLtime, Majorless1

**ANOVA(b)**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	18.938	7	2.705	7.837	.000(a)
	Residual	29.691	86	.345		
	Total	48.629	93			

- a Predictors: (Constant), Ave-gr-int, Majorless2, Class, Ave-ev-cont, Ave-sen-exp, ReLtime, Majorless1  
b Dependent Variable: Ave-kn-tran

**Coefficients(a)**

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.392	.568		4.209	.000
	Majorless1	-.015	.212	-.010	-.072	.943
	Majorless2	-.231	.255	-.121	-.904	.369
	Ave-sen-exp	.074	.074	.113	1.001	.319
	Class	.102	.133	.081	.769	.444
	Ave-ev-cont	.320	.082	.381	3.911	.000
	ReLtime	.065	.100	.080	.648	.519
	Ave-gr-int	.146	.095	.179	1.540	.127

- a Dependent Variable: Ave-kn-tran

**Discussion:**



**Analysis:** In the regression model,  $R^2$  value is .340, indicating that 34 percent of the variation in knowledge transfer is explained by the variation in all of the independent variables. The coefficient (a) Table shows, again, that the contribution of the evaluator is the major factor for knowledge transfer within groups. The other independent variables show less effect on knowledge transfer, with the exception of group interaction. This can be explained by a positive influence represented by an increase in group member's interaction as a result of constant evaluation and discussions by the evaluator of the member's released work. In other words, evaluator's constant evaluation of the group's work resulted in increase in interaction, hence an increase in the transfer of knowledge.

**Measurement:** The analysis shows the minor effects the Major, time spent at the university, and the class of the members has on the transfer of knowledge when considered with other variables such as evaluator contribution, seniority/experiences, and prior knowledge. Interestingly, this can be explained by the fact that the student's contribution to the term project's development increases mainly as a result of the evaluator contribution. The evaluator's involvement during the term project development affects all other independent variables on the transfer of more knowledge as a result of increase in interaction among the members where the members past expertise and know-how play decisive role as knowledge enablers.

#### **Assumption satisfaction/dissatisfaction**

Assumption 1 (A1) is being tested here. The results show that the progressive building of a shared document, wherein the process knowledge can be captured, is possible as a result of engaging all the independent variables except the Major. All other assumptions are tested here as well. The results prove that all assumptions are true except A2 as the results show that the major has no effect on the transfer of knowledge when combined with the seniority of the members.

**Note:** A different type of analysis, namely, the Independent "t" test was administered on the questionnaire's results to identify the differences between the major and the sub-dimension of knowledge transfer, group interaction, evaluator's contribution, and

seniority/experiences in order to make sure that the results of the regression analysis in regards to the Major were true. The results of the “t” test were in accordance with the regression analysis results and showed minimal effect on knowledge transfer by the Major if taken alone or in combination with the other independent variables.

### **6.5.6 – Justification of the results based on Sarker’s 4C platform**

Sarker’s (4 Cs) framework was adopted in this research to study the knowledge transfer among the distributed groups in the experiment. Its 4 factors (capability, credibility, extent of communication, and culture) were used as the basis of this study and tested to find out whether they play major roles on the externalization and measurement of knowledge among the students. The justifications of the results are presented below and they mainly address the extent of the transfer of knowledge. Nonetheless, the other aspects of externalization (articulated, creation, sharing, and retention) are also considered as parts of the transfer of knowledge success. Knowledge to be transferred has to be articulated and or created, shared and later retained. Only then is its transfer successful.

#### **6.5.6.1- Capability**

Capability is a factor affected by 5 elements; namely, class, major, prior knowledge, seniority/experiences, and evaluator contribution. These elements, or any combination of them, affect the externalization of knowledge among the group members. The results of the analysis presented earlier show that the students assumed that their peers are capable if:

- The evaluator’s contribution to individual’s work, presented as comments and appraisal of their work as well as assessment was positive
- The members had prior knowledge
- The members were seniors and have past general experiences.

In regard to the transfer of knowledge (questions 1 – 7 in the questionnaire, students' answers were mostly strongly positive regarding the effect of these three factors on their transfer of knowledge. This demonstrates that the students relied on their peers who have had evaluator's appraisal and whose partial evaluator's marks were high. This resulted in an increase of their contribution in the form of more knowledge creation and release of their opinions and ideas.

The results showed the significant effect of the evaluator's contribution on the transfer and sharing of the members' opinions and ideas, and had direct effect on the other independent variables. It was clear from the analysis that group interaction was high when it was taken in conjunction with the evaluator's contribution. In other words, the evaluator's comments triggered more contribution by the members, more discussions, and consequently more nurture and retention of the created and released opinions and ideas.

Based on the results, it is clear that members have considered others in their groups to be capable of creating and transferring opinions and ideas if they had profound prior knowledge and are seniors with previous experience in problems solving and/or similar topics. Analysis demonstrated that members were encouraged to contribute more in creating and releasing more of their own opinion and ideas based on the prior knowledge, seniority, and past experiences of their peers. They also engaged in more constructive discussions towards the development of their term projects as a result. The tabulation-analysis showed an increased in knowledge transfer in groups where there were members with high prior knowledge. The released know-how acted as a trigger for other members to engage in different activities. The analysis showed similar results for seniority/experiences as well. This could also be attributed to awakening dormant knowledge in those members.

Noticeably, the results demonstrated that the Major and/or the class were not considered by the students as factors identifying capable peers. This might be due to the topics of the term projects selected which does not necessarily conform to the Major or the class of



the students. The analysis, on the other hand, showed a slightly higher effect than the Major on the capability of the members, mainly due to the experience accumulated by the students during their years of study.

#### **6.5.6.2 Credibility**

A credible member is someone whom his/her peers consider reliable and trustworthy based on the quality of his/her opinions and ideas and contribution towards the term project development. The quantity of knowledge released by members was thought to be a factor which might increase his/her credibility status with others. Another factor for credibility was the evaluator's positive comments on the member's contribution in general, and on his/her released opinions and ideas. The initial grades he/she received from the evaluator could also play an important role in his/her reliability among his/her peers. These two factors raise the awareness of his/her peers as a credible contributor to the development process.

The analysis also demonstrated that these two factors do play a vital role in the acceptance of credible members within groups. These two factors are highly related, as knowledge released by the members is considered to be of value to others in the group only after it is assessed by the evaluator. The regression analysis showed the major effect of the evaluator's involvement in assessing a member's contribution. Major increase in the transfer of knowledge within groups was noticed in situations where there was valuable and positive evaluator's assessment as well as high marks for a member in the group.

*Note: As an evaluator, I have noticed major increase in input from the student's immediately after my assessment of individual's work. The other evaluator made similar observations.*

Finally, the analysis demonstrated that the release of opinions and ideas, and contribution of members within such groups increased considerably in situations such as the ones described above. This resulted in an increase in knowledge transfer.

**6.5.6.3- *Extent of communication***

The transfer of knowledge is a result of extensive interaction between individuals, be it in face-to-face or in remote groups or communities, while engaged in development of a product or service. Individuals have to communicate, exchange ideas and opinions, and hold discussions for the proper externalization of knowledge. Consequently, the success in transferring knowledge within groups is highly dependent on the level of interaction they engage in. Consequently, success in knowledge creation, sharing, filtration, and nurture as well as member's awareness is possible with the availability of communication, cooperation, and interaction channels. These facilitate individuals' release and creation/formation of ideas and opinions vital to the success of knowledge transformation, hence its externalization.

The analysis of the collected data demonstrated that where the members interacted constantly there was an increase in the release and creation of opinions and ideas and consequently more knowledge transfer. The core of this increase was the exchange of messages and extensive dialogue among the members as vital for the formation of opinions and ideas. The regression analysis showed that group interaction is an integral factor affecting the transfer of knowledge. It was considered by itself in some instances in the regression analysis, and in some other instances was combined with other independent variables. In both cases, the analysis showed that knowledge transfer increases with a boost in interaction. On the other hand, the Cross Tabulation Table results showed that group interaction was higher in mixed groups than in those with only business students. This could be due to the variety of know-how in mixed groups as well as the diverse opinions and ideas in such groups which have contributed to increased interaction, resulting in an increase in the overall transfer of knowledge.

These are expected result as most literary research showed that it is hard, if not impossible, to successfully externalize knowledge without a proper platform for interaction and without proper technological support. In face-to-face interactions, meetings are essential for any knowledge exchange, as it is a key for ideas formation, articulation, sharing and release. Amongst distributed individuals, the same-time presence is not a necessity but the technology to bring individuals' opinions and ideas closer is vital. Once such a platform is available for the support of groups and communities, then knowledge transfer becomes possible.

**6.5.6.4 Culture**

Culture was not addressed as extensively as the three other factors of the 4 Cs platform because of the nature of the students involved. At the start of the term, as in all other semesters at the university, interaction among group members and their engagement in group work was low as a result of individualism in the Lebanese culture. Students always preferred to carry out their homework, projects and even tutorial activities individually as they could not easily foresee the benefits of working together as a means for better results. Success stories in the Lebanese society in particular and in the region in general are mainly individualistic and these stories have had a major effect on the society. Such cultures cultivate and appraise individual work much more than group work. Only recently have businesses in Lebanon started to accept that innovation, decision making, engineering, re-engineering, and such, are much more productive in groups than with individuals. It was clear to the author, having taught in Lebanon that the students prefer to do their term projects, assignments, home works, and quizzes individually more than in groups.

**6.5.7 Chapter's Conclusion**

This chapter's results and findings demonstrated that there are integral elements which should be present for an effective tacit knowledge externalization and measurement among geographically distributed individuals. Firstly, tacit knowledge must be categorized as its externalization and measurement in its entirety is complex and cannot yield expected results. Secondly, choice of technology is critical as a tool for cooperation and communication between individuals. Thirdly, measurement of the externalization of



the categorized types should be based on an existing or developed platform which offers a means for the justification of the results. Based on the adopted platform in this research, it is clear that capability, credibility, and extent of communication played an integral role in the experiment's findings.

## **CHAPTER SEVEN– Conclusion and Future Work**

### **7.1 INTRODUCTION**

This dissertation makes a number of significant and original contributions in the area of tacit knowledge externalization (creation, sharing, transformation, nurture, and retention) among geographically distributed individuals, as well as the measurement of such knowledge. These contributions can be summarized as the categorization of tacit knowledge into types, selection of a tool and a measurement process, choice of a method for the externalization of the categorized types, and measurement of the externalized types. Some theoretical proposals are also suggested in the research (chapter 4); namely, the KM Cycle for distributed individuals, the Reflection-Articulation-Interpretation model, and the Spiral for Knowledge Transformation in remote settings, as opposed to Nonaka's (1995) face-to-face spiral. These theoretical contributions are essential parts of the research as they form the basis upon which remote cooperation is based, and they pave the way for those who are working on the externalization of tacit knowledge in distributed settings to identify features which are drastically different from face-to-face settings.

The dissertation demonstrated, in chapter 5, that current research in this field lacks a methodology which could provide support for distributed individuals, as cooperative work among remotely located individuals is still an area which has no predefined standards, rules, and procedures. In addition, technological support for such interaction is diverse and businesses resort to available technologies which are not appropriate for distributed individuals. Globalization was sudden and expansion in trade rushed organizations to use whatever means available to interact based on available face-to-face methods, techniques, tools, and systems. These were discussed in the thesis and demonstrated to be fairly inefficient in providing the required level of cooperation and collaboration.

These contributions propose a possible solution to the problems associated with tacit knowledge externalization among dispersed individuals. The adoption of the proposed solution should allow researchers to successfully externalize and measure their categorized types. Chapter 2 of this dissertation introduced two hypotheses and a set of assumptions. The methodology is developed to provide a practical and demonstrated solution to the hypotheses based on the assumptions. All assumptions were used in the process of demonstrating the reliability and validity of the hypotheses.

The method used for the demonstration of these contributions was accomplished through an experiment (chapter 6) which was conducted on small groups of university students during the development of their term projects. A wide range of future research might be identified based on these contributions. Future research might look at categorizing different types of tacit knowledge and draw a generalized process similar to that followed in the dissertation.

## **7.2 Categorization of Tacit Knowledge**

Tacit knowledge in the literature is addressed poorly and researchers working on it do not catalogue it into types, but address it in its entirety. The dissertation argued that a major part of the persistent problems in tacit knowledge externalization is the attempts to manage this knowledge assuming that it is an entity which can be handled similarly to information. The dissertation demonstrated that this knowledge has to be analyzed and those parts of it which are easier to externalize have to be identified. Chapter 3 introduced the categorization as the first and essential step in the externalization and measurement of tacit knowledge. This step suggests that tacit knowledge should be classified or categorized into types/kinds as this knowledge cannot be externalized in its entirety. Different researchers can categorize different types depending on many factors, such as, needs, environment, groups, communities, and such. An essential aspect of this is the establishment of correspondences between the categorized types and tacit knowledge. Without the latter, externalization is not effective. This step also suggests that



without establishing this correspondence, it is very highly likely that externalization is not effective.

The novelty in the proposed categorization of tacit knowledge is the lack of literature in this area of research. The topic is still debatable among researchers in the field of KM and knowledge transformation. Not many researchers venture to address this, mainly due to the lack of a proper definition of knowledge as well as the need for conceptual, experimental and technological support for KM, and knowledge externalization processes. Few observations and conclusions can be drawn from the dissertation in terms of categorization of tacit knowledge and its externalization and measurement.

### **7.3 Selecting a tool and a measurement process**

Chapter 3 suggests that both a tool and a measurement process should be available for the use and measurement of the categorized types. After categorizing tacit knowledge into types, the process of finding the right tool for the process of externalization is imperative so it can be measured. The dissertation demonstrated that the available tools lack integration; hence they are not suitable for the research because of its specificity and the distributed nature of the individuals. In chapter 5, the dissertation introduced an example tool which was specifically developed as an integrated tool to help small group members in the externalization of the categorized types. Its development was based on the arguments presented in the dissertation in regard to the diversity of the available tools in supporting the processes of the KM processes and the externalization of knowledge. The thesis argued that the use of different tools, or combination of tools, during the execution of the processes is problematic, inefficient, and hinders the proper externalization of the categorized parts. The introduced tool was developed consequently and the thesis argues that it might be used with other categorized types.

## **7.4 Choice of a method for Knowledge Externalization**

The choice of a method for the externalization of the categorized types is the third step of the methodology introduced in chapter 3 and is emphasized in subsequent chapters. This step suggests a method through which the externalization of the categorized types using the selected or developed tool can be accomplished. Different methods can be used depending on the size of the groups and the categorized types as well as the effectiveness of the selected/developed tool.

The thesis used a questionnaire as one such method. The questionnaire was developed keeping in mind the specificity of the categorized types in addressing the students' use of the tool during the building of their term projects. The methodology does include a supportive method such as an interview because of the big number of participants and their assumed prior knowledge. The participants finished their assignment working with the developed tool and the questionnaire introduced questions which mainly focused on the transfer of knowledge between them. The idea behind developing the questionnaire with this focus is because the success in successful transformation of knowledge is a result of its proper capture, sharing and consequential retention. The dissertation acknowledges the need for other methods to collect data in order to measure other categorized types. Businesses should not rely solely on questionnaires and they should resort to a combination of other methods depending on the size of the group as well as on the tool(s) used for interaction and communication. The dissertation argued that an integrated tool is essential to the success of externalization as it makes the exchange of categorized types easier and more effective. Hence, the choice of the method is also dependent on the tool used and the dissertation argues that fewer methods are required with an integrated tool.

## **7.5 Measurement of the externalization of the categorized type**

The measurement of the externalization of the categorized types is accomplished through the analysis of the data collected from the questionnaire. The questionnaire focused on

collecting data relevant to the measurement of the dependent entities such as knowledge transfer, knowledge sharing, knowledge retention. It also considered independent entities such as seniority, class, prior knowledge, evaluator, and qualifications. The extent to which the independent entities affect the transfer of knowledge was the basis of the measurement. The dissertation used different well-developed techniques for the measurement, as shown in chapter 6. All data collected were used in the analysis and the different techniques demonstrated very close results in terms of the extent of the transformation of opinions and ideas in relation to the independent entities. These findings were integral to the reliability and validity of the two hypotheses introduced in chapter 2. The results also demonstrated that the eight assumptions can be used as a basis for future results in similar experiments.

### **7.6 Limitations and implications of the research**

A number of limitations can be identified in the dissertation. These limitations can be listed as those related to the experiments and those related to the categorization of only two types of tacit knowledge. On the one hand, the experiment was conducted in a non-profit organization, namely, the university, and the participants were from the same culture. The latter was not considered to be a factor affecting the transformation of knowledge. On the other hand, the tool used was developed specifically for the purpose of the dissertation and is expected to be altered if it is to be adopted in organizations. It is assumed that some researchers will find it limited in other aspects as well. Finally, the dissertation argued that a major limitation is the lack of similar research in its context. Most prior research relied heavily on the use of concepts, tools, and techniques which are more suitable to face-to-face cooperation. Accordingly, the dissertation lacks a comparative analysis with any other similar research conducted previously.

Given these limitations, the dissertation in its originality makes a number of interesting contributions, and builds on the literature's scarce but available research on distributed cooperation, knowledge externalization, KM, and the development of distributed group support systems.



## **7.7 Future Work**

The thesis lays the platform for future research in different areas. Its originality in addressing the externalization and measurement of tacit knowledge will encourage researchers as well as businesses to adopt its methodology in their quest for better results in the field of KM.

Researchers working on the transformation of knowledge may benefit from the dissertation's introduced KM Cycle introduced in chapter 4. This cycle might be improved and developed further for business needs. More emphasis could be placed on the articulation of different categorized types of tacit knowledge. In addition, the nurture process (chapter 4) could be elaborated further in relationship with different categorized types.

Future work may also look at categorizing other types of tacit knowledge such as talents, instincts, and expertise, to name only a few, and conduct similar experiments and develop comparative studies with the findings of this research. In so doing, the new types might be tested using the developed tool or other tools and the same method. Alternatively, similar methods for measurements might be adopted. Consequently, both the dissertation's results and potential new results could be compared and possibly a generalization could be drawn.

## APPENDIX A

### Questionnaire

Major: \_\_\_\_\_

Class: Freshman   Sophomore   Junior   Senior

Group name: \_\_\_\_\_

#### Please answer the following two questions:

A) Did you have knowledge about any of the followings during the development of your term-project? (You may circle more than one)

- a- knowledge management
- b- Group Support Systems
- c- Tacit/Explicit knowledge
- d- Remote Virtual Interaction
- e- Remote virtual systems

B) If you answered yes to the previous question, then how long have you had the knowledge for?

- a- More than 2 years
- b- Two years
- c- Between 1 and 2 years
- d- Less than a year

P.S:

- a- Opinions/Ideas and Tacit Knowledge are used interchangeably in the questions
- b- Released knowledge is used to mean both tacit knowledge, explicit knowledge or both

---

Thank you

#### Please circle or underline your answers to the following questions:

- 1- To what extent were your opinions/ideas affected by others' opinions/ideas in your group?  
7 (high)      6      5      4      3      2      1 (Low)
- 2- To what extent have you learnt about others' analytical skills by being exposed to their problem solving activities?  
7 (high)      6      5      4      3      2      1 (Low)
- 3- To what extent have you learnt about others' ways of thinking by being exposed to their individualistic solutions?  
7 (high)      6      5      4      3      2      1 (Low)
- 4- To what extent were your opinions/ideas affected by the explicit knowledge available in your group's memory?

- |  |          |   |   |   |   |   |         |
|--|----------|---|---|---|---|---|---------|
|  | 7 (high) | 6 | 5 | 4 | 3 | 2 | 1 (Low) |
|--|----------|---|---|---|---|---|---------|
- 5- To what extent were your opinions/ideas affected by the tacit knowledge released by members of your group?  
7 (high)      6      5      4      3      2      1 (Low)
- 6- To what extent were your opinions/ideas affected by discussions/feedback to your queries by experts in the system?  
7 (high)      6      5      4      3      2      1 (Low)
- 7- To what extent has the exchange of messages within your group influenced your opinions/ideas?  
7 (high)      6      5      4      3      2      1 (Low)
- 8- To what extent have the evaluator's comments acted as enablers for additional opinions/ideas creation in your group?  
7 (high)      6      5      4      3      2      1 (Low)
- 9- To what extent has the evaluator's constant assessment on members' released knowledge helped them come up with additional knowledge?  
7 (high)      6      5      4      3      2      1 (Low)
- 10- To what extent have the evaluator's comments on individuals work within your group reduced conflict among them?  
7 (high)      6      5      4      3      2      1 (Low)
- 11- To what extent has the availability of the evaluator's comments on individual work improved your overall contribution of knowledge?  
7 (high)      6      5      4      3      2      1 (Low)
- 12- To what extent is the nurture of opinions/ideas close to the mental idea development in face-to-face interaction?  
7 (high)      6      5      4      3      2      1 (Low)
- 13- To what extent have messaging among members in your group helped in nurturing opinions/ideas?  
7 (high)      6      5      4      3      2      1 (Low)
- 14- To what extent have the release/capture of knowledge helped in nurturing your group's opinions/ideas?  
7 (high)      6      5      4      3      2      1 (Low)
- 15- To what extent was filtration of released knowledge affected by constant exposure to the group's goals/objectives?  
7 (high)      6      5      4      3      2      1 (Low)
- 16- To what extent have the process of filtration resulted in conflict among your group members?  
7 (high)      6      5      4      3      2      1 (Low)
- 17- To what extent has the seniority of the members in your group affected the transfer of knowledge?  
7 (high)      6      5      4      3      2      1 (Low)
- 18- To what extent has personal expertise on key concepts by members affected the transfer of knowledge in your group?  
7 (high)      6      5      4      3      2      1 (Low)



## APPENDIX B

### Copyright

Copyright (c) Jamal El-Den (jamal.el-den@cdu.edu.au), All rights reserved.

Redistribution and use in source and binary forms, with or without modifications, are permitted provided that the following conditions are met:

1. Redistributions of source code is not allowed
2. Redistributions in binary (or web-server hosted) form must reproduce the above copyright notice, and the following disclaimer in the documentation and/or other materials provided with the distribution.
3. You may not use the source code for commercial use without prior permission
4. The code can be used as-is or with modification (after permission) for educational purpose

### Example of the SQL table structure used in VIPGSS

#### Table structure for table `documentdata`

```
CREATE TABLE `documentdata` (  
  `id` int(11) NOT NULL auto_increment,  
  `docid` int(11) default NULL,  
  `memberid` int(11) default NULL,  
  `dt` datetime default NULL,  
  `version` int(11) default NULL,  
  `flags` int(11) default '0',  
  `readcount` int(10) unsigned default '0',  
  PRIMARY KEY (`id`)  
) ;
```

#### Table structure for table `documentevaldata`

```
CREATE TABLE `documentevaldata` (  
  `id` int(11) NOT NULL auto_increment,  
  `docdataid` int(11) default NULL,  
  `evaltype` tinyint(3) default NULL,  
  `evaldate` datetime default NULL,  
  `grade1` double default '0',  
  `grade2` double default '0',  
  `description` text,  
  `gradeldesc` text,  
  `grade2desc` text,  
  PRIMARY KEY (`id`)  
) ;
```

#### Table structure for table `documentevalfinal`

```

CREATE TABLE `documentevalfinal` (
  `id` int(10) unsigned NOT NULL auto_increment,
  `docid` int(10) unsigned default NULL,
  `memberid` int(10) unsigned default NULL,
  `grade1` float default '0',
  `grade2` float default '0',
  PRIMARY KEY (`id`)
) COMMENT='Document final evaluation' ;

```

#### Table structure for table `documenthdr`

```

CREATE TABLE `documenthdr` (
  `id` int(11) NOT NULL auto_increment,
  `ownerid` int(10) unsigned default NULL,
  `groupid` int(10) unsigned default NULL,
  `evalid1` int(11) default NULL,
  `evalid2` int(11) default NULL,
  `readcount` int(11) default NULL,
  `generaleval1` double default NULL,
  `generaleval2` double default NULL,
  `creationdate` datetime default NULL,
  `lastreaddate` datetime default NULL,
  `flags` int(11) default NULL,
  `title` varchar(250) default NULL,
  `language` varchar(20) default NULL,
  `type` varchar(30) default NULL,
  `description` text,
  `goals` text,
  `original_filename` varchar(250) default NULL,
  `generaleval1desc` text,
  `generaleval2desc` text,
  `keywords` text,
  PRIMARY KEY (`id`),
  FULLTEXT KEY `bytitle` (`title`)
) ;

```

#### Table structure for table `groupmembers`

```

CREATE TABLE `groupmembers` (
  `id` int(11) NOT NULL auto_increment,
  `memberid` int(11) default NULL,
  `groupid` int(11) default NULL,
  `privilege` int(10) unsigned default NULL,
  PRIMARY KEY (`id`),
  UNIQUE KEY `membership` (`groupid`,`memberid`)
) ;

```

#### Table structure for table `groups`

```

CREATE TABLE `groups` (
  `id` int(11) NOT NULL auto_increment,
  `ownerid` int(11) default NULL,
  `attributes` int(10) unsigned default NULL,
  `name` varchar(200) default NULL,
  `description` tinytext,
  `createdate` datetime default NULL,
  PRIMARY KEY (`id`),
  FULLTEXT KEY `bygroup` (`name`)
) ;

```

Table structure for table `mailboxes`

```

CREATE TABLE `mailboxes` (
  `id` int(11) NOT NULL auto_increment,
  `name` varchar(200) default NULL,
  PRIMARY KEY (`id`)
) ;

```

Table structure for table `mailmessages`

```

CREATE TABLE `mailmessages` (
  `id` int(11) NOT NULL auto_increment,
  `msgowner` int(10) unsigned default NULL,
  `mailboxid` int(11) default NULL,
  `from_member` int(11) default NULL,
  `to_member` int(11) default NULL,
  `msglinkedto` int(10) unsigned default '0',
  `date` datetime default NULL,
  `status` tinyint(3) unsigned default NULL,
  `title` varchar(200) default NULL,
  `message` mediumtext,
  PRIMARY KEY (`id`)
) ;

```

Table structure for table `members`

```

CREATE TABLE `members` (
  `id` int(11) NOT NULL auto_increment,
  `privilege` int(10) unsigned default '0',
  `username` varchar(20) default NULL,
  `password` varchar(20) default NULL,
  `email` varchar(200) default NULL,
  `registerdate` datetime default NULL,
  `fname` varchar(50) default NULL,
  `lname` varchar(20) default NULL,
  `addr` tinytext,
  `city` varchar(30) default NULL,
  `country` varchar(30) default NULL,
  `phone` varchar(20) default NULL,

```



```

`knowledge` varchar(250) default NULL,
`interest` varchar(250) default NULL,
`qualification` varchar(250) default NULL,
`keywords` text,
`lastsignin` datetime default NULL,
`isonline` tinyint(1) default '0',
`preference` varchar(250) default NULL,
PRIMARY KEY (`id`),
FULLTEXT KEY `byusername` (`username`),
FULLTEXT KEY `bykeywords` (`keywords`)
) ;

```

Table structure for table `systemlog`

```

CREATE TABLE `systemlog` (
  `id` int(11) NOT NULL auto_increment,
  `groupid` int(11) default NULL,
  `memberid` int(11) default NULL,
  `docid` int(11) default NULL,
  `date` datetime default NULL,
  `activityname` varchar(30) default NULL,
  `description` varchar(250) default NULL,
  PRIMARY KEY (`id`)
) ;

```

## Code for Awareness

<?

```
/** Group was edited */
define ('AW_GRPEDIT', 1);

/** Group was deleted */
define ('AW_GRPDEL', 2);

/** Group membership was changed */
define ('AW_GRPMEMBERSHIPCHG', 7);

/** A new document was created */
define ('AW_DOCCREATE', 3);

/** A document was deleted */
define ('AW_DOCDEL', 4);

/** Document header was edited */
define ('AW_DOCEDIT', 5);

/** New document version was submitted by user
*/
define ('AW_DOCNEWVER',
6);

/** Document was retrieved for editing */
define ('AW_DOCEDITING',
14);

/** Document editing was canceled */
define ('AW_DOCCANCELEDITING', 15);

/** Document was made public or
private */
define ('AW_DOCPUBSTAT',
8);

/** Document was finalized */
define ('AW_DOCFINALIZED', 10);

/** Document was finalized */
define ('AW_DOCFINALGRADED', 13);

/** You were elected for document evaluation */
define ('AW_DOCEVALELECTION', 18);

/** You were voted out of document evaluation */
define ('AW_DOCEVALVOTEOUT', 19);
```

```

/** Document was un-finalized
*/
define ('AW_DOCUNFINALIZED', 20);

/** Document was exported to another group */
define ('AW_DOCEXPORTEd', 21);

/** Document version was graded for given user */
define ('AW_DOCVERSIONGRADED',
16);

/** A message was sent to a member */
define ('AW_MSGSEND', 11);

/** A message was received by a member */
define ('AW_MSGRECV', 12);

/** Misc. activity */
define ('AW_MISC', 17);

$AW_STR_DEF = array(
  AW_GRPEDIT => 'GROUP-EDITED',
  AW_GRPDEL => 'GROUP-DELETED',
  AW_GRPMEMBERSHIPCHG => 'GROUP-MEMBERSHIP-CHANGE',
  AW_DOCCREATE => 'DOC-CREATED',
  AW_DOCDEL => 'DOC-DELETED',
  AW_DOCEDIT => 'DOC-DEFINITION-EDIT',
  AW_DOCNEWVER => 'DOC-NEW-VER',
  AW_DOCEDITING => 'DOC-EDITING',
  AW_DOCCANCELEDITING => 'DOC-CANCELED-EDITING',
  AW_DOCPUBSTAT => 'DOC-PUBLIC-STATUS-CHANGED',
  AW_DOCFINALIZED => 'DOC-FINALIZED',
  AW_DOCFINALGRADED => 'DOC-FINAL-
GRADED',
  AW_DOCVERSIONGRADED => 'DOC-YOUR-VERSION-GRADED',
  AW_MISC => 'MISC',
  AW_DOCEVALVOTEOUT => 'DOC-EVAL-VOTEOUT',
  AW_DOCEXPORTEd => 'DOC-EXPORTED',
  AW_DOCEVALELECTION => 'DOC-EVAL-ELECTION'
);

//
// Recipients of an awareness
notification
//

define ('AW_RECIP_GROUP_MEMBERS', 1);
define ('AW_RECIP_YOU', 2);
define ('AW_RECIP_DOC_EVAL', 3);

```



```

$AW_STR_RECIPIENTS = array(
    AW_RECIP_GROUP_MEMBERS => 'Group members',
    AW_RECIP_YOU => 'You',
    AW_RECIP_DOC_EVAL => 'Doc eval'
);

class
cls_awareness
{
    function insert_entry($who, $recipient,
    $recipientsid, $groupid, $docid, $descid, $description)
    {
        $who = (int)
$who;
        $recipient = (int) $recipient;
        $recipientsid = (int) $recipientsid;
        $groupid = (int) $groupid;
        $docid = (int) $docid;
        $descid = (int) $descid;
        $description = my_addslashes($description);

        $q = "INSERT INTO awareness(who, recipient,
recipientsid, groupid, docid, dt, descid, description)
VALUES($who, $recipient, $recipientsid,
$groupid, $docid, NOW(), $descid, '$description')";
        show_mysql_query($q);
    }

    function broadcast_entry($who, $recipientsid,
    $groupid, $docid, $descid, $description, $effective_group = -1)
    {
        if ($recipientsid == AW_RECIP_GROUP_MEMBERS)
        {
            $g = new cls_groups();
            if ($effective_group == -1)
                $effective_group = $groupid;

            if (($membersids = $g->get_group_members_ids
($effective_group, "")) === false)
                return false;

            foreach ($membersids as $recipient)
            {
                $this->insert_entry($who, $recipient,
$recipientsid, $groupid, $docid, $descid, $description);
            }
            return true;
        }
    }

    function delete_entry($id)
    {

```

```

    $id = (int) $id;
    mysql_query("DELETE FROM awareness
WHERE id=$id");
}

```

```

function get_user_entries($recipient)
{
    $recipient = (int) $recipient;
    $q = "
SELECT
    awareness.id AS entryid,
    awareness.dt,
    awareness.descid,
    awareness.description,
    awareness.recipientsid,
    g.name AS groupname,
    m_recipient.username AS
recipientname,
    m_who.username AS originatorname,
    d.title AS doctitle
FROM
    awareness
    INNER JOIN groups    AS g
    ON awareness.groupid = g.id
    INNER JOIN members   AS m_who
    ON awareness.who = m_who.id
    INNER JOIN members   AS m_recipient
    ON awareness.recipient = m_recipient.id
    INNER JOIN documenthdr AS d
    ON awareness.docid = d.id

WHERE

recipient=$recipient
ORDER BY
    entryid DESC, dt DESC
";
    $result = show_mysql_query($q);
    if (!$result ||
!mysql_num_rows($result))
        return false;
    return $result;
}

```

### Code for 'Documentms' Handling

<?

```

// Document HEADER flags
define ('DOC_HDR_PRIVATE',      0x00000001);
define ('DOC_HDR_PUBLIC',       0x00000002);
define ('DOC_HDR_FINALIZED',    0x00000004);

```

```

define ('DOC_HDR_FINALGRADED',    0x00000008);

// This constant specifying that the document is
being edited
// I assume that this number shall never be
reached and thus will treated it as a special number
define ('DOC_EDITING_CONST', 2147483647);

// Document DATA flags
define ('DOC_DATA_NOTHING',      0x00000000);
define ('DOC_DATA_EDITING',      0x00000001);
define ('DOC_DATA_CLOSED',       0x00000002);

// Eval flags
define ('DOC_EVALDATA_OPINIONS', 0x00000001);
define ('DOC_EVALDATA_RESOURCES', 0x00000002);

class
cls_documents
{

    /**
    @return The string representation of the document
    type constant
    * @desc
    This method returns the string representation of
    the DOC_EVALDATA_XXX flags
    */
    function get_evaldata_type_to_name($type)
    {
        $type = (int) $type;
        $r = array(
            DOC_EVALDATA_OPINIONS => 'Opinions/Ideas',
            DOC_EVALDATA_RESOURCES => 'Resources'
        );

        if (!isset($r[$type]))
            return false;
        return $r[$type];
    }

    /**
    * @return An array containing the document languages
    * @desc
    This method returns an array containing document
    languages
    */
    function get_doc_langs()
    {
        return array(
            'English', 'French', 'German', 'Arabic', 'Spanish', 'Italian'
        );
    }
}

```



```

}

/**
 * @return An array containing the document types
 * @desc
 * This method returns an array containing document types allowable
 */
function get_doc_types()
{
    return array(
        'normal', 'program', 'expertise', 'knowledge',
'other'
    );
}

/**
 * @return An array containing the grade to string values
 * @desc
 * This method returns an associative array
 * containing the grade_number <-> grade_string values
 */
function get_eval_strings()
{
    $r = array(
        0 => 'not graded',
        1 => 'irrelevant',
        2 => 'fair',
        3 => 'good',
        4 => 'very
good',
        5 => 'outstanding'
    );
    //return array_merge(array_flip($r), $r);
    return $r;
}

/**
 * @return boolean
 * @param docid
 * @param evaluators IDs (pass 0 if you want to
keep)
 * @desc
 * Changes the document's evaluators
 */
function change_doc_evaluators($docid, $eval1)
{
    $cond = array();

    $docid = (int) $docid;

    if ($eval1 != 0)

```

```

    $cond[] =
"evalid1=$eval1";

    if (empty($cond))
        return false;

    $cond = join(',', $cond);

    mysql_query("UPDATE documenthdr SET $cond
WHERE id=$docid");

    return true;
}

```

```

/**
 * @return Records of all documents in a given
group
 * @param group
id

```

```

 * @param (optional) member id
 * @desc
    Returns documents in a given group.
    May optionally return only documents that
belong to a given user
 */

```

```

function get_group_documents($grpid,
$memberid = 0)
{
    $grpid = (int) $grpid;
    $memberid = (int) $memberid;

```

```

    if ($memberid)
        $cond = " AND ownerid=$memberid";
    else
        $cond = "";

```

```

    $q ="
    SELECT
        documenthdr.*,
        g.name AS groupname,
        m_eval.username AS evalname,
        m_owner.username AS ownername
    FROM
        documenthdr
        INNER JOIN members AS m_owner
ON documenthdr.ownerid = m_owner.id
        INNER JOIN members AS m_eval
ON documenthdr.evalid1 = m_eval.id
        INNER JOIN groups AS g    ON
documenthdr.groupid = g.id
    WHERE

```

```

        documenthdr.groupid=$grpid
        $cond
    ";
    $result = show_mysql_query($q);
    if ($result &&
mysql_num_rows($result))
        return $result;
    return false;
}

```

```

/**
 * @return records of document HDR
 * @param doc title
 * @desc
 Returns the record of the document with the given title
 @todo should we just check if same title exists in same
 group? (rather than have a unique document title globally?)
 */

```

```

function exists($title)
{
    $title = my_addslashes($title);
    $result = mysql_query($q =
"
        SELECT
        H.*,
        M.username AS ownername,
        G.name AS groupname,
        M1.username AS evalname1
        FROM
        documenthdr AS H
        INNER JOIN members AS M1 ON H.evalid1
        INNER JOIN members AS M ON H.ownerid
        INNER JOIN groups AS G ON H.groupid
        WHERE
        H.title='$title'

```

```

AND
        H.evalid1 = M1.id

```

```

AND
        G.id = H.groupid

```

```

AND
        M.id = H.ownerid
    ");

```

```

    if ($result &&
mysql_num_rows($result))
    {
        $r = mysql_fetch_array($result);
        mysql_free_result($result);
    }

```



```

        return $r;
    }
    return false;
}

/**
 * @return Record of
document
 * @param docid
 * @desc
Returns the record of the document found with ID
 */
function exists_by_id($docid)
{
    $docid = (int) $docid;
    $result = mysql_query($q =
"
        SELECT
        H.*,
        M.username AS ownername,
        G.name AS groupname,
        M1.username AS evalname1
        FROM
        documenthdr AS H
        INNER JOIN members AS M1 ON H.evalid1
        INNER JOIN members AS M ON H.ownerid
        INNER JOIN groups AS G ON H.groupid
        WHERE
        H.id=$docid

AND
        H.evalid1 = M1.id

AND
        G.id = H.groupid

AND
        M.id = H.ownerid
");

    if ($result &&
mysql_num_rows($result))
    {
        $r = mysql_fetch_array($result);
        mysql_free_result($result);
        return $r;
    }
    return false;
}

/**

```

```

* @return boolean
* @param docid and flag
* @desc
  Updates the document header's flags
*/
function update_doc_flags($docid,
$flag)
{
  $flag = (int) $flag;
  $docid = (int) $docid;

  $result = show_mysql_query("UPDATE
documenthdr SET flags=$flag WHERE id=$docid");
  return true;
}

/**
* @return boolean OR updates record
* @param basic document hdr info
* @desc
  Updates simple matters regarding a document
*/
function update($docid, $title, $description,
$goals, $keywords, $type = "", $language = "")
{
  $docid = (int) $docid;
  if ( ($r_doc = $this->exists_by_id($docid)) === false)
    return false;

  if (($r_doc['id'] != $docid)
&&
    strcmp($title, $r_doc['title']) ==
0)
  {
    return false;
  }

  $description = my_addslashes($description);
  $goals = my_addslashes($goals);
  $keywords = my_addslashes(build_keywords($keywords));

  $result = show_mysql_query($q = "UPDATE
documenthdr SET title='$title', description='$description',
goals='$goals', keywords='$keywords' WHERE id=$docid");
  if (!$result)
    return false;

  return $this->exists_by_id($docid);
}

/**
* @return return array(doc_hdr,

```

```

doc_data)
* @param document creation IDs
* @desc
  Creates a new document hdr + version0 record
*/
function create($grpid, $memberid,
  $valid1,
  $title, $language, $type, $description, $goals,
  $keywords, $orgfilename = "")
{
  $title = my_addslashes($title);
  if (!$this->exists($title) === false)
    return false;

  $grpid      = (int) $grpid;
  $memberid   = (int) $memberid;

  $language    = my_addslashes($language);
  $type        = my_addslashes($type);
  $description  = my_addslashes($description);
  $goals       = my_addslashes($goals);
  $orgfilename = my_addslashes($orgfilename);
  $keywords    = my_addslashes(build_keywords
($keywords));

  $doc_flags   = DOC_HDR_PRIVATE;

  $result = show_mysql_query($q = "
    INSERT INTO
      documenthdr(ownerid, groupid, valid1,
        readcount, generaleval1,
        creationdate, lastreaddate, flags,
        title, language, type, description, goals,
keywords, original_filename)
    VALUES('$memberid', '$grpid', '$valid1',
      0, 0.0,
      NOW(), NOW(), $doc_flags, '$title', '$language',
'$type', '$description', '$goals', '$keywords', '$orgfilename')
  ");

  if (
    // We managed to insert?
    !$result
    ||
    // load the inserted
record
    !($r_dochdr = $this->exists_by_id(mysql_insert_id()))
  )
  {
    return false;
  }
}

```



```

}

$docid = $r_dochdr['id'];

// Create initial version
$r_docdata = $this->create_docdata($docid, $memberid, 0,
0);

if ($r_docdata === false)
{
    // delete document hdr
    show_mysql_query("DELETE FROM documenthdr WHERE
id=$docid");
    return false;
}
return array($r_dochdr, $r_docdata);
}

/**
 * @return TRUE if document exists
 * @param docid
 * @desc
    Deletes a private document by deleting
all table entries and associated files
 */
function
delete_private_document($docid)
{
    $docid = (int) $docid;

    // get document docdata IDs
    $result = show_mysql_query("SELECT *
FROM documentdata WHERE docid=$docid");

    if (!$result ||
!mysql_num_rows($result))
    {
        // document necessarily does not exist if it
doesn't have at least one entry
        return false;
    }

    // delete all files associated with that document
    // delete all eval data
    while ($r = mysql_fetch_array($result))
    {
        $docfile = sprintf("%s/%s_%d.bin",
VGS_UPLOADDOCS, VGS_UPLOADDOCS_FILEPREFIX, $r['id']);

        // delete eval entries
        show_mysql_query("DELETE FROM

```

```

documentevaldata WHERE docdataid = {$r['id']}");

    // delete the file
    @unlink($docfile);
}

// delete all version entries
show_mysql_query("DELETE FROM
documentdata WHERE docid=$docid");

// delete final eval entries
show_mysql_query("DELETE FROM
documentevalfinal WHERE docid=$docid");

// delete document entry
show_mysql_query("DELETE FROM
documenthdr WHERE id=$docid");

return true;
}

/**
 * @return TRUE if document exists
 * @param docid
 * @desc
 * Deletes a public document by:
 * - delete all but last version
 * - delete all associated eval data
 * - move document to public group (change document container)
 */
function
delete_public_document($docid)
{
    $docid = (int) $docid;

    // get document docdata IDs reversly ordered
    $result = show_mysql_query("SELECT * FROM
documentdata WHERE docid=$docid ORDER BY version DESC");

    if (!$result ||
!mysql_num_rows($result))
    {
        // document necessarily does not exist if it doesn't
        have at least one entry
        return false;
    }

    // grab first entry and skip it, since it will be the
    last version of document
    $r_lastversion = mysql_fetch_array($result);

    // delete all files associated with that document

```

```

// delete all eval data
while ($r = mysql_fetch_array($result))
{
    $docfile = sprintf("%s/%s_%d.bin", VGS_UPLOADDOCS,
VGS_UPLOADDOCS_FILEPREFIX, $r['id']);

    // delete eval entries
    show_mysql_query("DELETE FROM documentevaldata
WHERE docdataid = {$r['id']}");

    // delete the file
    @unlink($docfile);
}

$docdataid = $r_lastversion['id'];

// delete all version entries; skip last entry
show_mysql_query("DELETE FROM documentdata
WHERE docid=$docid AND id<>$docdataid");

// delete final eval entries
show_mysql_query("DELETE FROM documentevalfinal
WHERE docid=$docid");

// update document entry container
$pubgrpuid = VGS_PUBGROUPID;
show_mysql_query("UPDATE documenthdr SET
groupid=$pubgrpuid WHERE id=$docid");

return true;
}

/**
 * @return Returns the updated/closed record
 * @param docdataid
 * @desc
 * Closes the document. Returns the updated/closed record
 */
function close_docdata($docid, $docdataid)
{
    $docdataid = (int) $docdataid;
    $VER_EDITING = DOC_EDITING_CONST;

    // Get the greatest version (except the EDITING_VERSION)
    $result = show_mysql_query($q = "
SELECT
*
FROM
    documentdata
WHERE
    (docid=$docid)

```



```

AND
(version != $VER_EDITING)
ORDER BY
version DESC
LIMIT 1
");

if (!$result && mysql_num_rows($result))
return false;

$r = mysql_fetch_array($result);
mysql_free_result($result);

// Increment to next version
$version = (int) $r['version'] + 1;

// Close the docdata entry
$flags = DOC_DATA_CLOSED;
$result = mysql_query("UPDATE documentdata
SET dt=NOW(), flags=$flags, version=$version
WHERE id=$docdataid");
if (!$result)
return false;

$result = mysql_query("SELECT * FROM
documentdata WHERE id=$docdataid");
$r = mysql_fetch_array($result);
mysql_free_result($result);
return $r;
}

/**
@return return a user constructed array of
the newly inserted record
* @param document data creation IDs
* @desc
Creates a new document data: version, flags.
Creates also document eval data
*/
function create_docdata(
$doid,
$memberid,
$version = 0,
$flags = DOC_DATA_NOTHING)
{
$result = show_mysql_query($q = "
INSERT INTO documentdata(doid, memberid, dt,
version, flags)
VALUES($doid, $memberid, NOW(), $version, $flags)
");

```

```

if (!$result)
    return false;

$docdataid = mysql_insert_id();

if ($version != 0)
{
    // create the document eval data (only for not first version)
    $evaltype = DOC_EVALDATA_OPINIONS;
    mysql_query("INSERT INTO documentevaldata
(docdataid, evaltype) VALUES($docdataid, $evaltype)");
    $evaltype = DOC_EVALDATA_RESOURCES;
    mysql_query("INSERT INTO documentevaldata
(docdataid, evaltype) VALUES($docdataid, $evaltype)");
}

return array(
    'id' => $docdataid,
    'docid' => $docid,
    'memberid' => $memberid,
    'version' => $version,
    'flags' =>
$flags);
}

/**
 * @return Records of all members that participated in a given document
 * @param document id
 * @desc
    This method fetches the records of all members that participated in a given
document
 */
function get_doc_participants($docid)
{
    $docid = (int) $docid;

    $result = show_mysql_query("
    SELECT DISTINCT
        members.*
    FROM
        members,
        documentdata
    WHERE
        documentdata.docid = $docid

AND
    members.id = documentdata.memberid
");

if (!$result && !mysql_num_rows($result))
    return false;

```

```

    return $result;
}

/**
 * @return Boolean
 * @param document id
 * @desc
    This method checks whether a given document
    is graded with final grade.
 */
function is_doc_final_graded($docid)
{
    $docid = (int) $docid;
    $result = mysql_query("SELECT * FROM
documentevalfinal WHERE docid=$docid LIMIT 1");
    if ($result &&
mysql_num_rows($result))
    {
        mysql_free_result($result);
        return false;
    }
    return true;
}

/**
 * @return TRUE
 * @param document id
 * @param evalnum EVAL1
 * @param The final grade
    • @param Grades array of the form: array(memberid =>
    • grade, memberid => grade, ....)
 * @desc
    This method submits the final grades for the given
    document.
    The documenthdr flag will also hold DOC_HDR
    _FINALGRADED flag.
 */
function submit_final_grades($docid, $evalnum, $grades,
$finalgrade, $finalgradedesc = "")
{
    $docid = (int) $docid;
    $evalnum = (int) $evalnum;
    $finalgrade = (int)
$finalgrade;
    $finalgradedesc =
my_addslashes($finalgradedesc);

    // Insert all members grades
    $grade = "grade{$evalnum}";
    while (list($id, $grade) = each($grades))
    {

```



```

$grade = (int) $grade;
$id = (int) $id;

$result = mysql_query("INSERT INTO documentevalfinal
(docid, memberid, $grade) VALUES($docid, $id, $grade)");
}

// Now insert final grade into the document's fields
$grade = "generaleval{$sevalnum}";
$desc = "generaleval{$sevalnum}desc";

$fl_finalgraded = DOC_HDR_FINALGRADED;

$result = mysql_query("
UPDATE
  documenthdr
SET
  $grade=$finalgrade,
  $desc='$finalgradedesc' ,
  flags = (flags | $fl_finalgraded)
WHERE
  id=$docid
");

return true;
}

/**
 * @return Array(grade1) or FALSE
 * @param document id
 * @param memberid
 * @desc
 * This method returns the final grades of the given user
 */
function get_doc_final_grades($docid, $memberid)
{
  $docid = (int) $docid;
  $memberid = (int) $memberid;

  $result = mysql_query("
  SELECT
    *
  FROM
    documentevalfinal
  WHERE
    docid=$docid
  AND
    memberid=$memberid
  ");

```

```

    if ($result &&
mysql_num_rows($result))
    {
        $r = mysql_fetch_array($result);
        mysql_free_result($result);
        return array($r['grade1']);
    }
    return false;
}
/**
 * @return IDs of all members that participated in
a given document
 * @param document id
 * @desc
    This method fetches the IDs of all members that
participated in a given document.
    It internally uses the get_doc_participants method
 */
function
get_doc_participants_ids($docid)
{
    $result = $this->get_doc_participants($docid);
    if ($result === false)
        return false;
    $ids = array();

    while ($r = mysql_fetch_array($result))
        $ids[] = $r['id'];
    mysql_free_result($result);
    return $ids;
}

/**
 * @return Boolean
 * @param docid and userid
 * @desc
    Checks whether users other than you are
editing the document.
    If users are editing the document then the
document cannot be finalized
 */
function can_finalize_document($docid)
{
    // document editing
condition
    $flagcond = sprintf("((documentdata.flags & %1\$d) =
%1\$d)", DOC_DATA_EDITING);

    $docid  = (int) $docid;

    // See if user has already requested the document for editing

```

```

$result = show_mysql_query("
SELECT
*
FROM
documentdata
WHERE
docid=$docid
AND
$flagcond

LIMIT 1");

if ($result &&
mysql_num_rows($result))
{
mysql_free_result($result);
return false;
}
return true;
}

/**
@return returns the DOCDATA records of other users
that are editing the document
* @param docid and userid
* @desc
Checks whether users other than you are editing the
document. If so their DOCDATA records are returned
*/
function is_doc_with_other_users_for_editing($docid,
$memberid)
{
$force = 0;

$flagcond = sprintf("(documentdata.flags & %1\$d) =
%1\$d)", DOC_DATA_EDITING);

$docid = (int) $docid;
$memberid = (int) $memberid;

// See if user has already requested the document
for editing
$result = show_mysql_query("
SELECT
documentdata.*,
members.username AS membername,
members.id AS memberid
FROM
documentdata,
members
WHERE
docid=$docid

```



```

AND
    members.id = documentdata.memberid
AND
    memberid != $memberid
AND
    $flagcond", $force);

if ($result &&
mysql_num_rows($result))
    return $result;

return false;
}

/**
 * @return returns the DOCDATA edit record
 * @param docid and userid
 * @desc
    Checks whether a DOCDATA editing record is already
    associated with the given user
    It returns the found record, or FALSE
 */
function is_doc_with_user_for_editing($docid, $memberid)
{
    $force = 0;

    $flagcond = sprintf("((documentdata.flags & %1\$d) = %1\$d)",
DOC_DATA_EDITING);

    $docid  = (int) $docid;
    $memberid = (int) $memberid;

    // See if user has already requested the document for editing
    $result = show_mysql_query("SELECT * FROM documentdata
WHERE docid=$docid AND memberid=$memberid AND $
flagcond", $force);

    if ($result &&
mysql_num_rows($result))
    {
        $r = mysql_fetch_array($result);
        mysql_free_result($result);
        return $r;
    }
    return false;
}

/**
 * @return returns a new editing record
 * @param docid and userid
 * @desc

```

Creates a new document data: version=DOC\_EDITING\_CONST,  
flags=EDITING

If there was already a record of that sort we return FALSE

\*/

function get\_document\_for\_editing(  
\$docid,  
\$memberid)

{  
\$docid,  
\$memberid)

// can user get document for EDITING or he already have it?  
if (\$this->is\_doc\_with\_user\_for\_editing(\$docid, \$memberid)

!= false)  
return false;

\$docid = (int) \$docid;

\$memberid = (int) \$memberid;

// create an un-assigned version for EDITING only

// we will re-adjust the version / record only after the  
user SAVES the document that he was editing

\$r = \$this->create\_docdata(\$docid, \$memberid,  
DOC\_EDITING\_CONST, DOC\_DATA\_EDITING);

return \$r;

}

/\*\*

@return returns the documents that a given member  
(or evaluator) is evaluating

@param \$grpid Optional, if not passed, then  
all documents

in all groups that are evaluated by this user

\* @desc

This method returns the documents that are evaluated  
by the given member in the given group

\*/

function get\_evaluator\_docs(\$memberid, \$grpid =  
0)

{

\$grpid = (int) \$grpid;

\$memberid = (int) \$memberid;

if (\$grpid > 0)

\$cond = " AND groups.id = \$grpid ";

else

\$cond = "";

\$result = show\_mysql\_query(")

SELECT

members.id as memberid,

members.username AS username,

documenthdr.title AS document\_title,

documenthdr.id AS docid,

documenthdr.flags AS docflags,

```

    groups.id AS groupid,
    groups.name AS group_name
FROM
    members,
    documenthdr,
    groups
WHERE
    documenthdr.evalid1 = $memberid
    AND
    groups.id = documenthdr.groupid
    AND
    members.id = $memberid

$cond
    "");

    if ($result &&
mysql_num_rows($result))
        return $result;
    else
        return false;
}

/**
 * @return returns the record of the latest document that
 * can be READ
 * @param doc id
 * @param updatestats ? whether we should update the
 * stats or not
 * @desc
    Locates the latest version of the document that is final
(not being edited)
    If a record was found then the document statistics are
updated
appropriately
*/
function get_document_for_reading($docid, $updatestats =
true)
{
    // A document is retrieved for reading using this criteria:
    // - must not be in EDITING flag (any other flag is accepted)
    // - must have a higher version than other matches

    $flagcond = sprintf("((documentdata.flags & %1\$d) != %1\$d)",
DOC_DATA_EDITING);
    $docid = (int) $docid;

    $result = show_mysql_query("
    SELECT
        members.username AS ownername,
        documenthdr.title AS doctitle,
        documenthdr.original_filename AS original_filename,

```



```

documentdata.*
FROM
    documentdata,
    documenthdr,
    members
WHERE
    $flagcond
AND
    documentdata.docid = $docid
AND
    documenthdr.id = documentdata.docid
AND
    members.id = documentdata.memberid
ORDER BY
    documentdata.version DESC
LIMIT 1
");

if (!(($result && mysql_num_rows($result)))
    return false;

$r = mysql_fetch_array($result);
mysql_free_result($result);

if ($updatestats)
{
    // update READ count of this DOCDATA
    mysql_query("UPDATE documentdata SET readcount=
readcount+1 WHERE id={$r['id']}");
    $r['readcount']++;

    // update WHOLE document READ info
    mysql_query("UPDATE documenthdr SET readcount=
readcount+1, lastreaddate=NOW() WHERE id=$docid");
}
return $r;
}

/**
 * @return returns TRUE or FALSE
 * @param doc id, member id
 * @desc
    Locates an editing record, if found it deletes it and all its associated
data
 */
function cancel_document_editing($docid, $memberid)
{
    $docid = (int) $docid;
    $memberid = (int) $memberid;

```

```

    $r_edit = $this->is_doc_with_user_for_editing($docid,
$memberid);
    if ($r_edit === false)
        return false;

    $docdataid = $r_edit['id'];

    // delete document data
    show_mysql_query("DELETE FROM documentdata
WHERE id=$docdataid");

    // delete document eval data
    show_mysql_query("DELETE FROM documentevaldata
WHERE docdataid=$docdataid");

    return true;
}

/**
 * @return returns FALSE or versions visible for a user
 * @param doc id, member id
 * @desc
    Shows all closed versions, and only the memberid's
non-closed version (editing)
 */
function get_user_document_versions($docid, $memberid,
$sort = 'version DESC')
{
    // - document must be in CLOSED state
    $docid = (int) $docid;
    $memberid = (int) $memberid;

    $VER_EDITING = DOC_EDITING_CONST;

    $result = show_mysql_query("
SELECT
    *
FROM
    documentdata
WHERE
    docid = $docid
AND
    (
        ( (version != $VER_EDITING) AND (version != 0) )
    OR
        (memberid=$memberid AND version=$VER_EDITING)
    )
ORDER BY $sort
");

```

```

if (!$result && mysql_num_rows($result))
    return false;

return $result;
}

/**
 * @return returns FALSE or all versions visible
 * @param doc id
 * @desc
 * Shows all closed versions
 */
function get_document_versions($docid, $sort = "")
{
    $docid = (int) $docid;
    $VER_EDITING = DOC_EDITING_CONST;

    $result = show_mysql_query($q = "
        SELECT
            documentdata.*,
            members.username AS ownername
        FROM
            members,
documentdata
        WHERE
            members.id = documentdata.memberid
            AND
            documentdata.docid = $docid
            AND
            (version != $VER_EDITING)
        $sort
    ");
    if (!$result && mysql_num_rows($result))
        return false;
    return $result;
}

/**
 * @return Boolean
 * @param grade1 optional, pass 0
 * @param grade1desc
 * optional
 * @desc
 * This method upgrades the doc version's grade
 */
function update_document_grades($docverid,
$grade1, $grade1desc)
{
    $docverid = (int) $docverid;

```

```

$cond = array();

$grade1desc = my_addslashes($grade1desc);

if ($grade1 != 0)
{
    $cond[] = "grade1=$grade1";
    $cond[] = "grade1desc='{ $grade1desc}'";
}

if (empty($cond))
    return false;

$cond[] =
"evaldate=NOW()";
$cond = join(',', $cond);

// update READ count of this DOCDATA
show_mysql_query("UPDATE documentevaldata SET
$cond WHERE id=$docverid");

return true;
}

/**
 * @return FALSE or latest version
 * @desc
 * This method returns the latest version number
 * (of closed document)
 */
function get_document_last_version($docid)
{
    $docid = (int) $docid;
    $VER_EDITING = DOC_EDITING_CONST;

    $result = show_mysql_query($q = "
        SELECT MAX(version) AS lastversion
        FROM
documentdata
        WHERE
        (docid = $docid)
        AND
        (version != $VER_EDITING)
    ");
    if (!$result && mysql_num_rows($result))
        return false;
    $r = mysql_fetch_array($result);
    return $r['lastversion'];
}

```



```

/**
 * @return Returns the doc's evaluation data
 * @param docid
 * @param evaltype [1,2,-1] If -1 then both
evaluations
@param memberid If ZERO then no member
filter (all members returned);
 * @param $fromver $tover can be ZERO (optional)
 * @desc
  This method will return the evaluation data for
the given document
 */
function get_document_evaluation($docid,
$evaltype = 0, $sort =
", $fromver = 0, $tover = 0, $memberid = 0)
{
  $docid = (int) $docid;
  $memberid = (int) $memberid;

  $VER_EDITING = DOC_EDITING_CONST;

  $vercond = "";
  $evalcond = "";
  $membercond =
";

  if (empty($sort))
    $sort = 'ORDER BY version DESC';

  if ($evaltype > 0)
    $evalcond = " AND documentevaldata.evaltype =
$evaltype";

  if ($fromver && $tover)
  {
    $t = max($fromver, $tover);
    $tover = min($fromver, $tover);
    $fromver = $t;
    $vercond = " AND ((documentdata.version <= $fromver)
AND (documentdata.version >= $tover)) ";
  }

  if ($memberid >
0)
    $membercond = " AND (members.id = $memberid) ";

  $result = show_mysql_query("
SELECT
  members.username AS ownername,
  members.id AS ownerid,
  documenthdr.title AS doctitle,
  documenthdr.original_filename AS original_filename,

```

```

        documentdata.version AS
docversion,
        documentdata.dt AS docdatadate,
        documentevaldata.evaltype,

documentevaldata.grade1,
        documentevaldata.description AS evaldescription,
        documentevaldata.evaldate AS evaldate
FROM
        documentdata,
        documenthdr,
        members,
        documentevaldata
WHERE
        documenthdr.id = $docid
AND
        documentevaldata.docdataid = documentdata.id
AND
        documenthdr.id = documentdata.docid
AND
        members.id = documentdata.memberid
AND
        (documentdata.version != $VER_EDITING)
$evalcond
$membercond
$vercond
$sort
");

if (!$result && !mysql_num_rows($result))
    return false;

return $result;
}

/**
 * @return returns document's version
 * information along
 * w/ header info
 * @param docdataid
 * @param should we update stats
 * @desc
Returns the docdata's information in the form of:
array(docdata+partial_hdr_info,
array(opinions, resources)
)
*/
function get_document_by_version($docdataid,
$updatestats = true)
{
    $docdataid = (int) $docdataid;

```

```

$result = show_mysql_query("
SELECT
  members.username AS ownername,
  documenthdr.title AS doctitle,
  documenthdr.original_filename AS original_filename,

documentdata.*
FROM
  documentdata,
  documenthdr,
  members
WHERE
  documentdata.id = $docdataid
AND
  documenthdr.id = documentdata.docid
AND
  members.id = documentdata.memberid
");

if (!$result && mysql_num_rows($result))
  return false;

$r = mysql_fetch_array($result);
mysql_free_result($result);

if ($updatestats)
{
  // update READ count of this DOCDATA
  mysql_query("UPDATE documentdata SET
readcount=readcount+1 WHERE id={$r['id']}");

  // update returned to user record
  $r['readcount']++;

  // update WHOLE document READ info
  mysql_query("UPDATE documenthdr SET readcount=
readcount+1, lastreaddate=NOW() WHERE id={$r['docid']}");
}

// For non initial version, also retrieve the eval data
if ($r['version'] !=
0)
{
  $evaltype = DOC_EVALDATA_OPINIONS;
  $result = show_mysql_query("SELECT * FROM
documentevaldata WHERE docdataid=$docdataid AND
evaltype=$evaltype");
  if (!$result && mysql_num_rows($result))
    return false;

```

```

    $r1 = mysql_fetch_array($result);
    mysql_free_result($result);

    $evaltype = DOC_EVALDATA_RESOURCES;
    $result = show_mysql_query("SELECT * FROM
documentevaldata
WHERE docdataid=$docdataid AND evaltype=$evaltype");
    if (!$result && mysql_num_rows($result))
        return false;

    $r2 = mysql_fetch_array($result);
    mysql_free_result($result);
}
else
{
    // return empty array
    $r1 = $r2 = array();
}

```

<?

/\*

This is responsible for handling actions  
related to the document header.

Example:

- READ LASTEST VERSION
- GET FOR MODIFICATION
- SAVE / UNSAVE / PUBLISH / UNPUBLISH

\*/

```

require_once ('inc_headers.php');
require_once ('cls_groups.php');
require_once ('cls_members.php');
require_once ('cls_documents.php');
require_once ('cls_awareness.php');

```

// clear script timeout

```
set_time_limit(0);
```

```
$debug_state = 0;
```

```
$g = new cls_groups();
```

```
$d = new cls_documents();
```

// Less conditions when in ANY mode

```
if (get_var('any'))
```

```
{
```

```
    // - must pass GROUPID
```

```
    // - must pass DOCID
```

```
    // - group must exist
```

```
    // - document must exist

```



```

// - document belongs to the given
group
// - document must be public and final
if (
    !($groupid = (int)
get_var('groupid')) ||
    !($docid = (int) get_var('docid')) ||
    ( ($r_group = $g->exists_by_id($groupid)) === false ) ||
    ( ($r_doc = $d->exists_by_id($docid)) === false ) ||
    ( $r_doc['groupid'] != $groupid ) ||
    (!has_attr($r_doc['flags'], DOC_HDR_FINALIZED |
DOC_HDR_PUBLIC))
)
{
    js_die("FATAL ERROR ON READDOCUMENTANY
document($groupid, $docid)");
    die;
}

// Retrieves the latest document for reading
if (get_var('readdocument'))
{
    $r = $d->get_document_for_reading($docid);
    if ($r === false)
        js_die("FATAL ERROR ON READDOCUMENT
($groupid, $docid)");
    download_docdata($r);
}
die;
}

require_once ('fnc_islogged.php');

function
download_docdata($r_docdata)
{
    $fullpath = sprintf('%s/%s_%d.bin', VGS_ULOADDOCS,
VGS_ULOADDOCS_FILEPREFIX, $r_docdata['id']);

    $filename =
        $r_docdata['doctitle'] .
        ' (ver_' . $r_docdata['version'] . ')' .
        $r_docdata['ownername'] . ')' .
        '.';
    extract_file_extension($r_docdata['original_filename']);

    $filename = str_replace(' ', '_', $filename);

    dload_file($filename, $fullpath);
}

$memberid = $LOGGED['id'];

```

```

// - must pass GROUPID
// - must pass DOCID
// - group must exist
// - logged user must be a group
member
// - document must exist
// - document belongs to the given
group
if (
    !($groupid = (int) get_var('groupid'))
||
    !($docid = (int) get_var('docid')) ||
    ( ($r_group = $g->exists_by_id($groupid)) === false ) ||
    ( ($r_member = $g->is_user_group_member($groupid,
$memberid)) === false ) ||
    ( ($r_doc = $d->exists_by_id($docid)) === false ) ||
    ( $r_doc['groupid'] != $groupid )
)
{
    Header("Location: frm_groupdocuments.php?wksnum=
$wksnum&groupid=$groupid");
    die();
}

$docid = $r_doc['id'];

$refreshtree = 0;

if ($r_doc['ownerid'] == $memberid)
    $b_can_edit = true;

function goback($msg = "", $page = "")
{
    global $groupid, $docid, $refreshtree;

    if (empty($page))
        $page =
'frm_docview.php';

    $back = "$page?groupid=$groupid&docid=$docid&
refreshtree=$refreshtree";

    if (!empty($msg))
    {
        $back .= '&err=' . urlencode($msg);
    }
// echo "back=$back";
    Header("Location: $back");
    die();
}

```

```

$a = new cls_awareness;

// Retrieves the latest document for reading
if (get_var('readdocument'))
{
    $r = $d->get_document_for_reading($docid);
    if ($r === false)
        js_die("FATAL ERROR ON READDOCUMENT
($groupid, $docid)");
    download_docdata($r);
}
// =====
=====
// Retrieves the latest document for modification
// =====
=====
else if
(get_var('getdocument'))
{
    $r_editdoc = $d->get_document_for_editing($docid, $memberid);
    if ($r_editdoc === false)
    {
        goback('You are already editing this
document');
    }

    // Get latest document
    $r = $d->get_document_for_reading($docid,
false);
    if ($r === false)
    {
        goback('Error retrieving latest document!');
    }

    // Notify members that document was retrieved for edition
    $a->broadcast_entry(
        $memberid,
        AW_RECIP_GROUP_MEMBERS,
        $groupid,
        $docid,
        AW_DOCEDITING,
        'Document retrieved for
modification');

    // Download latest
document
    download_docdata($r);
}
//
// Cancels the document's modification
//

```

```

else if (get_var('canceledocument'))
{
    $r_editdoc = $d->is_doc_with_user_for_editing
($docid, $memberid);
    if ($r_editdoc === false)
    {
        goback('You are not modifying this document!');
    }

    $r = $d->cancel_document_editing($docid, $memberid);
    if ($r === false)
    {
        goback('Failed to discard your modifications!');
    }

    // Notify members that document modification was
canceled
    $a->broadcast_entry(
        $memberid,
        AW_RECIP_GROUP_MEMBERS,
        $groupid,
        $docid,
        AW_DOCCANCELEDDITING,
        'Document modification canceled!');

    $refreshtree = 1;
    goback("", "");
}
// Retrieves a specific document
version
else if (get_var('readdocumentver') && ($docdataid =
(int) get_var('docdataid')))
{
    if ($r = $d-
>get_document_by_version($docdataid))
    {
        download_docdata($r[0]);
    }
}
// Unfinalize a given
document
else if (get_var('unfinalizedoc') && ($docid =
(int) get_var('docid')) && ($groupid = (int) get_var('groupid')))
{
    if (!$r_doc = $d-
>exists_by_id($docid))
        goback('Error invalid document!');

    // Notify members that document was un-
finalized
    $a->broadcast_entry(
        $memberid,

```



```

    AW_RECIP_GROUP_MEMBERS,
    $groupid,
    $docid,
    AW_DOCUNFINALIZED,
    'Document was un-finalized');

$refreshree = 1;
// remove finalized flag
// remove PUBLIC flag
$d->update_doc_flags($docid, $r_doc['flags'] &
~DOC_HDR_FINALIZED &
~DOC_HDR_PUBLIC | DOC_HDR_PRIVATE);
goback(", ");
}
// =====
// Finalize a given document
// =====
else if (get_var('finalizedoc') && ($docid = (int) get_var
('docid')) && ($groupid = (int) get_var('groupid')))
{
    if (!$r_doc = $d-
>exists_by_id($docid))
        goback('Error invalid document!');

    $refreshree = 1;
    $d->update_doc_flags($docid, $r_doc['flags'] |
DOC_HDR_FINALIZED);

    // Notify members that document was finalized
    $a->broadcast_entry(
        $memberid,
        AW_RECIP_GROUP_MEMBERS,
        $groupid,
        $docid,
        AW_DOCFINALIZED,
        'Document was finalized');

    goback(", ");
}
// Delete a document
else if (get_var('deletedoc') && ($docid =
(int) get_var('docid'))
&& ($groupid = (int) get_var('groupid')))
{
    // This is a very delicate procedure:
    // - delete temporary database entries
    // - delete associated files
    // - delete all versions and associated data
    if (!$d->delete_private_document($docid))
    {
        // mysql_query("UPDATE documenthdr SET evalid1=
{$r_doc['evalid1']} WHERE docid=$docid");
    }
}

```

```

    goback('Could not delete this document!');
}

$msg = "Document \"{$r_doc['title']}\" was deleted by
\"{$LOGGED['username']}\"
" from group \"{$r_group['name']}\"";

// Notify group members that a document was deleted
$a->broadcast_entry(
    $LOGGED['id'],
    AW_RECIP_GROUP_MEMBERS,
    $groupid,
    VGS_FICTDOCID,
    AW_DOCDEL,
    $msg);

// Remove stale evaluators
$g-
>delete_stale_evaluators($groupid);

header("Location: frm_groupdocuments.php?groupid=$
groupid&refresh=1");
die;
}

// Make public/private
else if (get_var('makepublic') && ($docid = (int)
get_var('docid'))
&& ($groupid = (int) get_var('groupid')))
{
    if (!$r_doc = $d-
>exists_by_id($docid))
        goback('Error invalid document!');

    // Flip PUB/PRV flags
    $flag = $r_doc['flags'];

    // make public
    if (has_attr($flag,
DOC_HDR_PRIVATE))
    {
        $flag = $flag & ~DOC_HDR_PRIVATE |
DOC_HDR_PUBLIC;
        $b_pub = true;
    }
    // make private
    else if (has_attr($flag, DOC_HDR_PUBLIC))
    {
        $flag = $flag & ~DOC_HDR_PUBLIC |
DOC_HDR_PRIVATE;
        $b_pub = false;
    }
}

```

```

// Notify members that document pub/prv status changed
$a->broadcast_entry(
    $memberid,
    AW_RECIP_GROUP_MEMBERS,
    $groupid,
    $docid,
    AW_DOCPUBSTAT,
    'Document was made ' . ($b_pub ? 'public' : 'private')
);

$d->update_doc_flags($docid, $flag);
goback("", "");
}

?>

```

### Code for Sessions Handling

```

<?
include_once('inc_consts.php');

// ini_set('session.cookie_lifetime',
VGS_SESSION_LIFETIME);
// ini_set('session.cookie_lifetime',
VGS_SESSION_LIFETIME);
session_set_cookie_params(VGS_SESSION_LIFETIME);

session_start();

function
sessuserLogin($r)
{
    $_SESSION[VGS_SESSION_USER] = $r;
}

function
sessuserIsLoggedIn()
{
    if (!isset($_SESSION[VGS_SESSION_USER]))
        return false;
    return $_SESSION[VGS_SESSION_USER];
}

function sessuserLogout()
{
    unset($_SESSION[VGS_SESSION_USER]);
}

?>

```

## Code for Groups Handling

<?

```
// group attributes and flags
define ('GROUP_ATTR_PRIVATE',      0x00000001);
define ('GROUP_ATTR_PUBLIC',      0x00000002);

// the group is about to be delete
define ('GROUP_FLAG_CONFIRMDELETE', 0x00000004);

// User group membership privileges
define ('GROUP_MEMBER_READ',      0x00000001);
define ('GROUP_MEMBER_WRITE',     0x00000002);
define ('GROUP_MEMBER_DELETE',    0x00000004);
define ('GROUP_MEMBER_DECISION',  0x00000008);
define ('GROUP_MEMBER_CREATEGROUP', 0x00000010);
define ('GROUP_MEMBER_EVALUATOR', 0x00000020);
define ('GROUP_MEMBER_ADMINISTRATOR', 0x00000040);
define ('GROUP_MEMBER_ALL',      0xFFFFFFFF);

class cls_groups
{
    /**
     * @return a map of privileges values and their's string
     * representations
     * @param (none)
     * @desc
     * Returns a map of privileges values and their's string
     representations.
     Useful for mapping between string and numerical
     representation of a privilege
     */
    function group_membership_privileges
    ($mask = GROUP_MEMBER_ALL)
    {
        $all = array(
            GROUP_MEMBER_READ      => 'READ',
            GROUP_MEMBER_WRITE     => 'WRITE',
            GROUP_MEMBER_DELETE    => 'DELETE',
            GROUP_MEMBER_DECISION  => 'DECISION',
            GROUP_MEMBER_CREATEGROUP => 'CREATE_GROUP',
            GROUP_MEMBER_EVALUATOR => 'EVALUATOR',
            GROUP_MEMBER_ADMINISTRATOR => 'ADMINISTRATOR'
        );

        $r = array();

        while (list($k, $v) = each($all))
        {
```



```

        if (($mask & $k) == $k)
            $r[$k] = $v;
    }
    return $r;
}

/**
 * @return String description
 * @param $priv privilege integer value
 * @param $join optional, the join value of the
 *           privilege strings
 * @desc
 * This method returns string representation of a
 * given privilege flags
 */
function groupmember_priv_to_string($priv, $join = ',')
{
    $r = $this->group_membership_privileges();
    $a = array();
    while (list($key, $val) = each($r))
    {
        if (($priv & $key) == $key)
            $a[] = $val;
    }
    return join($join, $a);
}

/**
 * @return bool
 * @param $grpid The group's ID
 * @desc
 * Deletes an empty group.
 * Make sure you cleaned the documents (manually)
 * first, if any documents are still there it will FAIL
 */
function delete_group($grpid)
{
    // delete members association
    show_mysql_query("DELETE FROM groupmembers
WHERE groupid=$grpid");

    // delete group entry
    show_mysql_query("DELETE FROM groups
WHERE id=$grpid");
}

function delete_stale_evaluators($grpid)
{
    $grpid = (int) $grpid;
    if ( ($members = $this->get_group_members_ids
($grpid, "GROUP_MEMBER_EVALUATOR")) === false)
        return false;
}

```

```

    if ( ($evals = $this->get_group_effective_evaluators_ids
($grpid)) === false)
        return false;

```

```

    $rem = array_diff($members, $evals);
    if (!count($rem))
        return false;

```

```

    $rem = join(',', $rem);
    mysql_query($q = "DELETE FROM
groupmembers WHERE
groupid=$grpid AND memberid IN
($rem)");
    //echo "q=$q";
    return true;
}

```

```

/**
 * @return FALSE or $result
 * @param grpid
 * @desc
This method returns the group's evaluators IDs.
 * @sa get_group_effective_evaluators
 */

```

```

function get_group_effective_evaluators_ids($grpid)
{
    $result = $this->get_group_effective_evaluators($grpid);
    if ($result === false)
        return array();
    $ar = array();
    while ($r = mysql_fetch_array($result))
        $ar[] = $r['id'];
    mysql_free_result($result);
    return $ar;
}

```

```

/**
 * @return FALSE or $result
 * @param grpid
 * @desc
This method returns the group's evaluators records.
Effective means the current / actual evaluators for all the
documents in the group
 */

```

```

function get_group_effective_evaluators($grpid)
{
    $grpid = (int) $grpid;

    $result = mysql_query("
SELECT

```

```

        members.*,
        documenthdr.id AS docid,
        documenthdr.title AS documenttitle,
        documenthdr.groupid AS groupid,
        groups.name AS groupname
    FROM
        documenthdr, members, groups
    WHERE
        documenthdr.groupid=$grpid
    AND
        members.id = documenthdr.evalid1
    AND
        groups.id = documenthdr.groupid
    ");

    if (!$result || !mysql_num_rows($result))
        return false;

    return $result;
}

/**
 * @return FALSE or $result
 * @param grpid
 * @desc
 * This method returns the candidate evaluators for
 * a given group
 * The records returned are of:
 * The members that are not part of the group and
 * evaluators
 * of the group (though they
 * became members)
 * - Not the logged user (you)
 * - The evaluators in the group
 */
function get_group_potential_evaluators($grpid,
$you = 0)
{
    $grpid = (int) $grpid;

    $excl = array();
    $incl = array();

    if ($you)
        $excl[] = $you;

    $result = $this->get_group_effective_evaluators($grpid);
    if ($result !== false)
    {
        while ($r = mysql_fetch_array($result))
            $incl[] = $r['id'];
    }

```

```

    mysql_free_result($result);
}

// Get group members
$sids = $this->get_group_members_ids($grpid, "");
if ($sids !== false && count($sids))
{
    foreach ($sids as $id)
        $excl[] = $id;
}

// Make array unique
$excl = array_unique($excl);

// Remove from exclusion list the evaluators
$excl = array_diff($excl, $incl);

if (count($excl))
    $excl = ' WHERE id NOT IN (' . join(',', $excl) . ')';
else
    $excl = "";

$result = mysql_query("
    SELECT
        *
    FROM
        members
    $excl
");
if (!$result || !mysql_num_rows($result))
    return false;

return $result;
}

/**
 * @return $record or FALSE
 * @param cond_user The criteria of group listing
 * @param sort The sorting method for groups
 * @desc
 Returns the groups list
 */
function get_groups_list($cond_user = "", $sort = "")
{
    $cond = sprintf(" WHERE (id<>%d)", VGS_PUBGROUPID);

    if (!empty($cond_user))
        $cond .= " AND ($cond) ";

    if (empty($sort))

```



```

    $sort = 'name';

    $result = show_mysql_query("SELECT * FROM
groups $cond
ORDER BY $sort");
    if ($result && mysql_num_rows($result))
        return $result;
    else
        return false;
}

/**
 * @return $record or FALSE
 * @param memberID
 * @param sorting criteria
 * @desc
Returns the groups records that the user belongs to
*/
function get_user_groups($memberid, $sort = 'groupname')
{
    $memberid = (int)$memberid;
    $result = mysql_query("
        SELECT
            groups.id AS groupid,
            groups.ownerid,
            groups.name AS groupname,
            groups.createdate AS groupcreatedate,
            members.username AS groupownername
        FROM
            groupmembers, groups, members
        WHERE
            groupmembers.memberid = $memberid
        AND
            groupmembers.groupid = groups.id
        AND
            members.id = groups.ownerid
        ORDER BY $sort
    ");

    if ($result && mysql_num_rows($result))
        return $result;
    return false;
}

/**
 * @return FALSE or Array(id1, id2, id3, ...)
 * @param memberID
 * @desc
Returns the groups ids that the user belongs to
*/
function get_user_groups_ids($memberid)

```

```

{
    $result = $this->get_user_groups($memberid);
    if ($result === false)
        return false;

    $ids = array();
    while ($r = mysql_fetch_array($result))
    {
        $ids[] = $r['groupid'];
    }
    return $ids;
}

/**
 * @return members that are visible to you
 * @param memberid
 * @desc
 It returns all the members that are visible to you.
 In other words all members that are subscribed to
 the same groups
 as you are
 */
function get_groups_members($memberid)
{
    $memberid = (int) $memberid;

    // get the groups that user is subscribed in
    $result = mysql_query("
        SELECT
            groups.id
        FROM
            groupmembers,
            groups
        WHERE
            groupmembers.memberid = $memberid
        AND
            groupmembers.groupid = groups.id
    ");

    if (!$result && mysql_num_rows($result))
        return false;

    $ids = array();

    while ($r = mysql_fetch_array($result))
        $ids[] = $r['id'];

    $ids = join(',', $ids);

    mysql_free_result($result);
}

```

```

$result = mysql_query("
SELECT
    groupmembers.*,
    members.username AS username,
    members.fname AS firstname,
    members.lname AS lastname
FROM
    members, groupmembers
WHERE
    groupmembers.memberid = members.id
    AND
    groupmembers.groupid IN ($ids)
GROUP BY memberid
");

if (!$result && mysql_num_rows($result))
    return false;

return $result;
}

/**
 * @return $records or FALSE
 * @param groupID
 * @param sorting criteria
 * @desc
 Returns the members that belong to a given group
 */
function get_group_members($groupid, $sort =
'memberusername',
$membershipflags = -1)
{
    if ($membershipflags != -1)
        $cond = " AND ((groupmembers.privilege &
$membershipflags)=
$membershipflags)";
    else
        $cond = "";

    $groupid = (int) $groupid;
    $result = show_mysql_query($q =
"
SELECT
    members.username AS memberusername,
    members.fname AS fname,
    members.lname AS lname,
    members.privilege AS memberpriv,
    members.id AS memberid,
    groupmembers.privilege AS membershippriv,
    groupmembers.id AS membershipid
FROM

```

```

        groupmembers, members
WHERE
    groupmembers.groupid = $grpid
    AND
    groupmembers.memberid = members.id
    $cond
ORDER BY $sort
");
// echo "q=$q";
if ($result && mysql_num_rows($result))
{
    return $result;
}
return false;
}

/**
 * @return ARRAY or comma separated values
 * @param $grpid
 * @param $join optional, if not passed then
 * comma is used; if empty then
 * an array is returned
 * @desc
 * Returns the IDs of the group members
 */
function get_group_members_ids($grpid, $join =
',', $membershipflags = -1)
{
    $result = $this->get_group_members($grpid,
'memberusername', $membershipflags);
    if (!$result)
        return false;

    $ids = array();
    while ($r = mysql_fetch_array($result))
        $ids[] = $r['memberid'];

    mysql_free_result($result);
    if (empty($join))
        return $ids;
    else
        return join($join, $ids);
}

/**
 * @return $record or FALSE
 * @param group name
 * @desc
 * Checks if the given group exist (by name)
 */
function exists($name)

```



```

{
$name = my_addslashes($name);
$result = mysql_query($q = "
SELECT
    groups.*,
    members.username AS ownername
FROM
    groups, members
WHERE
    groups.name='$name'
AND
    members.id = groups.ownerid
");
if ($result && mysql_num_rows($result))
{
    $r = mysql_fetch_array($result);
    mysql_free_result($result);
    return $r;
}
return false;
}

```

```

/**
 * @return $record or FALSE
 * @param group name
 * @desc
 Checks if the given group exist (by name)
 */
function exists_by_id($grpid)
{
    $grpid = (int) $grpid;
    $result = show_mysql_query("
SELECT
    groups.*,
    members.username AS ownername
FROM
    groups, members
WHERE
    groups.id = $grpid
AND
    members.id = groups.ownerid
");

    if ($result && mysql_num_rows($result))
    {
        $r = mysql_fetch_array($result);
        mysql_free_result($result);
        return $r;
    }
    return false;
}

```

```

}

/**
 * @return $record or FALSE
 * @desc
 Creates a new group and adds the user to the group's membership
 */
function create($name, $description, $attributes, $ownerid)
{
    global $debug_state;
    $attributes = (int) $attributes;
    $name       = my_addslashes($name);
    $description = my_addslashes($description);
    $ownerid    = (int) $ownerid;
    $result = mysql_query($q = "
        INSERT INTO
        groups(name, description, ownerid, attributes, createdate)
        VALUES('$name', '$description', $ownerid,
$attributes, NOW())
        ");

    if (!$result)
        return false;

    if ($debug_state)
        echo "<!--cls_group-->create@$q-->";

    $r = $this->exists($name);

    $this->add_user_to_group(
        $r['id'],
        $r['ownerid'],
        GROUP_MEMBER_READ |
        GROUP_MEMBER_WRITE |
        GROUP_MEMBER_DELETE |
//      GROUP_MEMBER_ADMINISTRATOR |
        GROUP_MEMBER_DECISION);

    return $r;
}

/**
 * @return TRUE
 * @param groupid
 * @param memberid
 * @param member/group privilege
 * @desc
 Makes a user a member of a given group
 */
function add_user_to_group($grpid, $memberid, $priv)
{

```

```

    $grpid = (int) $grpid;
    $memberid = (int) $memberid;
    $priv = (int) $priv;
    $result = mysql_query("INSERT INTO groupmembers
(memberid, groupid,
privilege) VALUES($memberid, $grpid, $priv)");
    return true;
}

```

```

/**
 * @return TRUE
 * @desc
 Removes all memberships of a given group
 */

```

```

function reset_group_memberships($grpid)
{
    $grpid = (int) $grpid;
    $result = show_mysql_query("DELETE FROM
groupmembers WHERE
groupid=$grpid");
    return true;
}

```

```

/**
 * @return TRUE
 * @desc
 Adds an array of members to a given group
 (all with the same passed privileges)
 */

```

```

function add_users_to_group($grpid, $memberslist, $priv = 0)
{
    foreach ($memberslist as $id)
    {
        $this->add_user_to_group($grpid, $id, $priv);
    }
    return true;
}

```

```

/**
 * @return membership record or FALSE
 * @desc
 Checks if the user belongs to a given group
 */

```

```

function is_user_group_member($grpid, $memberid)
{
    $grpid = (int) $grpid;
    $memberid = (int) $memberid;

    $result = show_mysql_query($q = "
SELECT
    groupmembers.*,

```

```

        members.username AS membername,
        groups.name AS groupname
FROM
    groupmembers,
    groups,
    members
WHERE
    members.id = $memberid
AND
    groups.id = $grpid
AND
    groupid=$grpid
AND
    memberid=$memberid");
if ($result && mysql_num_rows($result))
{
    $r = mysql_fetch_array($result);
    mysql_free_result($result);
    return $r;
}
return false;
}

/**
 * @return updated record or FALSE
 * @param group name
 * @desc
 Checks if the given group exist (by name)
 */
function update($groupid, $name, $description, $attributes)
{
    $attributes = (int) $attributes;
    $name = my_addslashes($name);
    $description = my_addslashes($description);
    $groupid = (int) $groupid;

    $result = mysql_query("
        UPDATE groups SET name='$name', description='$description',
attributes='$attributes'
        WHERE id=$groupid
    ");
    return $this->exists_by_id($groupid);
}

function groupAttributesToString($attr, $join = ',')
{
    $attr = (int) $attr;
    $s = array();
    if ( ($attr & GROUP_ATTR_PRIVATE) == GROUP_ATTR_PRIVATE)
        $s[] = 'PRIVATE';

```



```

if ( ($attr & GROUP_ATTR_PUBLIC) == GROUP_ATTR_PUBLIC)
    $s[] = 'PUBLIC';

if (!count($s))
    $s[] = 'none';

return join($join, $s);
}
}

?>

```

### Code for Members Handling

```

<?

define ('MEMBER_FLAG_ADMIN',          0x00000001);
define ('MEMBER_FLAG_EVALUATOR',
0x00000002);
define ('MEMBER_FLAG_CREATEGROUP',
0x00000004);
define ('MEMBER_FLAG_ALL',           0xFFFFFFFF);

class
cls_members
{
    function member_privileges($mask =
MEMBER_FLAG_ALL)
    {
        $all = array(
            MEMBER_FLAG_ADMIN
=> 'ADMIN',
            MEMBER_FLAG_EVALUATOR
=> 'EVALUATOR',
            MEMBER_FLAG_CREATEGROUP
=> 'CREATE GROUP'
        );

        $r = array();
        while (list($k, $v) = each($all))
        {
            if (($mask & $k) == $k)
                $r[$k] = $v;
        }
        return $r;
    }
}

/**
 * @return SQL condition / bit flags

```

```

* @param flag
value
* @param [optional] table field name
* @desc
Returns an SQL condition based on a given flag mask
*/
function sql_flag($flag, $field =
'privilege')
{
    return sprintf('(%1$s & %2$d)=%2$d)', $field, $flag);
}

/**
* @param memberid
* @param priv
* @desc
Updates the given member's privilege
*/
function update_member_privilege($memberid,
$priv)
{
    $memberid = (int) $memberid;
    $priv = (int)
$priv;

    $result = show_mysql_query("UPDATE members SET
privilege=$priv WHERE id=$memberid");
    return true;
}

/**
* @return $record or
FALSE
* @param username
@param $byid Determines whether to use the
'username' value as the
memberID and fetch by ID
* @desc
Checks if the username exist. We use this prior
to registering a user
*/
function member_exists($username, $byid =
false)
{
    $fl_admin = $this->sql_flag(MEMBER_FLAG_ADMIN);
    $fl_eval = $this-
>sql_flag(MEMBER_FLAG_EVALUATOR);
    $fl_crgrp = $this->sql_flag(MEMBER_FLAG_CREATEGROUP);

    if ($byid)
    {
        $username = (int) $username;

```

```

    $cond =
    "id='$username'";
}
else
{
    $username = my_addslashes($username);
    $cond = "username='$username'";
}

$result = mysql_query("
    SELECT
        *,
        $fl_admin AS
IS_ADMIN,
        $fl_eval AS IS_EVAL,
        $fl_crgrp AS
CAN_CREATEGROUP
    FROM
        members
    WHERE
        $cond
    LIMIT 1
");

if ($result &&
mysql_num_rows($result))
{
    $r = mysql_fetch_array($result);

mysql_free_result($result);
    return $r;
}
return false;
}

/**
 * @return $record or
FALSE
 * @param username
 * @param password
 * @desc
    Checks if the username/password exist, if so,
his online flags are updated.
    The user's record is returned also, for further session
registration
    In case username/password mismatch, then FALSE is
returned
 */
function login($username,
$password)
{
    $username = my_addslashes($username);

```

```

$password = my_addslashes($password);

$fl_admin = $this->sql_flag(MEMBER_FLAG_ADMIN);
$fl_eval = $this-
>sql_flag(MEMBER_FLAG_EVALUATOR);

$result = mysql_query("
SELECT
    *
    $fl_admin AS
IS_ADMIN,
    $fl_eval AS IS_EVAL
FROM
    members
WHERE
    username='$username'

AND
    password='$password'
");
if ($result &&
mysql_num_rows($result))
{
    $r = mysql_fetch_array($result);

    // update ONLINE status
    mysql_query($q = "UPDATE members SET
lastsignin=NOW(), isonline=1
WHERE id={$r['id']}");
    return $r;
}
else
    return false;
}

/**
 * @return void
 * @param username
 * @desc
 * Simply marks the given user's isonline flag as ZERO
 */
function
logout($username)
{
    $username = my_addslashes($username);
    // mark as
offline
    mysql_query("UPDATE members SET isonline=0 WHERE
username='$username'");
}

```



```

/**
 * @return set of keywords
 * @param a set of string $strings
 *   • @desc Given a phrase, it returns the keywords
 *   • that forms this phrase
(remove all redundant things)
*/
function _buildKeywords($strings)
{
    return build_keywords($strings);
}

/**
 * @return FALSE or updated record
 * @param a set of string $strings
 * @desc Updates the user's profile
 */
function update($username,
$password,
    $fname, $lname, $email, $addr, $city, $country, $phone,
    $knowledge, $interest, $qualification,
$preference)
{
    $username    = my_addslashes($username);
    $password    = my_addslashes($password);
    $fname      = my_addslashes($fname);
    $email      =
my_addslashes($email);
    $lname      = my_addslashes($lname);
    $addr       =
my_addslashes($addr);
    $city       = my_addslashes($city);
    $country    = my_addslashes($country);
    $phone      = my_addslashes($phone);
    $knowledge   =
my_addslashes($knowledge);
    $interest    = my_addslashes($interest);
    $qualification =
my_addslashes($qualification);
    $preference  = my_addslashes($preference);

    $keywords    = $this->_buildKeywords("$fname $lname
$qualification $interest $knowledge");

    $q =
"
        UPDATE members SET
            password
        ='$password',
            fname = '$fname', lname=
'$lname',

```

```

        email = '$email',
        addr = '$addr', city='$city',
country='$country',
        phone = '$phone',
knowledge='$knowledge',
        interest='$interest', qualification='$qualification',
preference='$preference',
        keywords='$keywords'
        WHERE username='$username'
";

$result =
mysql_query($q);

if (!$result)
    return false;

return $this->member_exists($username);
}

/**
 * @return inserted record
 * @desc
 * Creates a new profile
 */
function create(
    $username, $password,
    $fname, $lname, $email, $addr, $city, $country, $phone,
    $knowledge, $interest, $qualification,
    $preference)
{
    $username    = my_addslashes($username);

    if (!($this->member_exists($username) ===
false))
        return false;

    $password    = my_addslashes($password);
    $fname       = my_addslashes($fname);
    $email       =
my_addslashes($email);
    $lname       = my_addslashes($lname);
    $addr        =
my_addslashes($addr);
    $city        = my_addslashes($city);
    $country     = my_addslashes($country);
    $phone       = my_addslashes($phone);
    $knowledge    =
my_addslashes($knowledge);
    $interest    = my_addslashes($interest);
    $qualification =
my_addslashes($qualification);

```

```

$preference = my_addslashes($preference);

$keywords = $this->_buildKeywords
("$qualification $interest $knowledge");

$privilege =
MEMBER_FLAG_CREATEGROUP;

$q =
"
    INSERT INTO members(username, password,
registerdate, fname, lname,
                        addr, city, country, phone,
knowledge, interest, qualification,
                        keywords, privilege, lastsignin,
isonline, email, preference)
    VALUES('$username', '$password',
NOW(), '$fname', '$lname',
'$addr', '$city', '$country', '$phone',
'$knowledge', '$interest', '$qualification',
'$keywords', $privilege, NULL, 0, '$email',
'$preference')
";

$result =
mysql_query($q);

if (!$result)
    return false;

// will always succeed!
return $this->member_exists($username);
}

function list_all_evaluators($sort = "")
{
    return $this->list_all_members($sort, $this->sql_flag
(MEMBER_FLAG_EVALUATOR));
}

function list_all_admins($sort = "")
{
    return $this->list_all_members($sort, $this-
>sql_flag(MEMBER_FLAG_ADMIN));
}

/**
 * @return returns records of all
members
 * @param SQL condition
 * @param sort criteria
 * @desc

```

```

Returns the record of all members
*/
function list_all_members($sort = "", $cond = "")
{
    global $debug_state;

    if
(!empty($cond))
        $cond = " WHERE
$cond";

    if
(!empty($sort))
        $sort = " ORDER BY $sort";

    $fl_admin = $this->sql_flag(MEMBER_FLAG_ADMIN);
    $fl_eval = $this-
>sql_flag(MEMBER_FLAG_EVALUATOR);

    $result = show_mysql_query($q = "
        SELECT
            *,
            $fl_admin AS
IS_ADMIN,
            $fl_eval AS IS_EVAL
        FROM
            members
            $cond
            $sort");

    if
($debug_state)
    {
        echo "<!--cls_members.list_all_members() ->\n$q\n--
>\n";
    }

    if ($result &&
mysql_num_rows($result))
        return $result;
    else
        return false;
}

/**
 * @return returns TRUE or FALSE
 * @param member ID
 * @desc
Returns whether the given member
is online or offline
It makes use of the VGS_ISONLINE
_COUNTER const

```



```

*/
function
is_member_online($memberid)
{
    $memberid = (int) $memberid;

    $minutes = VGS_ISONLINE_COUNTER;

    $result = show_mysql_query("
    SELECT
    (DATE_ADD(lastsignin, INTERVAL
    $minutes MINUTE) >= NOW()) AND
    (isonline = 1) AS online

FROM
    members
WHERE
    id=$memberid
    ");

    if ($result &&
mysql_num_rows($result))
    {
        $r = mysql_fetch_array($result);

mysql_free_result($result);
        return
        $r['online'];
    }
    return false;
}
}

?>

```

### Code for Messages

```

<?
define ('MBX_MSG_READ',
1);

class
cls_messages
{
    function _sql_is_read($tbl_prefix = "")
    {
        $r = (int)
MBX_MSG_READ;
        return "({$tbl_prefix}status & $r) =
        $r";
    }
}

```

```

/**
 * @return SUCCESS
 * @param msgid
 * @desc
   Deletes the messages with the
given IDs
 */
function delete_messages($ids)
{
  if
(!is_array($ids))
    $ids = array($ids);

    $ids = join(',', $ids);

    $result = mysql_query("DELETE FROM
mailmessages WHERE id IN ($ids)");
    return true;
}

/**
 * @return returns the messages list
 * @param msgid
 * @desc
   Returns the messages in a given boxid for
a given user, in a given sorting criteria
 */
function list_box($boxid, $memberid, $sort = 'date
DESC')
{
  $read_cond = $this-
>_sql_is_read('T. ');
  $result = mysql_query("
SELECT

T.*,
    $read_cond AS
msgread,
    M1.username AS from_username,
    M2.username AS to_username,
    M3.username AS
owner_username
  FROM
    mailmessages AS T
    INNER JOIN members AS M1 ON T.from_member
    INNER JOIN members AS M2 ON
T.to_member
    INNER JOIN members AS M3 ON
T.msgowner
  WHERE

```

```

        T.msgowner =
$memberid

AND
        T.mailboxid = $boxid

AND
        T.from_member = M1.id

AND
        T.to_member = M2.id

AND
        T.msgowner = M3.id
        ORDER BY $sort
    ");

    if (!($result && mysql_num_rows($result)))
        return false;

    return $result;
}

function list_inbox($memberid, $sort = 'date
DESC')
{
    return $this->list_box(VGS_MBX_INBOX, $memberid);
}

function list_outbox($memberid, $sort = 'date
DESC')
{
    return $this->list_box(VGS_MBX_OUTBOX, $memberid);
}

/**
 * @return returns the message's info
 * @param msgid
 * @param markasread - should we mark the message as
read?
 * @desc
    Returns the complete message info
    If MARKASREAD is set, the message will be flagged
    If MARKASREAD_LINKEDTO = its linked to
message is flagged
 */
function load_message($msgid, $markasread = false,
$markasread_linkedto = false)
{
    $msgid = (int) $msgid;

```

```

$FREAD = (int) MBX_MSG_READ;

$result = mysql_query("
SELECT
T.*,
  ((T.status & $FREAD) = $FREAD) AS
msgread,
  M1.username AS from_username,
  M2.username AS to_username,
  M3.username AS
owner_username
FROM
  mailmessages AS T
  INNER JOIN members AS M1 ON T.from_member
  INNER JOIN members AS M2 ON
T.to_member
  INNER JOIN members AS M3 ON
T.msgowner
WHERE
  T.id =
$msgid

AND
  T.from_member = M1.id

AND
  T.to_member = M2.id

AND
  T.msgowner = M3.id
");

if (!$result && mysql_num_rows($result))
  return false;

$r = mysql_fetch_array($result);

mysql_free_result($result);

// mark linked message
$linkedito =
$r['msglinkedto'];
if ($markasread_linkedto && ($linkedito != 0))
  mysql_query($q = "UPDATE mailmessages
SET status=
(status | $FREAD) WHERE id=$linkedito");

// mark message id
if
($markasread)
  mysql_query($q = "UPDATE mailmessages SET
status=status |

```



```

$FREAD WHERE id=$msgid");

    return $r;
}

/**
 * @return SUCCESS
 * @param mail sending params
 * @desc
    Sends a messages FROM a recipient to another
    recipient
    "Keep" will save the sent message in your
    outbox
 */
function send_message($from, $to, $title, $msg, $keep =
true)
{
    $title = my_addslashes(strip_tags($title));
    $msg = my_addslashes(strip_tags($msg));
    $from = (int) $from;
    $to = (int) $to;

    $inboxid = VGS_MBX_INBOX;

    // create a message to recipient
    $result = mysql_query("
        INSERT INTO mailmessages(msglinkedto,
msgowner, mailboxid,
from_member, to_member, date, status, title,
message)
        VALUES(msglinkedto, $to, $inboxid, $from, $to,
NOW(), 0, '$title', '$msg')
    ");

    $id1 = mysql_insert_id();

    // keep a copy for you in your
    OUTBOX
    if (!$keep)
        return true;

    $outboxid = VGS_MBX_OUTBOX;

    $result = mysql_query("
        INSERT INTO mailmessages(msglinkedto, msgowner,
mailboxid, from_member,
to_member, date, status, title, message)
        VALUES($id1, $from, $outboxid, $from, $to, NOW(), 0, '$title',
'$msg')
    ");

```

```
$id2 = mysql_insert_id();

// link sent messages to the saved message
mysql_query("UPDATE mailmessages SET msglinkedto=
$id2 WHERE id=$id1");

return true;
}
}
?>
```

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