TRANSFERRING TACIT KNOWLEDGE INTO EXPLICIT:

A CASE STUDY IN A FULLY (SEMI) AUTOMATED PARKING GARAGE

Haytham B. Ali, Fahim A. Salim
A Faculty of Technology, Natural Sciences and Maritime Sciences,
University of South-Eastern Norway
Haytham.Ali@usn.no Fahim.A.Salim@usn.no

ABSTRACT

Academia cooperates with industries within research through what we call applied research. Industries realize that the knowledge management process is vital for a competitive advantage and survival. Within applied research, we strive to transfer tacit knowledge into explicit.

In this paper, we aim to explain and understand tacit knowledge from two perspectives-, i.e., the philosophical and sociological perspectives. We illustrate the philosophical perspective through Michael Polanyi's model of tacit knowledge, where we consider the sociological perspective through Harry Collins's classification of tacit knowledge.

However, Collins state that not all types of tacit knowledge can be converted to explicit, where we believe that we can generally transfer all types of tacit knowledge using Systems Engineering and Systems Thinking.

Further, we explain Nonaka and Takeuchi's model of knowledge creation. We adapt this model to transfer tacit knowledge into explicit in terms of data and visualization knowledge through a use case study. We apply mainly Systems Thinking and its tool, i.e., Systemigram, for this transformation. The outcome of the use case study encouraged us to believe that Systems Thinking and its visualization and communication tool could aid at preserving and managing the tacit knowledge. In other words, this paper also is an attempt to add the Systems Thinking and Systems engineering perspective to the body of knowledge.

INTRODUCTION

All knowledge is tacit in its origin (Polanyi, 1966). Thus, transforming tacit knowledge into explicit in terms of data is crucial for both academia and industries. Academia cooperates with industries within research through what we call applied research. Industries realize that the knowledge management process is a vital factor for a competitive advantage and survival. Grab et al. emphasize two types of knowledge from the epistemological perspective – i.e., ("know-how") and ("know that") (Ghrab et al., 2017). Know-how, also called procedural knowledge, is the capacity to conduct an action (Dudek & Patalas-Maliszewska, 2016; Ghrab et al., 2017). An example of know-how is knowing how to do something, e.g., ride a bicycle (Fantl, 2012). While Know-that, also called declarative knowledge, shows the relation between a thinker and a proposition and attaches a truth value to the proposition (Dudek & Patalas-Maliszewska, 2016; Ghrab et al., 2017). An example of know-what is knowing some correct facts, e.g., Plato said, "I know that I know nothing" (Fantl, 2012). In this paper, we aim to understand the concept of tacit knowledge, focusing on how we can transfer it into explicit in terms of data and visualization using Systems Thinking and its tool, i.e., Systemigram.

KNOWLEDGE TAXONOMY

Many researchers classify knowledge into two main types – i.e., explicit knowledge and tacit knowledge (Collins, 2010; Nonaka, 1994; Polanyi, 1983).

Explicit knowledge is that knowledge that we can articulate, codify, and transfer into, for example, symbols or natural language (Alavi & Leidner, 2001). Harry Collin calls such a medium for transformation a string (Collins, 2010). Collins concentrates half part of his book, i.e., "Tacit and Explicit Knowledge" on strings as a concept.

A string is a physical object and has patterns recorded on it. For instance, a picture is a pattern of ink recorded on paper, and words are patterns recorded on compressed air. Collins differentiates between transferring a string and translating a language.

Transferring a string occur through physical contacts, such as transferring the electric current into pixels' s patterns recorded on the screen. Collins also makes a distinction between analog strings and digital strings. Transferring an analog string needs human judgment and depends on its physical properties. In contrast, we can transfer digital string into explicit patterns or steps or both without losing its information. Thus, we can transfer knowledge into explicit knowledge when we transfer it into a digital string (ibid).

Tacit knowledge has a property of personal quality and is embedded in the action, involvement, and commitment within a particular context (Nonaka, 1994). Tacit knowledge is tough to articulate as it attributes mental models, personal skills, and "know-how", which are deep-rooted in individuals (Polanyi, 1983).

In the following two subsections, we aim to discuss the nature of tacit knowledge from two perspectives-, i.e., the philosophical and sociological perspectives. We illustrate the philosophical perspective through Michael Polanyi's model of tacit knowledge, where we consider the sociological

perspective through Harry Collins's classification of tacit knowledge.

Polanyi's model of tacit knowledge

Michael Polanyi's famous statement that describes "tacit knowing" is "we can know more than we can tell" (Polanyi, 1983, p. 4). Polanyi defines the tacit knowing within two terms-, i.e., the proximal and distal terms.

The proximal term indicates the features that lead to recognizing the things we know, e.g., features for an individual's facial attributes.

The distal term suggests the meaning of these features, e.g., identifying the individual's identity.

Further, Polanyi illustrates the comprehensive entity as the combination of both terms, i.e., the proximal and distal terms within the development of tacit knowing. When this combination occurs, it is hard to recognize one of these two terms individually.

Polanyi illustrates losing the features' meaning scene when we pay attention to them individually detached from the comprehensive entity. For instance, if we pay attention to a family member's face features, the face becomes rapidly strange or uneven. This impact of uncontrolled clarity results from not being aware of the proximal term in isolation of the comprehensive entity (Polanyi, 1983, pp. 16–19).

Collin's classification of Tacit knowledge

Collin emphasizes tacit knowledge in the second part of his book- i.e., "Tacit and Explicit Knowledge" after defining eight definitions of cannot. Harry Collins describes tacit knowledge within the following three classifications: (1) Relational tacit knowledge, (2) Somatic tacit knowledge, and (3) Collective tacit knowledge.

Collins distinguishes between relational and somatic tacit knowledge on the one hand and collective tacit knowledge on the other hand regarding transferring tacit to explicit knowledge. We can generally transfer relational and somatic to explicit knowledge where we struggle more (cannot) to transfer the collective to explicit knowledge (Collins, 2010, p. 11). Table 1 shows that by classifying the strength of these three types of tacit knowledge regarding the ability to transfer it to explicit knowledge (Collins, 2010, p. 85).

Table 1 Comparison of Collin's tacit knowledge classification

Tacit knowledge classification	Strength	Nature	Transferring to explicit
Relational Tacit Knowledge (RTK)	Weak	Inherent in the uncertainty of the social life (social interaction)	Can be transferred to explicit
Somatic Tacit Knowledge (STK)	Medium	Implicit in human's body and brain nature	Can be transferred to explicit, in principle
Collective Tacit Knowledge (CTK)	Strong	Based on human society's nature	Can't be transferred to explicit

Nonaka and Takeuchi's model of knowledge creation

Nonaka and Takeuchi's model is an important model that shows how organizations, including industry and academia, can preserve and manage their knowledge, especially tacit knowledge. This preservation we can manage through converting tacit knowledge to explicit. Fig. 1 depicts the knowledge creation model, also called the Socialization, Externalization, Combination, and Internalization (SECI) model. This model demonstrates the knowledge transformation process. This knowledge arises due to social and intellectual processes (Chergui et al., 2020; Nonaka, 1994). There are four modes of knowledge transformation:

Socialization (from tacit to tacit knowledge): This knowledge includes the interaction between induvial within a specific group. Learning arises by sharing experience, observation, and imitation.

Combination (from explicit to explicit knowledge): This mode permits explicit knowledge formation. This formation is created through deduction or induction of a set of items that is restructured. These items comprise the explicit knowledge that has already been captured.

Internalization (from explicit to tacit knowledge): These modes transfer explicit to tacit knowledge. This transformation takes place through the "learning by doing" learning process.

Externalization (from tacit to explicit knowledge): This mode comprises explaining practices and beliefs. This mode transfers tacit knowledge to explicit concepts. Those concepts include, but are not limited to, hypotheses, concepts, and models (ibid).
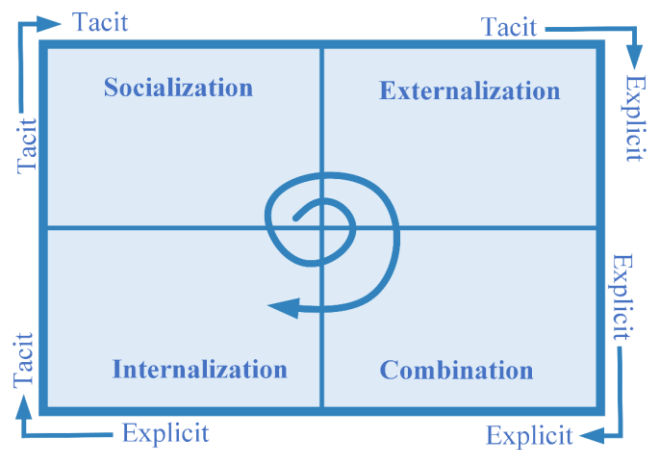

Fig. 1. Nonaka and Takeuchi's model based on (Nonaka, 1994)

RESEARCH METHODOLOGY

We used industry-as-laboratory as our research method (Potts, 1993). However, we also adapted case study research (Yin, 2012). We have a multiple-case design that is embedded (have multiple units of analysis). We attempt, in this paper, to highlight one of the analysis units within a one case study within an extensive research project.

We conducted workshops, semi-structured interviews, and informal interviews with the Company management and technicians, including service personnel (Longhurst, 2003; Moeller et al., 1980).

CASE STUDY

Our research is a part of a more significant research project called H-SEIF2.

H-SEIF2. H-SEIF stands for "Harvesting value from Big data and Digitalization through a Human Systems-Engineering Innovation Framework" (H-SEIF 2, 2020). In this project, we aim to enable data-driven methodology decisions within the early design phase of the product development process.

Company. A Company that delivers fully automated parking garages, including maintenance, primarily for land developers and building owners. The Company is transitioning from only selling to developing, producing, and marketing.

We have conducted a feasibility study for the Company's case study. We applied Systems Thinking and its tools for early validation of the value proposition. These tools included stakeholder analysis, context diagram, CATWOE, and Systemigram (Ali, "in press", 2022). The aim of this early validation is to articulate the tacit knowledge at an individual and collective level from both academia and Company.

The collective level is triggered as we are a group of researchers and key persons from the Company that worked together through workshops, interviews, and on-site observations.

Transferring Tacit Knowledge into Explicit Externalization mode using Systemigram & digital platforms

Systemigram. Systemigram also called a systematic diagram, is a Systems Thinking tool. Systemigram is a conceptual model representing a system structure with nodes and links in terms of storytelling. The nodes are mainly nouns, and links connect these nodes in an explanatory way (Boardman & Sauser, 2008).

Using Systems Thinking and its tools also aims at visualizing the Externalization mode of knowledge

Based on the workshops, informal interviews, and on-site observation, we have developed a Systemigram. This Sytemigram is transferring the externalization mode that is tacit to explicit. We have also communicated the Systemigram
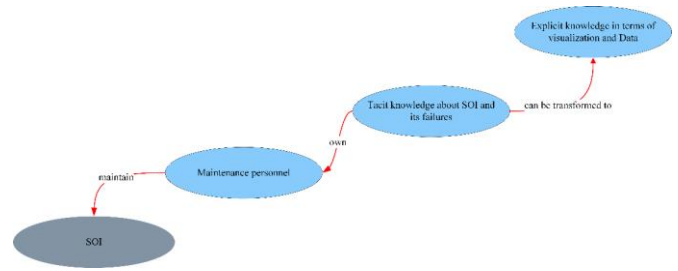

Fig. 2. Transferring tacit to explicit knowledge using Systems Thinking's tool, i.e., Systemigram showing the paper's focus

with the Company, and we have validated it through several iterations.

Fig. 2 shows part of this Systimgram. This part includes one node from the mainstay, i.e., the dark-grey blue node. In addition, Fig. 2 depicts the part we focus on in this paper. A more detailed Systemigram and its analysis can be found at (Ali, 2022). Ali (2022) visualizes the full version of Systemigram. The full version represents the case study definition. However, this paper focuses on one embedded unit of analysis within this case study. This unit has red lines and light blue nodes in Fig. 2. The dark grey-blue node is part of the main story, also called the mainstay. The mainstay is diagonal and presents the central message of the Systemigram.

The mainstay represents the case study definition. We can read the red line that represents the mainstay for this paper as follows: "*Maintenance personnel maintains System Of Interest (SOI) that own tacit knowledge about the SOI and its failures that can be transformed into explicit knowledge in terms of data and visualization.*" We refer to the fully (semi) automated parking garage as our SOI.

Systemigram is an attempt to transfer tacit knowledge into explicit knowledge in terms of data and visualization.

Digital platforms. We have also used digital interactive boards such as Miro as a tool to transfer tacit knowledge (Miro, n.d.). We apply Systems Engineering methodology and tools to develop the digital board. We have conducted several workshops with the Company and other industry partners. We articulated the tacit knowledge immediately within these workshops using Miro and its visualization tools, charts, and graphs.

Using digital interactive and dynamic board and its visualization tools, we transferred mainly the externalization mode and partly the socialization mode into explicit knowledge. All participants could also articulate their tacit knowledge using digital post-it within the workshops and interviews. In addition, the researchers articulated the conversations immediately using the digital, interactive board. Due to confidentiality, we cannot show examples of using the digital board as a tool.

DISCUSSION

Collin argues that we cannot transfer Collective Tacit Knowledge (CTK). We think that this is a very strong argument from our research field perspectives; Systems Engineering and Systems Thinking. In our research, we must

always take the context into account. In this case, we must make the social and cultural context explicit. There is a limit to how well we can do this, however, cannot sound too strong. One of the tools we use in this context is stakeholder analysis, context diagram, and so forth.

Further, we observe that it is hard to have a clear distinction between the different tacit knowledge modes and classification. Thus, there is a need to look at Tacit Knowledge from a new perspective and include other views and definitions in the body of knowledge.

We aim to support the articulated knowledge using data analysis results of the maintenance record data collected from the Company. Further, we can measure the efficiency of using Systemigram and digital interactive board to articulate the tacit knowledge using the analysis results.

CONCLUSION

In this paper, we aim at understanding and explaining tacit knowledge, focusing on transferring tacit knowledge into explicit in terms of visualization and data. We discuss knowledge taxonomy from different perspectives, including Polanyi and Collins's perspectives. We further adapt Nonaka and Takeuchi's model for transferring tacit knowledge to explicit. We articulate mainly the externalization mode of tacit knowledge for a real industry problem.

We use Systems Thinking approach and its tools, i.e., Systemigram, for transferring the externalization mode of the tacit knowledge into explicit knowledge. Additionally, we use a digital interactive board and its visualization tools to transfer mainly the externalization mode and partly the socialization mode of the tacit knowledge into explicit knowledge.

The quality of the articulated knowledge, also called explicit knowledge, affects the quality of the decision-making process based on this knowledge. Thus, conducting these tools within several iterations is essential. Further, preserving and managing the knowledge within the organization is crucial for success for academia and industry.

FURTHER WORK

We aim at analyzing the maintenance record data where the maintenance personnel manually log the failure events. Further, we aim to support the articulated knowledge using the digital, interactive board, Systems Thinking, and its tools, focusing on the Systemigram by the data analysis result. We can verify, validate the articulated tacit knowledge by the data analysis, also by combining several data sources, also called combination mode. Further, we aim at monitoring the working process, including the maintenance process, and develop an ontological model to articulate tacit knowledge, i.e., internalization mode. This monitoring can be conducted using observations, interviews, and recording videos of the maintenance process.

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