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# CONCEPT MAPPING IN KNOWLEDGE INTENSIVE PROCESS

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**Abstract**. Knowledge intensive processes such as research and development, innovation, new product development, design and product design are often driven and constrained by the mental model of experts. Often, this knowledge is not explicit but tacit. In order for the knowledge sharing to happen, it requires communicating tacit knowledge. CM functions as an externalization tool to facilitate this transformation and support knowledge construction. It has demonstrated best in domain knowledge construction and elicitation process during conceptual design. CM too functions as a storytelling and guide ideation process. In the same way, as Personal Knowledge Management tool, CM encourage individual to externalize their knowledge and contribute to collective intelligence across community of practice.

## 1 Introduction

Many describe Concept Map (CM) as an idea generating tools, some even classify them as an innovation tools. CM has proven successful in various areas; from a broad range of education fields, engineering, business processes, knowledge management (KM) to semantic and ontology design. Eppler (2001) described CM as a complex knowledge mapping techniques that merely as an enabler, as a vehicle for expressing and releasing the knowledge, creativity, and energy that lies within every group. However, this knowledge is always tacit in nature, subjective, personal and context- specific. In order for the knowledge sharing to happen, it requires communicating tacit knowledge. CM functions as an externalization tool to facilitate this transformation (Fisher, Wandersee and Wideman, 2000) while supporting knowledge construction.

To make tacit knowledge explicit, individual need to be aware of his or her style in managing their knowledge or thought process. In KM, a system that is designed by an individual for his or her own use, facilitates knowledge acquisition and assists in managing information overload is called Personal Knowledge Management (PKM) (Frand and Lippincott, 2005). CM was introduced as one of the PKM tool. Dorsey (2000) viewed PKM as a set of problem-solving skills that have both a logical or conceptual as well as physical or hands-on component**.** He defined seven core PKM skills as retrieving, evaluating/assessing, organizing, analyzing, presenting, securing, and collaborating around information. As such CM is beyond nodes and links but as a vehicle to demonstrate knowledge, understanding and performed as a window into one mental model. They implied the *deductive thinking* and *inductive thinking* style (Harris and Caviglioli, 2003) where *deductive thinking* deals with problem from the whole view before breaking into parts while *inductive thinking* see things from parts to whole.

Knowledge intensive processes such as research and development, innovation, new product development, design and product design are often driven and constrained by the mental model of experts. Often, this knowledge is not explicit but tacit, thus it is difficult to describe, examine and use. Designers or creator spent more times and deals with him or her thinking internally before reach to the final output (Dörner, 1999). As a result, knowledge developed during a design project often traps within individual designers and their artifacts (Schon, 1983). At the same time, designers usually conduct collaborative discussions and verbal critiques that influence the design of the final artifact with others; however this knowledge is rarely captured. The design process too always contributes to new development product, thus foster new knowledge in many ways (A.Rahman.KAA, Sugiyama, Watanabe 2001).

In every design process, the most difficult and important process is to conceptualize what we want to create and articulate why we want to do so (Preece, Rogers and Sharp, 2002). A conceptual design represents the structure of the system, as perceived by the user (deltamethod.net). The process includes the construction of *conceptual models,* that is " a description of the proposed system in terms of set of integrated ideas and concepts about what it should do, behave and look like, that will be understandable by the users in the manner intended" (Preece, Rogers and Sharp, 2002). Similarly, the early stage of innovation includes idea generation process and development of conceptual understanding (Thoben, 2007). Some describe this stage as the *ideation* where it refers to the preverbal idea stage. However, it is always happens that the *ideation* one have is not reflected into their *expression* - where the translation of those ideas into formal systems of communication take place. In some way, the idea they plan is lost during the transition to the executable form (Marlia, 2006). CM was then introduced at these stages to construct domain knowledge in knowledge acquisition phase as described in section 2. Consequently, it will guide the *ideation* process, used as storytelling and metaphors to codify development process.

## 2 Concept Map in Design Process

Learners (designers) in design and technology need a range of abilities and skills- the same abilities as designers and technologists in real life do (Petrina, n.d.). Lawson (1990) believes designer should own a good understanding of the technology in his field, a well-developed aesthetic appreciation, and an understanding of the project users' needs as they are involved in knowledge intensive process - turning the idea into product that creates experience. Concept Mapping was tested to 66 design and technology learners. The goal was to create an interactive multimedia application that stimulates creativity and expression using digital media technology. The application must apply user experience goals and usability principles, while CM was introduced in conceptual design. The process follow through threes stages; *The Knowledge Elicitation Method* (Ford and Sterman, 1997); The *Positioning Phase*, *Description Phase* and *Discussion Phases*.

### *2.1 The Positioning Phase*

The Positioning Phase is where context and goals is established. Learners explore the design problem by going deep into the subject matter. This involved research on the problems by conducting precedent studies on what others have done, find similarity and differences from various solutions. Learners were involved in knowledge elicitation process by actively building domain knowledge. The understanding was then illustrated in concept map as a structure or 'organizers' of information. The relations among nodes connect the construction of tacit understanding. The theory deals with organizing information for easy retrieval. However, various versions of concept maps were produced to formulate the final focus on the domain knowledge. Learners went through a process of information seeking as a series of thoughts, feelings and actions described by Information Search Model (ISP) by Kuhlthau. Table 1 summarized the context formulation process elicited using CM and mapped to ISP model.

| INFORMATION SEARCH PROCESS (KUHLTHAUS'S MODEL) | AFFECTIVE LEVEL: FEELINGS | CONTEXT |
|---|---|---|
| 1. Initiation | Uncertainty | The problem of pain |
| 2. Topic Selection | Optimism | Physical type, Mental type, Spiritual type, Emotional type |
| 3. Prefocus Exploration | Confusion, Frustration and Doubt | Negative Consequences of Pain, Positive Consequences of Pain |
| 4. Focus formulation | Clarity | Why and How Pain make one strong |
| 5. Information collection | Sense of direction/ confidence | Why suffering is Positive |
| 6. Writing | Satisfaction or dissatisfaction | Finalized Concept Map: " When I am Weak, Then I am Strong" |

**Table 1:** Carol Kuhlthaus's Six Stages Model of Information Search and the context formulation using CM

With concept mapping adopted at this stage, learners implied their understanding and mental model of the subject while allowing collaborative discussion, organizing concepts and determining the relations between concepts more clearly and focus, aware of main ideas and supporting detail, understand the relationships between them, and are able to use them appropriately. Learners whom struggling to create a good CM was themselves engaged in a creative process that promotes creative thinking. As a result, a clear understanding of knowledge domain gained from the CM has positively contributed to the visualization of idea in the next phase.

### *2.2 The Description Phase*

The Description Phase is where visual description (see visual in your mind) formulated from The Positioning Phase. It will be supported by verbal description, textual and graphic including design of the interaction that will take place. CM benefits from explanation or by telling a story. Conversely, telling a story paints a picture; it creates a model in the mind of the listener. As such, CM became a planning tool or as an alternative to essay writing, storytelling and storyboarding. Figure 1 explained metaphors used to indicate the domain knowledge of 'obstacles of life'. The two main relations - situation and indication, link its main concepts. As an example- the situation where the sheep turned into a wolf indicate the broken trust or betrayal of friends.

This flow of ideas creates a visual description which then turned into visualization of sketches in Figure 2. From the visualization, the digital interactive application was developed. The user interaction one has with the application defined their personal user experience. CM has become a guide to formulate domain knowledge and ideation process in this knowledge intensive process.

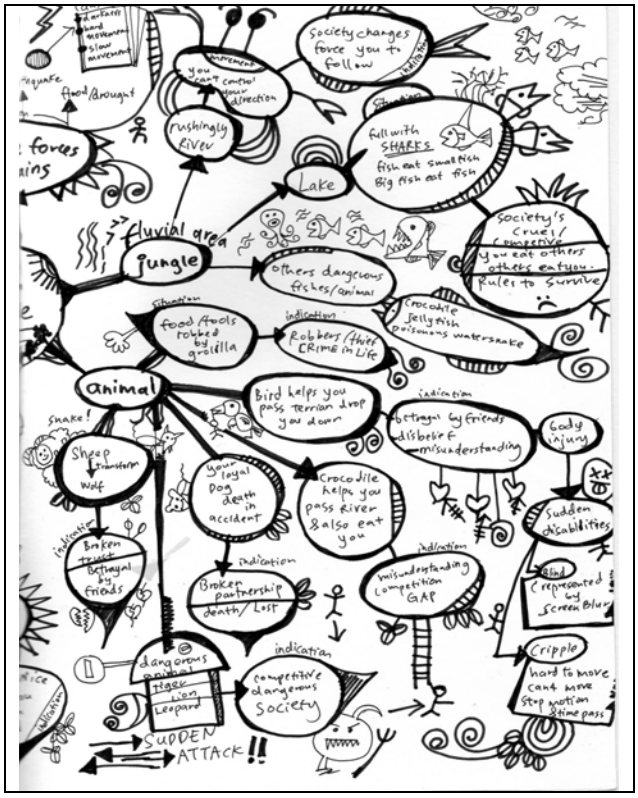


**Figure 1:** Concept Mapping on metaphor of domain knowledge

**Figure 2:** Conceptual Design to Final Application

### *2.3 The Discussion Phase*

The Discussion Phase is where discussion takes place iteratively in between Positioning Phase and Description Phase. Tacit knowledge is externalized in CM, shared with others, internalized feedback and refined design process. This phase executes the full knowledge cycle of SECI model by Nonaka – Socialization, Externalization, Combination and Internalization.

| **Knowledge Process** | **Learning Activities** |
|---|---|
| ***S**ocialization* | Learners communicating and exchanging their idea verbally, either with peers or teachers. |
| ***E**xternalization* | Learners presented their understanding in explicit artifacts – sketches, photographs, written, video, diagram and *concept mapping.* |
| ***C**ombination* | Explicit artifacts are use as a mean of communication, discussion and exchanging ideas between teachers and learners and between learners and learners. |
| ***I**nternalization* | Verbal critique and formative evaluation conducted, the feedback will help learners to improvised and make decision on their design |

Table 2: SECI model and learning activities in multimedia development process (Khalid, Woods and Rafi, 2006)

## 3 Results

To gauge the use of CM in conceptual design of knowledge intensive process, a questionnaire with Likert scale of 1 to 5 distributed to 66 participants. The result has demonstrated a positive acceptance of using CM in design process (Table 2), particularly in building domain knowledge and storytelling of ideation process. The use of CM in relating every concept involved in the domain knowledge scores the highest. It also allows knowledge construction and elicitation process been conducted from various perspectives. Thus, learners became more aware of main ideas and supporting ideas involved in the domain knowledge while raise their confidence level for verbal explanation.

| **CONCEPT MAPPING IN DESIGN PROCESS** | **Mean** |
|---|---|
| **Domain Knowledge Construction** | |
| CM allows to see how things relate to each other | 3.85 |
| CM helps to see things from various perspectives | 3.80 |
| CM allows awareness of main ideas and supporting ideas | 3.77 |
| CM support verbal explanation | 3.77 |
| CM helps understand better of the domain knowledge | 3.72 |
| CM useful in visualizing thinking | 3.72 |
| CM allows to see things critically | 3.67 |
| CM helps organized thoughts | 3.62 |
| CM freely expressed thinking | 3.55 |
| CM allows to focus on the domain knowledge | 3.55 |
| CM helps defined problem definition and preparation | 3.52 |
| CM allows easier collaboration | 3.43 |
| **Ideation Process** | |
| CM can be a storytelling to explain ideas | 3.65 |
| CM helps to focus the ideation process | 3.55 |
| CM helps ideation flow | 3.55 |
| CM in ideation process can guide visual development | 3.53 |
| CM become a constant reference to stay focus with idea developed | 3.48 |
| CM encourage critical thinking | 3.47 |
| CM helps to demonstrate understanding | 3.42 |
| CM function as a graphic organizer of content | 3.22 |

Table 3: Results of the Questionnaire

Accordingly, CM in ideation process shows the highest mean that CM can be a storytelling to explain idea. CM too function as a guide to visual development while became a constant reference to stay focus with the idea developed.

## 4 Future Work

Knowledge intensive process or activities are the essence of research and development (R&D) organization. Researchers and engineers collaborate in knowledge-intensive work that involves significant number of informal communications. However, this knowledge are rarely capture formally. Based on the above experiment with CM in conceptual design process, CM thus proposed as a personal knowledge tool that encourages problem-solving skills to support knowledge-intensive processes in R&D organization.

### *4.1 Concept Map and Collective Intelligence*

As a part of Community of Practice (CoP), members will connect together and share their CM in '*Think Space*' to form collective intelligence. '*Think Space*' allow groups to learn faster, visualize new possibilities, and reveal tacit knowledge (Figure 3) within and across community. The Collective Intelligence will be a foundation to build knowledge model as a mean of sharing knowledge among domain experts and users. CM will be shared collaboratively on the network and link to other maps as sharable content objects.

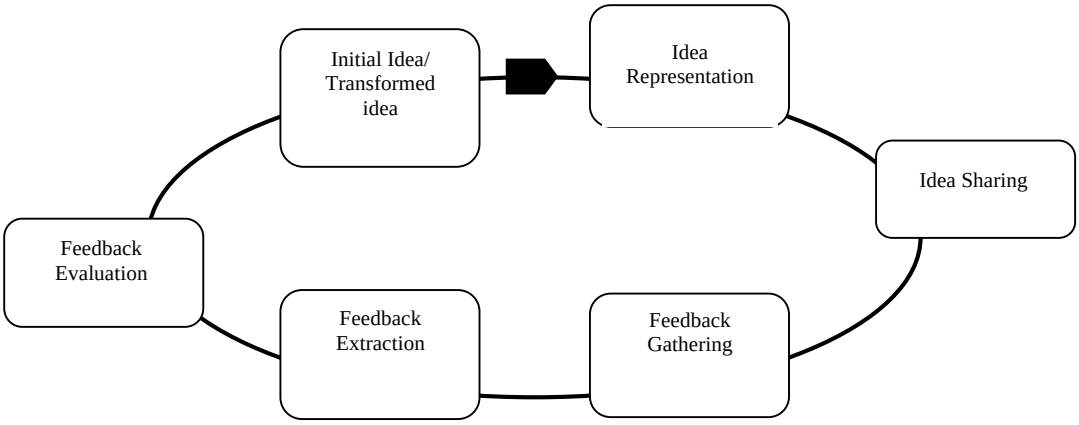


**Figure 3:** Personal Knowledge and Collective Intelligence

## 5 Summary

This paper has discussed and suggested CM contribution in knowledge incentive process. CM has demonstrated best in domain knowledge construction and elicitation process. It allows deep understanding and exploration of domain knowledge while encourage critical thinking. CM too functions as storytelling and guide ideation process. Both phases are shared similar doings with the front end of innovation process. Thus, CM can benefit research and development organization by encourages collective intelligence of shared CM to enable rich knowledge sharing among community.

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