

Full Length Research Paper

Knowledge creation in operational setting: a case study in Auto Manufacturing Firm

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These days, organizations concentrate on knowledge creation to improve their innovative processes (such as new product development) as well as routine activities. The process of knowledge creation has been vague before the evolution of the SECI knowledge creation theory, which was widely accepted, validated and implemented in several research fields. This research concentrates on the evaluation capability of this theory, and introduces the use of SECI theory to examine organizational practices. The assessment framework is developed upon the literature review and implemented based on content analysis method. The results of using this method for assessing a process audit in a car manufacturer, has helped researchers to identify the role of different activities in a process audit, and evaluate the role of each activity in creating working knowledge for the organization. Any divergence to the original consequence proposed in SECI theory has been analyzed, and some improvements are proposed to bring the sequence back to what is proposed in knowledge creation theory.

Key words: Knowledge Creation, SECI Theory, Automotive Industry, Knowledge Creation Assessment.

INTRODUCTION

New paradigms are emerging in the world of management repeatedly; each expected to add some new perspectives to what academicians and practitioners have known about the concept of organizational management. Since its inception, knowledge management has been one of the main concerns of organizations, software developers, and economists, among others. (Riera et al., 2009) This pinpoints the need to expand it to be used in an important organizational area like diagnosis.

Over the past years, knowledge has been identified as one of the most value-adding assets of organizations (Choi and Lee, 2002) which could be used to create competitive advantage (Nonaka, 1991, 1994; Nonaka et al., 2000a, 2000b; Nonaka and Takeuchi, 1995; Nonaka and Konno, 1998; Nonaka and Ichio, 2007; Gholipour, 2010). Organizations concentrate on knowledge creation activities during their improvement projects in order to win the competition via more innovative product design, lower

costs, and higher quality (Alam, 2009a). As a result, the knowledge creation process has become a highlighted issue for organizations (Nonaka et al., 2000). Although the researchers has been identified the need for clarification of the knowledge creation process (Nonaka et al., 2000), this process has been vague even by the evolution of SECI knowledge creation theory Their work has been widely accepted, validated and implemented in several research fields (Nonaka et al., 1994; Chou, 2005) and explained more and more in different cases by different researchers (Choi and Lee, 2002). While some researchers have focused on evaluating knowledge management capabilities of organizations (Afrazez, 2010), the knowledge creation capability is not mentioned in particular. This research concentrates on the evaluation capability of this theory, and introduces the use of SECI theory to evaluate organizational practices.

SECI believes that knowledge is created in the organizations by the continuous interactions of tacit and explicit forms, which are called knowledge conversions (named Socialization, Externalization, Combination and Internalization, which form SECI by their initials) doing these conversions in sequence is shown by a spiral

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which introduces the idea of knowledge elaboration in the organization (Alam, 2009b). This theory states that the failure to establish these exchanges in the aforementioned order in organizations can cause problems in the knowledge creation process (Nonaka et al., 1994). Since for effective knowledge creation, the current knowledge creation situation should be identified, and if the sequence was inappropriate (due to the SECI theory), the knowledge spiral is incomplete, and as a conclusion knowledge creation could be improved (Alam et al., 2010). Many researchers have focused on the importance of Knowledge Creation in Automobile Industry, although most of them are concentrated on New Product Development (NPD). Ichijo and Kohlbacher (2007) are one of the few researchers focused on the "Toyota way" of knowledge creation in the leading car manufacturer, while "the mainstream of the Toyota literature has hardly touched the fundamental issues of knowledge sharing or organizational learning as key drivers behind Toyota's remarkable achievements". Ma (2007) focuses on knowledge generation process of a racing car manufacturer and its suppliers in the Italian motorsport industry, which he claims is very essential for remaining the leader. Dyk et al. (2005) studies knowledge creation in new product development process from a car manufacturer, and analyzes the relative amount of intra organizational knowledge transfer occurring during periods of product redesign with the amount of knowledge transfer occurring during steady-state periods. Most of Nonaka's cases are also based on car manufacturing industry (i.e. Honda example of designing Civic in (Nonaka, 1991). This emphasis is not strange, because car manufacturers play a vital role in most economies all over the world. In this article, authors have reviewed the literature to build a framework for assessment of knowledge creation in car manufacturing context. This article introduces a graphical representation of the status of knowledge creation in organization's activities in combination with statistical analysis and qualitative inferences. This assessment is tested in one of the widely used activities in an auto manufacturer as case study. By this model, the bottlenecks of knowledge creation has been identified and reported, which means that they complete the SECI knowledge spiral.

LITERATURE REVIEW

Although there could be found a lot about the importance of knowledge creation, the fundamental theories describing how this knowledge is created by the organizations, are yet a few (Soo et al., 2004). One of the most referred one is the SECI theory, which is first introduced by Nonaka and Takeuchi (1994). Known by Nonaka's theory of knowledge creation, or "the knowledge spiral", SECI theory focuses on the continuous interactions involving tacit and explicit knowledge (Nonaka, 1994; Nonaka and Konno, 1998; Nonaka and Takeuchi,

1995). As Polany (1966): defined:

"Tacit, implicit or informal knowledge refers to the subjective insights and intuitions, which generally is derived from experience. As it is developed "on-the-job", and as a part of the formal organizational task, it is difficult to formalize or express."

"Explicit knowledge on the other hand is the codified knowledge, which could be expressed and shared easily. It mainly could be found in the organizational routines and documents".

According to SECI theory, four form of interactions, or as theory implies "knowledge conversions", could be supposed for these two form of knowledge (Figure 1) which are supported by the related organizational context (Ba) (Nonaka and Takeuchi, 95). The first step mentioned in the model, is Socialization, which is the exchange of tacit knowledge into tacit. This mainly involves sharing tacit knowledge among different persons from different department with different backgrounds. The result of this stage is a shared mental model. Following this step, doing Externalization is suggested, which means tacit to explicit knowledge exchange. In this step, based on the shared mental models, a concept is created which needs to be justified in the next step. Combination step which follows concept building, causes the detailed examination and setting the relevance of concepts in according to the previously existing concepts. This concepts are mainly found in the organizational documents, as the explicit knowledge. The final stage, which includes explicit to tacit knowledge exchange, is Internalization. In this stage the justified concept should be converted into a tangible result, as explicit form. This could be done as building prototypes, training employees, or any kind of exhibitions. This theory implies that knowledge creation is multiplied when all of the four conversions are actively pursued and reflected against each other. (Nonaka et al., 2000) It also suggest that this spiral could be continued many times, but also could be elaborated through cross-leveling mechanism, (Nonaka and Takeuchi,95) which means the created knowledge could be dispersed through the organization, and triggers the new spirals in the other context. This theory also explains about the context of knowledge creation (called "Ba") and the knowledge enablers which facilitate knowledge creation through the organization. (Nonaka,94)In summary, SECI states that the company using existing knowledge assets (as the input, output and moderator of knowledge creation process); creating new knowledge through the SECI stages that take place in ba; where facilitates the process. Once Knowledge is created, becomes in turn the basis for a new spiral of knowledge creation.

Background

Researchers believe that a failure to build dialogue

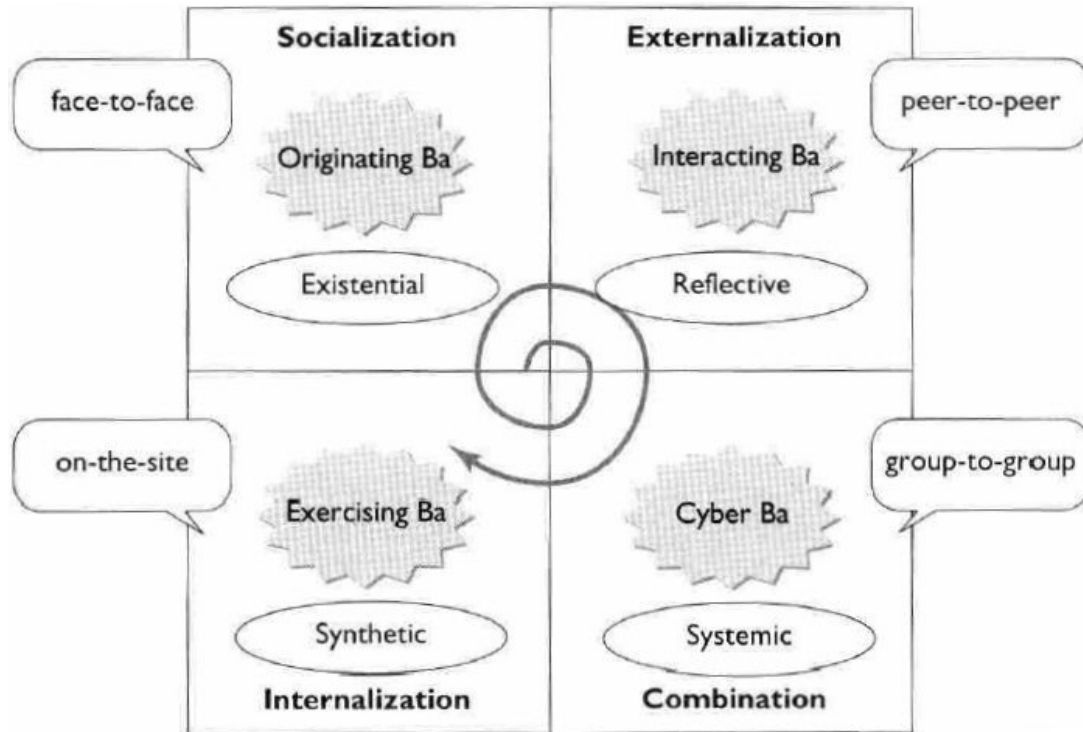


Figure 1. Knowledge Creation Process known as SECI process (from Nonaka and Konno, 1998).

between tacit and explicit knowledge can cause problems (Piera et al., 2007). The SECI proposes a consequence for these conversions includes Socialization, Externalization, Combination and Internalization. In response to this proposed consequence, the researchers suggest an assessment method based on this theory.

This study uses explanatory case study to build a framework for visualization and evaluation of Knowledge Creation Spiral in the manufacturing context. According to Yin (2003), case study research is preferred when the phenomena which is under study, could not distinguished from the context. As knowledge creation is a context-based process (Nonaka et al., 2000) and the context (which is named "Ba") has a remarkable role in knowledge creation. This proposes the application of this research method is appropriate. The case is one of the widely used quality practices in the shop floor level in a auto manufacturer, named as process audit. The auto manufacturer is the biggest Iranian auto manufacturer, based on the production capacity and also income level. This company is also a leading company in using new management methods, such as quality management. The practice which was selected, has been implemented for more that 8 years, So company has had a lot of experience in implementing it. This audit is mandatory in projects such as new product development, new production line (increasing capacity), or adding new features on an existing product or process, and satisfies the requirements of the foreign licensing body. By passing

this audit, the licensing company is assured of quality characteristics in the new implemented production line in the Iranian auto manufacturer. This audit enables company to perform corrective or preventive actions in the right time, to correct the errors or to protect the project from the negative effects of possible errors.

This audit is planned in the early stages of new product development project. In the specified time, the quality member of the NPD team, who is responsible for this audit, forms a cross-functional team which is responsible for the results of audit. Team members discuss and form the project scope and define the time line. They also define the items of the audit and their relative audit time based on their previous experiences. They assess these items in the specified phase, and report to the team, based on the observed nonconformities, corrective actions shall be taken. These new actions are going to be followed up as a part of the main project.

This project was ideal for tracking knowledge creation, due to some aspects. First of all, company had a lot of experience in performing process audit, which means the experience (knowledge stock) is enough. As the second factor, as documentation is one of the requirements of ISO 9000 system in the company, a huge amount of previous practices was documented which was accessible for the researcher. As the third point, the audit is forced by the licensing company who is the strategic partner of the company, which means company cares about the complete implementation of this practice. Another

important factor includes the responsibility and the leading role of this practice, which was dedicated to the quality assurance department which makes data and experience centrality in this organizational unit. As this practice is well-structured, and the requirements are specified using a checklist and an organizational procedure is maintained. Also, at the time frame of this research, this project was currently under implementation in a new production line, so the researcher could follow and participate in the actions. And the final point which is really important, this project is a part of NPD project, which is the classic example of the SECI model. This makes this audit as an ideal case, because the comparison with the literature is possible.

In this research, assessment of knowledge creation has been done by comparing the characteristics of each stage in SECI theory with all tasks of this activity. Organizational audit, which was the main concentration of this research, is called process qualification (PQ) in the shop floor, and has been done as one of main quality practices in the new product/production line development. This audit is planned by defining some certain mile stones, checking certain achievements of project in terms of documents and other evidences (including shop floor audit and worker observation) in a pre-scheduled plan.

Process Qualification consists of four main phases, which could be depicted as follows. The first phase is Project Initiation, which includes receiving the starting letter with the required documents, scope definition, and team formation. The second phase is named Audit Planning which includes defining the required items, planning the schedule, responsibilities, and the requirements and the reporting schedule. Monitoring the progress is the third phase of this practice. In this phase each item is implemented, and the documentation is completed. Also items are accomplished in the shop floor, and evidence and information are provided to review and verify each item and review the progress in the work group. Corrective or preventive actions are defined in follow up sessions according to the situation and the performance is reported on a regular basis. The last step requires all the items to be closed, and means the production line is ready for transformation to the mass production phase.

METHODOLOGY

In order to satisfy the validity criteria of the research method, in this section the researcher provides some details of research method, especially data gathering and analysis phases.

This paper follows a qualitative research method. The data is gathered through studying the documents and records of PQ, the aforementioned organizational practice. This study enabled researchers to build a standard list of tasks done in the practice. This list (which was formed hierarchical as a Work Break-down Structure (WBS)) played a central role in the followed interviews. Many field interviews with the corresponding team members were done in order to complete the document review phase. Each interviewee was asked to talk about the results and the expected

outcomes of each task in the WBS. Also, the exceptions and failing experiences were mentioned. Researchers were also present at some of the meetings, discussions, analysis sessions and audits of the team, and played the role of an observer, and asked some vague points after the events. This interviews and observations were targeted to be semi-structured data gathering process, and it was founded on a definition of knowledge as "workable information resulting from the process" (Ghanbartehrani, 2008). As researchers were not allowed to record the voice in the sessions, they took notes based on prepared note pages, declaring the WBS of the project.

Berg (2008) believes, interviews, field notes, and other types of qualitative data could not be analyzed unless the content is transformed to a meaningful manner. The method helped researchers to extract the information and analyze them, was Content Analysis (CA). As Holeski explains, content analysis is "any technique for making inferences by systematically and objectively identifying special characteristics of messages" (Berg, 2008). This method categorizes the components of a message into the pre-defined classes by the help of a coding protocol, and analyses the conveyed information by counting these frequencies and applies different statistical tests on them. CA includes 5 main steps (Riffe et al., 2005):

1. Define the problem and objectives, hypothesis or research questions
2. Define the coding protocol based on operational definitions
3. Define the analysis component or unit, and sampling method
4. Data gathering and coding
5. Analysis coding data and conclusion

As previously described, the main objective of this research is the identification of knowledge creation steps in the routine process of an organizational practice, and then the analysis could help to check the conformity with the SECI process.

According to the content analysis method, these data were analyzed using coding protocol (Riffe et al., 2005). The coding protocol was extracted from the literature review, as a checklist. As reviewed by the researcher, Nonaka's theory of knowledge creation has been used as a qualitative approach to describe how the knowledge is created in the organizational context. In order to use it as a practical means to assess knowledge creation, we have to build a framework consisting of measurable/observable items. This had been done by literature review, starting from the (Nonaka, 1991) and then proceed to some recent cases describing using Nonaka's theory in different contexts. (Nonaka and Takeuchi, 1995; Nonaka and Konno, 1998; Nonaka et al., 2000a, 2000b; Piera, 2007) and the most used features in each category of S, E, C and I were extracted. A sample of the resulted characteristics for the 'I' (Internalization category) are shown in Table 1.

The coding protocol was tested with two different coders due to the reliability issue addressed by (Riffe et al., 2005) and the analysis unit was set as each task of the predefined WBS. Coders were asked to describe each task, with a stage in the SECI theory. The result showed no significant difference between them (just one of tasks 1 out of 54) was different, which was lead to convergence after a short discussion), which was interpreted that the coding protocol is reliable.

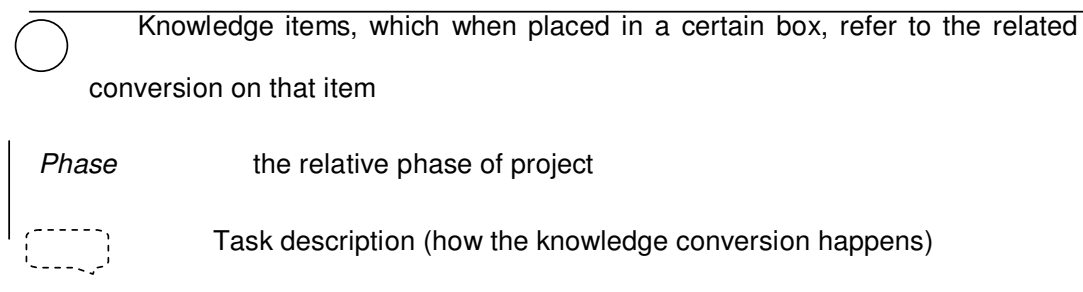
In this research, message was considered the text version of about 20 hours-interviews, conducted with the experts doing this practice in the organization for at least 3 years. These people include the quality assurance manager, and 2 of his employees, who were the head of audit teams (one has conducted 4 and the other 5 projects during his working experience in the organization) these texts were considered to bring a detailed description of the practice. Researchers also add the related organizational documents to these texts. These documents include the procedure and the forms. We used the unfilled (the raw material) and also the

Table 1. Extracted characteristics for Internalization item of SECI theory.

Definition	Item
Tacit to tacit knowledge conversion, Personal and organizational learning by applying explicit knowledge in action	i. Converting to graphs, documents, or oral presentation ii. It could be done by expressing others experiences iii. Results in experimental knowledge iv. The new achievements should be tested to be efficient v. Top manager defines some measures for this assessment vi. Redundancy of information facilitates the assessment

Table 2. Identification of Knowledge Creation Steps in the case.

Activity code	Description	KC Step (SECI)
3-1-1	Providing documentation for Each Item	E
3-1-1	Providing documentation for Each Item	C
3-1-2	Request for more Info	C
3-1-3	Implementation of Each Item	I
3-1-4	Presenting the Documents in the discussion meeting	E
3-1-5	Discussing on the documents	S
3-1-6	Request for verification	E
3-1-7	Verification of each Item	S
3-1-8	Audit of each item	S
3-1-8	Audit of each item	E

**Figure 2.** The legend of descriptive knowledge creation chart.

completed forms for the previous project as well as the ongoing one. We also added our observation from the field, and any divergence of observation from the procedures and interviews was discussed in the next interviews (as complementary material). The result of coding was entered to a table, which is shown for some items of the WBS in Table 2. As some of the tasks were matched with more than one step of SECI process, these Items were duplicated in the Table 2.

The result of this process has been depicted by a matrix, which could be seen in Figure 3. It has 2 rows and 2 columns, each dedicated to a knowledge form (tacit and explicit), which means each box shows a certain form of knowledge conversion due to SECI theory. Each knowledge item which is placed in each box means that the relative conversion is happened for that item. (that is, placing progress item in the upper left box means socialization is happened for this item, or by the other hand some tacit items of progress has been converted to the tacit items by discussion). Figure 2 provides the legend to interpret the graphical signs used in

Figure 3. As it could be seen in Figure 3, in some cases the knowledge items are converted to the other items (scope and schedule have become process and progress) which are due to the project progress. The related action has been described in the cloud attached to each item, and the project phase is also marked with the italic font next to the conversion. The arrows depict the flow of knowledge during the project.

As an example for depicting the research method, we consider the knowledge item related to the equipment. Fourteenth and thirty-first items of the checklist are related to the equipment, the first concentrates on the delivery of the equipment to the user department, and the last is about the delivery procedure. These information, cause the correct delivery and its correct future application and could be named as equipment knowledge.

In the initiation phase, the responsible people are introduced from the related departments (HR Knowledge item) which is a documented list which should be converted to the tacit knowledge of team leader to be used in the future stages. We have marked

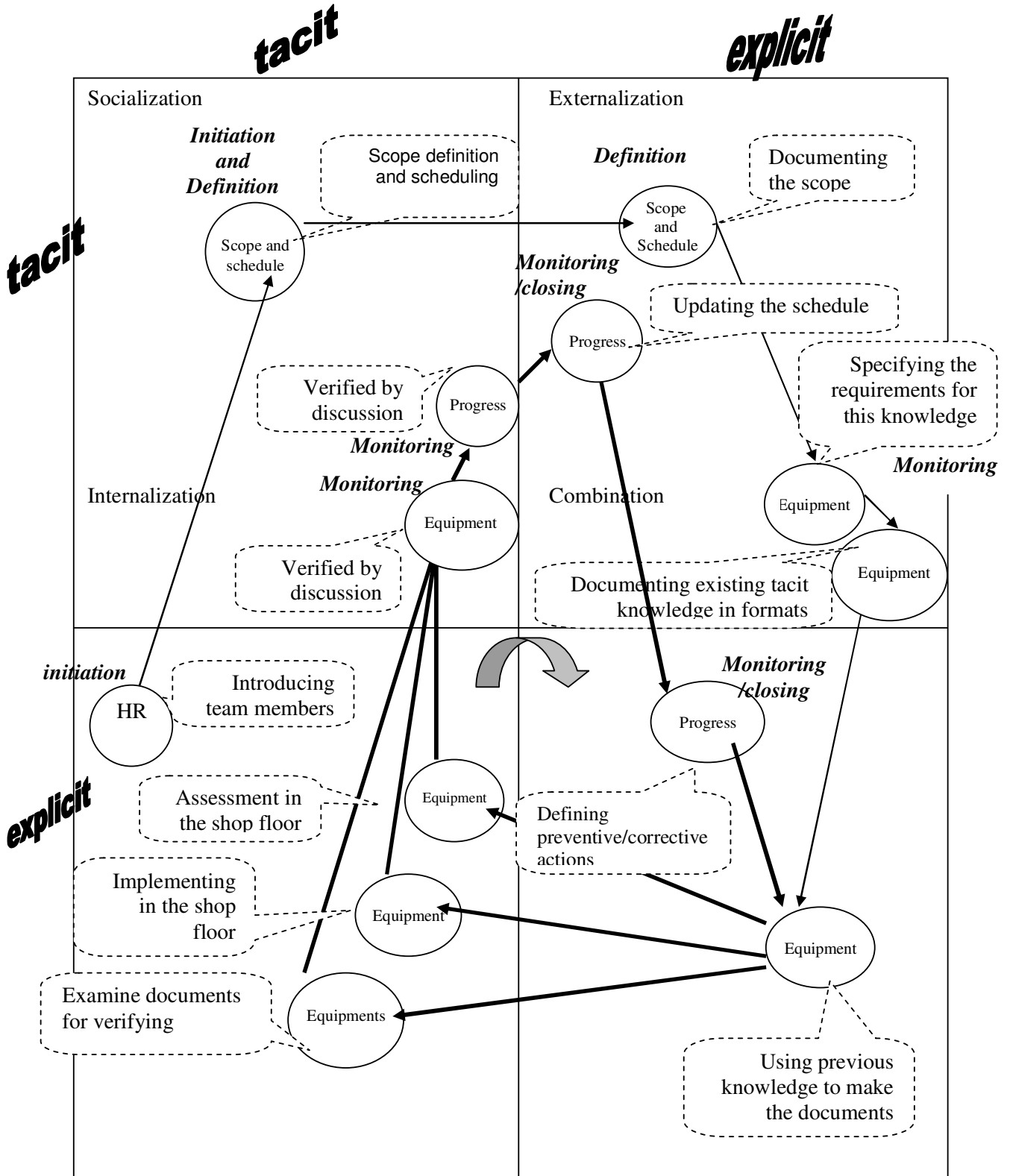


Figure 3. The graphical representation of Knowledge creation in the case study.

this conversion as internalization, which places the HR item in the lower left box.

In the audit definition phase, the scope knowledge item is created regarding the previous knowledge of personnel who invited to the

Table 3. Results of testing the randomness of sequence.

Runs test	Seci
Test value ^a	2
Cases < Test value	9
Cases >= Test value	16
Total cases	25
Number of runs	19
Z	2.661
Asymp. Sig. (2-tailed)	0.008

a. Median

Project (for instance, the team agrees on the passing criteria of this item, which could be the required documents including the catalogues, training personnel, required certificates, the responsibilities, required verifications and etc.). This knowledge item is first created from the oral conversations (socialization) which is a draft, and then documented and become detailed in the externalization phase. Next, it is converted to the specific knowledge for each item in the checklist. For example, the team agrees that which criteria are going to be satisfied for this item. This conversion makes the knowledge item different, but it is still a part of externalization conversion.

In the monitoring phase, the previously documented knowledge of organization is combined by personnel to form the required documents. This conversion is named combination in the SECI vocabulary, which places this item in the lower right box in figure 3. In the next stage, this knowledge is presented to be reviewed and verified by the specified person, which may also include the implementation and practical assessment in the shop floor. This stage is mainly internalization, but as the final verification is sometimes reached by discussing it in the meeting sessions, it also could be socialization.

So, in the monitoring phase, verification could be reached via discussion with the experts (socialization), implementing and assessing in the shop floor (internalization) or combining the existing knowledge to produce the required documents (combination).

By passing time, verifications make project progress, and the progress knowledge item is produced. This item is created via discussions (socialization) and then is documented (externalization), the verification is made through comparison with the defined scope (combination) and then it is monitored in the shop floor (internalization) and then makes another knowledge spiral in the project. These stages could be seen in Figure 3.

As could be seen in the Figure 3, an iterative cycle is detected in the figure, which works not only till the end of this project, but also it continues to work during the mass production phase. This iteration is due to the continuous improvement principle which is embedded in the shop floor due to the requirements of Quality system. This study shows that the knowledge creation steps are followed due to the SECI consequence, but during the study some evidences showed that the requirements of each step is not fully provided. In the checklist, which for example for the combination stage related to the monitoring step (for progress knowledge) just these criteria were true:

1. Depends on the previously existing knowledge
2. Structured knowledge is obtained
3. Details are very important
4. Building a model or prototype to represent the resulting process or product
5. Technocrats from different departments do the job
6. Different departments collaborate (partly)
7. Redundancy of information is required(not enough)

Table 4. The result of sequence analysis based on SECI theory.

Number of sequenced tasks (chain)	Frequency of chain
6	1
4	1
3	2
2	4
1	1

8. Business objectives (somehow vague)

There was a lack, especially in:

1. Using computer and communication networks and databases
2. Collaboration of different departments
3. Information redundancy
4. Clarity of business objectives, which connects the different expertise and technologies, and make people collaborate

These items were suggested for the better conduction of this audit in the future.

DISCUSSION

For concluding on the observation, a statistical test was done on the data to show if the sequence of knowledge creation steps in the activities (as S, E, C and I) is by accident or not. The Runs Test procedure tests whether the order of occurrence of two values of a variable is random (SPSS). The order of knowledge creation steps was set as a run to the SPSS 16, and "NPar Tests" was run. Table 3 shows the result of the test. As significance factor is less than 0.05, H₀ is rejected and it could be inferred that the sequence is not random.

As the sequence is not random, the researchers searched for the proposed sequence (S-E-C-I in a cycle, which includes E-C-I-S, C-I-S-E, I-S-E-C and any subset of 2 and 3 of them). The tasks which contained repeatedly steps (such as S-S or E-E for example) were eliminated to one, because it was assumed that the mentioned step is not completed in the first task, and is continued in the next task. Analyzing the knowledge creation sequence in practice, showed some chains of sequenced task conforming the SECI theory. The maximum sequenced tasks were 6, and just one task was out of sequence. The result of sequence analysis is shown in Table 4. This means the knowledge creation is rather not halted, but has some minor unconformities. As a result, the regarded activities were reported to the team to be reviewed for change.

As shown in Table 5, all of these chains are activated by entering some kind of implicit knowledge to the organizational practice, which is followed by Internalization or Socialization step; this emphasizes the importance of implicit knowledge in the organization. Most of these chains

Table 5. Halting analysis for the chains.

Chain	Knowledge creation process	
	Starts with...	Ends with...
1	I	S
2	I	E
3	S	I
4	S	E
5	S	E
6	S	C
7	S	E
8	S	E

are also halted by an Externalization process, which could be interpreted to the compulsory role of upper level for documentation, which could be an obstacle in the knowledge creation process. This pinpoints the need for the organizational process and technologies for facilitating the Combination step. These technologies are mainly the integrated system which could include documents, information and procedures about different production lines and products, which enable team members to integrate their formalized knowledge (output of Externalization process) in the overall organizational knowledge architecture.

There was also some inference about the frequency of each step itself, which could help the managers to facilitate the knowledge creation context (organizational Ba) for the team members. These results are not mentioned in this article.

These findings were presented in a feedback session for the managers and team members, and there were agreed that the licensing body is forcing some unnecessary documentation which interrupts their procedures. The next step is defining a new procedure for the audit, which conforms to both requirements of the licensing body and the SECI theory.

CONCLUSION AND FURTHER RESEARCH

The evidence found in this research, showed the management of shop floor that knowledge management is not only a new fad, but it is embedded in their routine activities, and could be improved by some small adjustment of procedures and the conditions. Another result of this study was adding more evidence for some small decision making issues for example which were about to add a new sharing area for some documents, to share them through the team. Due to some capacity consideration, these documents should be prioritized to be shared.

This study showed the team a clear understanding of why sharing some documents is more important, in order to utilize the knowledge creation aspect of organizational activities.

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