Three Dimensional Knowledge Management And Explicit Knowledge Reuse

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ABSTRACT:

A new model is being proposed for the knowledge management in three dimensions by extending the two dimensional knowledge management models of Nonaka and Takeuchi and MITRE which accounts knowledge reusability as a third dimension. Present work propose that Knowledge reusability play the vital role like knowledge and should be treated independently as a third dimension unlike the model of Nonaka and Takeuchi model where knowledge reusability has not been considered and MITRA's model in which the knowledge reusability was not considered explicitly. Present research is in continuation to our previous published and presented work on software, data, information and knowledge reusable concepts in the three dimensions. Present work demonstrates analytically that reusable knowledge may enhance the effective knowledge in an organization and should have its independent existence like knowledge assets. Present work may be valuable to manage knowledge in three dimensional knowledge intensive environments where knowledge reusability not only increases the entire knowledge of the organization while it also increases the quality of knowledge.

Keywords: *Knowledge management, Three dimensional model, Mitre model, Nonaka model.*

Introduction

The organizational knowledge creation theory was initiated and advanced by Nonaka and his colleagues (Nonaka, 1994; Nonaka et al., 1994; Nonaka, and Takeuchi, 1995; Nonaka et al., 2000; Nonaka et al., 2000). According to some workers real picture of knowledge creation emerged during studies of information creation in innovating companies (Nonaka, 1988a; Nonaka, 1988b). It is not very clear in literature that how and why reusable knowledge has been considered or adopted? What are the relationship between the existing reusable knowledge and knowledge? How both knowledge and reusable knowledge simultaneous revolves with time? It is beyond doubt that Nonaka (1994) theory of organizational knowledge creation is the most important theory in knowledge management. However, the concept of explicit reusable knowledge and its consequences are absent in the theory. Moreover, according to the work of Gourlay , (2003) empirical basis for the Nonaka (1994) model is highly unsatisfactory. He indicated that the “evidence for the processes is week or non-existent which thus calls into question the SECI model itself”. Gourlay (2003) found many unsatisfactory details about the Nonaka’s model during case studies and explanation of above Nonaka (1994) and Nonaka et al. (1994) work. According to

Gourlay (2003) “SECI model has thus never had a sound empirical grounding, which must call its status into question”.

Work of Jorna (1998) demonstrates that four phases of knowledge creation in above work of Nonaka (1994) and Nonaka et al. model (1994), can not explain the change of signs due to transformation of knowledge from one form to another and therefore a “semiotic framework for dealing with sign is required” (Gourlay, 2003).

It is not difficult to say that knowledge reuse has become the necessity of not every day life while also for the many technical projects. Reusable knowledge brings the quality because of its verification status in at-least some kind of projects. However, its adoption and adaption according to the nature of the project is a question to be dealt properly.

It is a surprising fact that in spite of great attention to knowledge creation and sharing theories and issues, the reusable knowledge has not been discussed explicitly during knowledge transformation in the Nonaka model. Harsh and Sajeev (2006) proposed a three dimensional model for software reuse which deals with the component based explicit reuse. In addition, Harsh (2007a) has proposed an analytical model to include the knowledge reusability by extending the work of Gene Bellinger (2004) on the data and information. Harsh (2007a; 2007b; 2008) has also proposed a three dimensional model by incorporating knowledge reusability and which was presented in the international conference held in Lecee, Italy. Earlier, Harsh (2006) worked on the knowledge reusable issues during management of software metrics. Recently Joshi and Harsh (2008) accounted the effect of technology and knowledge flow during knowledge reuse. However their work could not include the enough knowledge reuse issues in details which could deal reusable knowledge transformation similar to Nonaka and Takeuchi model (1995). Therefore, in the present work an another method of realizing knowledge in the three dimensional environment is being proposed by extending the above work to account greater details of knowledge components and its reuse during knowledge transformation in the extended Nonaka (1994) model. In the present work the Nonaka and Takeuchi (1995) model has been extended from two to three dimensional Knowledge Management model. In addition, MITRE (Small and Tatalias, 2000).commercial model on knowledge management has also been properly explained by using the appropriate concept of knowledge reusability and knowledge management. Present work has been extended to incorporate the discussion on the knowledge-sharing issues in experimental software engineering environment by considering the work of Shull et al. (2004) **(**which is also based on the Nonaka and Takeuchi (1995) model) by involving the concept of knowledge reusability.

According to Grant (1996) knowledge reuse models may be divided “into those that focus on knowledge acquisition (or replication) and those that focus on knowledge integration” while Szulanski (2000) suggested knowledge reuse as replication. It has been inferred that knowledge reuse normally increases with the increase of initial shared experiences between source and recipient Argote (2000).

Nonaka and Takeuchi (1995) defined two dimensional model of knowledge transformations of tacit to explicit knowledge which consists phases of socialization,

externalization, combination and internalization processes (see Figure 1). According to this model knowledge transfer takes place through information (externalized) "and then converted back from information to knowledge" (1995).

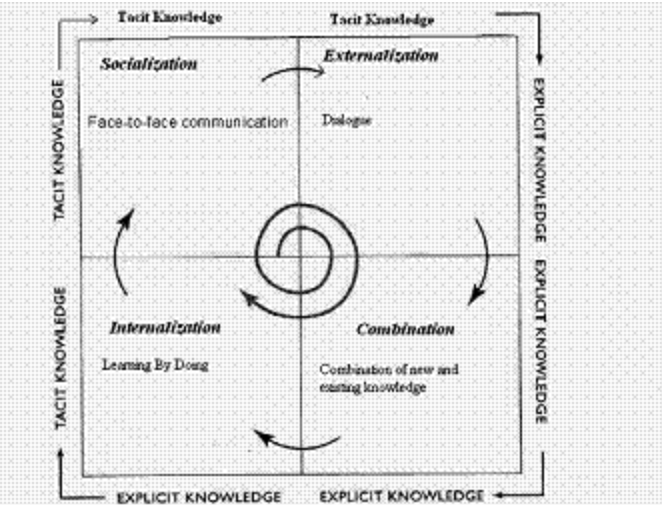


Figure 1: Original Nonaka And Takeuchi Model (1995).

There is no indication in Nonaka's model about the knowledge which repeatedly passing through same phase of transformation.

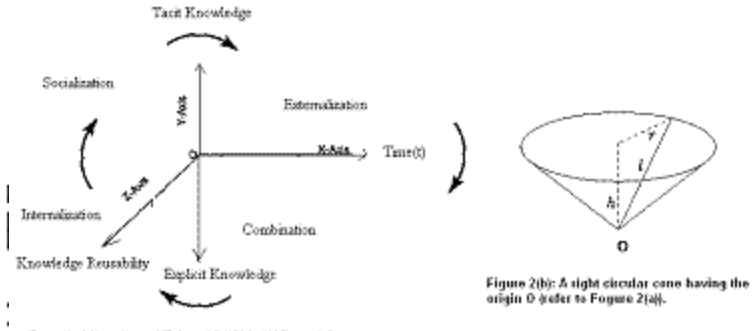
In the present article it is believed that transfer of knowledge consumes time which is also evident from this fact that knowledge of an organization changes with time. Effective knowledge of an organization may be increased through the reuse of knowledge. Time is required to collect information, to organize knowledge, to transfer knowledge from one form to another useful form. It means that organization becomes enriched through knowledge. Based on time and knowledge reusability, we define a new three dimensional model which is based on the Figure 2(a) and Figure (2(b). From these Figures, one can judge that as the reusability increases then knowledge increases (from one form to another). Under such situations the locus of the knowledge will be a solid cone (Figure 2(b) and Figure 2 (c)) whose centre may be defined as the origin and axis lies along the axis of time. This model also includes all types of knowledge transformations as indicated in Nonaka and Takeuchi's Model (1995), (e.g. through socialization, externalization, combination and internalization processes (Figure 2(c)). The final form of knowledge cone or spiral will depend upon this fact that what type of knowledge will be converted during what types of the activities? If the knowledge is continuously converted from usable and reusable knowledge then its locus will be a solid cone in three dimensions. A good example is conversion of knowledge of fabrication to knowledge of R & D (Research & Development) exploration where every time we reuse the fabrication related knowledge for the R & D exploration knowledge and the knowledge is converted from Explicit to more Explicit Forms (due to knowledge reusability) and under the Low Complexity to High Complexity. Such

knowledge will be more qualitative because it has been processed or used several times and we are surer about its nature of applications.

A more crucial example of Knowledge Conversion is from Explicit Forms to Tacit (High Complexity to High Complexity) with the example of conversion of Financial Management knowledge to Supply Chain Management knowledge where the knowledge of Financial Management (already exist so it is reusable) is continuously converted to knowledge of Supply Chain Management. So by using knowledge of Financial Management we can convert it into various types of Supply Chain Management knowledge by repetitively using the earlier one. It should be noted that rate of increase of knowledge will be more in the (with time) in three dimensional model as compared to the two dimensional model. In three dimensions it will be a solid cone and the metrics of the knowledge may be represented by radius, length and height of the knowledge cone in three dimensional space.

In the present work, a new dimension that is the knowledge reusability have been considered as the another dimension (tacit and explicit) while “time” dimension was already present in the Nonaka and Takeuchi model (1995). Present work suggests that knowledge reusability is an essential part for any organization. Thus knowledge reusability always enhances the effective and qualitative knowledge in any organization provided it is exploited under the right direction.

During the (one knowledge form to another form) knowledge transformation process, part of knowledge is also a reusable knowledge. Knowledge reusability is possible for both explicit and tacit knowledge. If we consider such knowledge as an independent knowledge like other knowledge then a separate axis is required to represent the knowledge reusability because it fulfills the condition of orthogonally. No doubt those both tacit and explicit types of knowledge are reusable and therefore, their transformation takes place with similar law. We propose in our extended model that both explicit and tacit knowledge are orthogonal to knowledge reusability while tacit and explicit knowledge are opposite to each other (Harsh 2007a; Joshi and Harsh 2008). In the present work we assume that like software reuse, knowledge reuse may be defined as systematic application of existing artifacts where like software there is a knowledge artifact which covers the design and transformation rules. With time, interaction between tacit and explicit knowledge increases (where the time may be considered along the x-axis) and hence the volume of the solid cone also increases due to increase of overall knowledge and finally reusability also **(**See Figures 2(a), 2(b) and Figure 2 (c)). Thus the extension of Nonaka and Takeuchi Model may be defined as the following linear view:



Extended Nonaka and Takeuchi (1991; 1995) model.

Figure 2(a)

Figure 2(b): A right circular cone having the origin O (refer to Figure 2(a)).

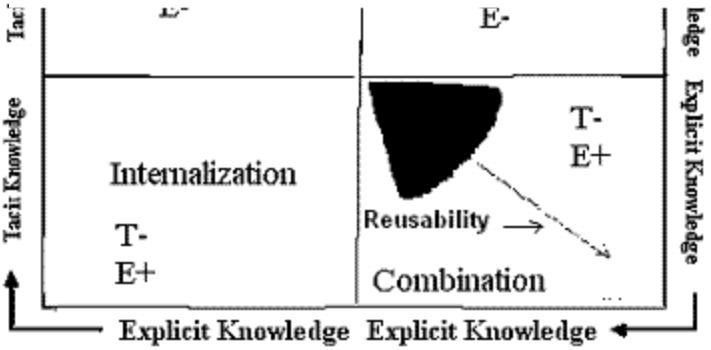


Figure 2(c): Revised Nonaka and Takeuchi Model

We can get a right circular (Figure 2b) cone if the rate of increase of tacit and explicit knowledge is same with time. The volume of the cone represents the accumulated knowledge (Figure 2 (b) and the metrics of the knowledge may also be determined by the Figure 2(b). In Figure 2(c), E-Refers to Explicit Knowledge and T-Refers to Tacit Knowledge. Refer to the Figure 2(a), 2 (b) and 2(c) above, we conclude that:

- ***Socialization*** which is the process of interaction between individuals and results in the tacit knowledge sharing (Nonaka and Takeuchi Model (1995)]), may take place more extensively and it can be viewed more interactively because in any organization employees not only share their experiences, mental models, beliefs and perspective while they also share their reuse experiences. Thus it can be assumed that the knowledge (residing peoples' brains (tacit knowledge)) reaching the community will get increased as a result of knowledge reusability. Socialization means the transfer of tacit to tacit knowledge and is represented in the upper left quadrant of the Figure 2 (a) where representation of tacit knowledge is positive and explicit knowledge is negative.

- ***Externalization*** is the process of capturing information about knowledge (Nonaka and Takeuchi Model (1995)) which means that the transformation of tacit into the explicit knowledge. Some of it examples are: speaking to somebody, writing a document, drawing a Figure, giving a presentation, or teaching. All these processes will be boosted as the time increases due to

involvement of reusable knowledge. This indicates that effectively more knowledge will be available to organization as compared to two dimensional model of Nonaka and Takeuchi Model (1995)). Moreover, at the same time there will be more confidence in the available knowledge because of repetition of knowledge. Externalization may be represented in the upper right quadrant in the Figure 2(a).

- ***Combination*** Under these circumstances tacit knowledge will be negative and the explicit knowledge will be positive quantities. Application of reusability of knowledge will create more combination of qualitative knowledge. People in the organization feel more linked with knowledge in less time and with less new type of the knowledge. Under such process both new and existing explicit knowledge plays crucial and significant role in the process of knowledge combination. There will be more rate of rise of knowledge because it is connected with the faster conversion of knowledge form one form to another. One can realize at this stage that explicit knowledge converted into the more (useful) explicit knowledge. Such explicit knowledge is more qualitative and useful for a given project.

- ***Internalization*** is the process of understanding the information, putting it into content with one's own existing knowledge (Nonaka and Takeuchi Model (1995)) and this may be viewed here in the three dimensions (Figures 2(a), 2(b) and 2(c)). These Figures clearly demonstrate that the knowledge transformation (from explicit to tacit and vice versa) increases with the time as well as with the increase of reuse. Thus we will be able to put more knowledge into our existing internal knowledge.

In present case, one can realize that knowledge will follow the same cycle as proposed by Nonaka and Takeuchi Model (1995); however, the rate of change of knowledge will be higher due to knowledge reusability. Present work suggests that locus of knowledge will be a solid cone in three dimensions (approximate) because it includes knowledge reusability as well time concepts where time is along the Z-axis. Because we assume here that, there is continuous and approximately uniform increase of knowledge with time (and conversion of tacit to explicit knowledge and vice versa) and there is also a uniform (approximately) rate of increase of reusability of knowledge. Concept of circular cone makes more sense than the concept of knowledge spiral (as proposed by Nonaka and Takeuchi Model (1995)) in three dimensions. It should be noted that we are not only interested about the way the knowledge increases while we are also concerned about the overall enhancement of knowledge due to presence of knowledge reusability and its consequences to knowledge transformation into three dimensions.

In the present work, the concept of ba's as proposed by Nonaka et al (2000) not only remains the same while it has been also extended to knowledge reusability as well as. As a result of three dimensional knowledge model, we can have four types of the knowledge management styles and four types of reusable knowledge management styles. These can give the idea of knowledge performance of an organization (this work is in progress subject to completion of industrial survey). All these styles could lead to the knowledge optimization.

MITRE Knowledge Management Model

According to MITRE's (Small and Tatalias, 2000) model Knowledge management may be felicitated from a two dimensional perspective. According to this model first dimension represents the activities that are critical to knowledge creation and innovation: which are knowledge exchange, knowledge capture, knowledge reuse and knowledge internalization while the second dimension represents the elements that influence knowledge creation activities (like the alignment of corporate and Knowledge Management strategies, measures of metrics captured to determine if Knowledge Management improvement is occurring or if a benefit is being derived and other are associated with policy, content, process, technology and the culture). MITRE' model has been proposed for an industrial setting environment.

Unlike the MITRE model (Small and Tatalias, 2000), present work assumes that reusability can not be kept with (parallel) knowledge exchange and knowledge capture (in any given organization) because reusability is not directly related with the knowledge exchange and capture and therefore, we propose the same Figure 2(a) in which knowledge reusability is shown separately.

As a result of above discussion of inclusion of knowledge reusability in MITRE model as a separate axis and the conversion of one form of knowledge to another (tacit to explicit and vice versa), the knowledge exchange at all levels of the organization would have high rating. Figure 2 (a) may be viewed as the refined MITRE model which shows that elements that are critical to knowledge creation and innovation and that enable or influence knowledge-creation activities, will be affected more rapidly.

We can demonstrate that due to present work, it becomes easier to locate reusable components once we establish the mathematical relations between the quantities along the entire three axes in a three dimensional model. Present model reduces the distance (organizationally or geographically) between the component developer and users because we know about the type of reusable (or friendly) components and hence one can get virtually more as well as qualitative knowledge in an organization which helps in faster, easier and smooth knowledge transfer.

In addition, one can realize that as a result of our proposal of Figure 2(a), approach to Knowledge Management advances from two fold to three fold, improves the state of corporate enables, rectify the pilot solutions to key knowledge challenge and enhances, optimise not only the entire effective knowledge of the organization while it also enable us in:

- Identifying and selecting less errorless and better knowledge because of increases in reusable knowledge
- Identifying, selecting and separating more useful Tacit and Explicit knowledge
- Quantifying more effective knowledge of the organization

- Using knowledge more confidently and frequently due to increased confidence of the users

- Getting faster knowledge transfer once we establish our knowledge reuse repository

However, it is difficult (at this stage) to discuss in details about the involvement of knowledge management styles unless we complete a survey study. A pilot study has already been completed successfully while the main study is in progress.

Software Engineering Environment And Present Knowledge Model

Knowledge is a function of time in any software organization and will continuously evolve with time. However, we can not say that knowledge will always evolve in the right direction as per requirement of the company. Now the point is not this that how the knowledge can be increased while the point is that how the useful knowledge can be increased?

Shull et al. (2004) dealt the Knowledge sharing problem during experimental software engineering. According to them tacit knowledge is important to experiment because this is a type of information but it is not documented. Shull et al. (2004) has encountered crucial problems in the area of socialization and internalization because of difficulties faced during transferring and absorbing tacit knowledge. In view of the present model this problem may be explained by incorporating the reusability issues. Reusability concept makes it easy to understand the identifiable and verifiable knowledge. It also boosts our confidence about the use of the available knowledge at a particular time. Reusable knowledge will set an environment of mutual trust among the experimenters and the replicators. Thus in the authors opinion, we can make a clear distinction between tacit and explicit reusable knowledge (by their respective reusability) which can reduce the problem of Shull et al. (2004), because a sharp distinction between internalization and socialization can be made.

Dingsoyr and Conradi (2002) conducted case studies of the use of knowledge management in software industries. Their work was on the knowledge involvement in eight case studies in which they assessed significant benefits. According to them (in their case study companies) only very few organizations claim to have reduced software production costs and the increased in the quality of the software was also low. However, according to them there was better work situation for software developers and managers in those organizations. According to present author (in all the above eight case studied), the issues related to knowledge reusability and time were not explicitly taken-up. For example knowledge reusability increases the quality of the knowledge as the time increases. As a result of knowledge reusability, knowledge sharing becomes frequent and smooth. As the time increases, it becomes more rapid trend to acquire more reusable knowledge. Such system will be more precise, coherent and allows us to transform more tacit knowledge into explicit knowledge with less effort.

Conclusions

In the present work a new three dimensional model has been proposed to find out analytically that how tacit and explicit knowledge evolve and converted into reusable knowledge. Knowledge reusability may bee considered an asset for any organization. Present research opens at-least a new door to understand knowledge management models in the reusable environments. Present work can manage knowledge efficiently, effectively and qualitatively and also helps in composing and developing reusable software knowledge components which may provide significantly better benefits. Present research is also valuable for the deployability and implementation of the reusable knowledge components. Detailed experimental study on the work is in progress and will be communicated in the future.

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References

Argote, L., P., 2000, Ingram, Knowledge transfer: A basis for competitive advantage in firms. Organ. Behavior Human Decision Processes 82(1), 150–169.

Bellinger, G., 2004, Knowledge Management-Emerging Perspective, Retrieved August 27, 2008 From: http://www.Systems-Thinking.Org/Kmgmt/Kmgmt.Htm

Dingsoyr, O. and Conradi, R., 2002, "A Survey of Case Studies of the Use of Knowledge Management in Software Engineering", In Journal of Software Engineering and Knowledge Engineering, l12(4), 391-414.

Gourlay, S. N., 2003, The SECI model of knowledge creation: some empirical shortcomings, in F. McGrath, and D. Remenyi, (eds), Fourth European Conference on Knowledge Management, Oxford, 18-19 September, pp. 377-385.

Grant, R. M., 1996, Prospering in dynamically competitive environments: Organizational capabilities as knowledge integration. Organizational Science 7(4) 375–387.

Harsh, O. K., 2006, Metrics and their Management for a Component- Based Reuse and Composition in Three Dimensions. Presented and Published in Proceedings of National Conference on Information Technology, held at Ibra, Oman in March.

Harsh, O. K. and Sajeev, A. S. M., 2006, Component-Based Explicit Software Reuse, Engineering Letters 13(1), 30-39.

Harsh, O. K., 2007a, Explicit Knowledge Management and Reuse, Presented in KMO workshop held in Lecee, Italy on Sept 10-11.

Harsh, O. K., 2007b, Data, Information and Knowledge & Reuse Management Techniques, Appeared in world Congress in Engineering held in London from July 2 to

July 4.

Harsh, O. K., 2008, Reusable Data, Information, Knowledge and Management Techniques, J. Knowledge Management Practice September, 9(3).

Harsh, O. K., and Joshi, N. K., 2008, "Role of Technology on the Knowledge Management and Reuse", Communicated to Engineering Letters.

Jorna, R., 1998, "Managing knowledge", Semiotic Review of Books, 9(2) (1998), http://www.chass.utronto.ca/epc/srb/managingknow.html (accessed 17 sept (2000).

Joshi, N. K. and Harsh, O. K., 2008, "Knowledge Management and Reuse due to Communication and Knowledge flows", Published in Sixth AIMS International Conference on Management (AIMS-6), Greater Noida, Delhi Region, India Dec 28 - 31.

Nonaka, I., 1988a, 'creating order out of chaos: self- renewal in Japanese firms'. California Management Review, 15, No.3, 57- 73.

Nonaka, I., 1988b, 'toward middle-up-down management: accelerating information creation. Sloan Management Review, 29, No.3, 9- 18.

Nonaka, I.., 1994, 'A dynamic theory of organizational knowledge creation'. *Organization Science*, 5, 1, 14-37.

Nonaka, I., Byosiere, P., Borucki, P.C. and Konno, N, 1994, 'Organizational Knowledge Creation Theory: a first comprehensive test'. International Business Review, 3, 4, 337-351.

Nonaka, I. and Takeuchi, H., 1995, The Knowledge-Creating Company: How Japanese Companies Create the Dynamics for Innovation. Oxford University Press, New York, NY.

Nonaka, I., Toyama, R. and Konno, N., 2000, 'SECI, Ba, and leadership: a unified model of dynamic knowledge creation'. Long Range Planning, 33, 5- 34.

Small, C. T. and Tatalias, J. (2000), "Knowledge Management Model Guides KM Process", The MITRE Advanced Technology News Letter, The MITRE Corporation, p 1-4. Retrieved Nov 5, 2008 from http://www.mitre.org/pubs/edge/ and now available at: http://www.providersedge.com/docs/km_articles/KM_Model_Guides_KM_Process.pdf

Shull, Forrest Basili, Victor, Mendonca, Jeffrey, Carver, Maldonado, Jose C, Fabbri, Sandra, Travassos, Guilherme Horta, and Ferreira, Maris Cristina (2004). Retrieved Sept 7, 2008; Retrieved from: http://www.springerlink.com/content/l774hk7585v010h7/

Szulanski, G, (2000), The process of knowledge transfer: A diachronic analysis of stickiness. Organ. Behavior Human Decision Processes 82(1), 9-27.

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