Increasing Transferability of Tacit Knowledge with Knowledge Engineering Methods

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Abstract: Knowledge transfer is a real challenge for organizations and particularly for those who have based their strategy on knowledge codification using knowledge engineering methods. These organizations are facing one major problem: their knowledge repository is used by few persons. Why? In this article, we identify barriers for transfer and appropriation of codified knowledge referential. We show that codified knowledge transfer should be a specific collaborative process taking into account three aspects: complexity and specificity of codified knowledge, readers' profiles, and exchange channels. Then, we propose to improve knowledge transfer process by developing new specifications for the codified knowledge to increase its transferability and by elaborating a pertinent shared context for knowledge interpretation. It is an empirical methodology which optimizes continuity between knowledge codification and knowledge transfer.

Keywords: knowledge management, knowledge transfer, knowledge capture and codification, knowledge engineering, knowledge sharing, knowledge appropriation, organizational learning, organizational memories

1. Introduction

The concept of Knowledge Transfer was first introduced by Teece (1977).

Knowledge Transfer can be defined as a process in which an organization recreates and maintains a complex, causally, ambiguous set of routines in a new setting (Szulanski 1996).

This process is a key part of knowledge management cycle and allows organizations to absorb and make optimal use of crucial knowledge.

Research on knowledge transfer focuses on three themes (Harrison and Hu 2012, Dalkir 2011, Alavi and Leidner 2001, Gupta and Govindarajan 2000, Zack 1999, Simonin 1999, Szulanski 1996, Mowery and al 1996, Zander and Kogut 1995):

- Factors which affect knowledge transfer; they are dimensions for measuring the degree to which knowledge can be easily communicated, understood and transferred
- Modes or processes of knowledge transfer which deal with mutual transformation between tacit knowledge and explicit knowledge
- Evaluation and measurement of the performance of knowledge transfer; the goal is to elaborate indicators to measure efficiency of knowledge transfer.

Our research deals with the two first themes. We refer to knowledge transfer models which consider knowledge elicitation as a possible stage for sharing and transferring knowledge. Focusing on knowledge engineering techniques for knowledge elicitation and organizational memories elaboration, we explore their limits analyzing codification effects on factors which affect knowledge transfer. Then we propose an approach allowing an optimal continuity between knowledge capture using knowledge engineering methods and knowledge transfer at individual and organizational levels

2. Factors influencing knowledge transfer

Relying on literature review, we can group factors influencing knowledge transfer into 4 dimensions:

- Characteristics of knowledge
- Knowledge transfer channels
- Absorptive capacity of receivers
- Cultural and Organizational contexts

2.1 Characteristics of knowledge

With characteristics of knowledge we can measure different aspects which may be facilitators or barriers for knowledge transfer.

Relying on the work of Zander and Kogut (1995) and Simonin (1999), we highlight three characteristics that would affect knowledge transfer: tacitness, complexity and specificity (or degree of contextualization).

- Tacitness versus explicitness

Polanyi described tacit knowledge as "things that we know but cannot tell" (Polanyi, 1967) and thus can only be transferred through interaction. Tacit knowledge is not easily articulated or formalized and is difficult to put into words, text, drawings or other symbolic forms. In fact, tacitness is a property of the knower: it is easily articulated by one person but may be very difficult to externalize by another.

Tacit knowledge is typically considered to be more valuable than explicit knowledge and requires more cognitive efforts of a sender and receiver to be transferred (Dalkir 2011, Harrison and Hu 2012).

Explicit knowledge is associated with declarative knowledge and "know why". Declarative knowledge and "know why" consist of descriptive elements (Garud 1997). Explicit knowledge represents content that has been captured in some tangible form such as words, audio recordings or images.

- Complexity

Knowledge complexity can be defined as the number of tools and routines used in the process of knowledge transfer (Reed and Defillippi 1990). Routines are actions based on unstated conventions that were derived from previous experiences and can embody the application of knowledge within an organization (Szulanski 1996).

Consequently, more routines are needed to interpret and appropriate knowledge more its transfer can be difficult (Argote and Ingram 2000).

- Specificity or Degree of contextualization

Specificity describes the degree to which knowledge and routines in which it is embedded can satisfy the knowledge receiver. In other terms, "specificity" captures the degree to which knowledge is dependent or not on many different contexts of use (Zander and Kogut 1995).

More the knowledge can be adapted to the context of the receiver, be absorbed and understood by the receiver the more it is valuable.

For example, knowledge tightly connected with local experiences and culture, can be a barrier to transfer and be difficult to transplant to other environment.

2.2 Knowledge transfer channels

Communication processes and information flows drive knowledge transfer in organizations. Existence and richness of transmission channels are success factors for knowledge transfer (Gupta and Govindarajan 2000).

Knowledge transfer channels can be informal or formal, personal or impersonal (Holtham and Courtney 1998).

Informal mechanisms (such as informal seminars or coffee break conversations) refer to socialization and are more effective in small organizations (Fahey and Prusak 1998).
However, such mechanisms may involve certain amounts of knowledge loss due to the lack of a formal coding of the knowledge (Alavi and Leidner 2001).

Formal transfer mechanisms (such as training sessions) may ensure greater distribution of knowledge but may inhibit creativity.

Personal channels (such as apprenticeships) may be more effective for distributing highly contextual knowledge whereas impersonal channels (such as knowledge repositories), may be most effective for knowledge that can be readily codified and generalized to other contexts.

Information Technologies can support all four forms of knowledge transfer channels.

2.3 Absorptive capacity of knowledge receivers

Gupta and Govindarajan (2000) identified absorptive capacity as a key element for knowledge transfer process.

Absorptive capacity can be defined of as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it." (Cohen and Levinthal 1990)

It seems very difficult to control absorptive capacity because knowledge must go through a re-combination process in the mind of the knowledge receiver. This re-combination depends on the recipient's cognitive capacity to process the incoming stimuli (Vance and Eynon 1998).

2.4 Cultural and organizational contexts

Inter-organizational knowledge transfer (across organizational boundaries) seems to be more complex compared to knowledge transfer within the organization. There are many reasons:

- Cultural distance can raise barriers for understanding partners and transferability of knowledge –based assets
- Organizational distance (centralized vs. decentralized, innovators vs. followers, entrepreneurial vs. bureaucratic) can accentuate the difficulty of transferring knowledge through interorganizational relationships (Simonin 1999)

In our study we limit the scope to a context of knowledge transfer within the Organization.

3. Modes of knowledge transfer

For better understanding of Knowledge transfer it is important to explore first two complementary approaches: social exchange and codification.

3.1 Social exchange versus codification

We can share and transfer knowledge through social exchange which is a process of personal communication and interaction. It is a socialisation process (focusing on tacit knowledge) as described by Nonaka and Takeuchi (1995) in their SECI knowledge management model.

Knowledge codification is the process for transforming knowledge into a tangible, explicit form such as document, that knowledge can then be communicated much more widely and with less cost.

In our article, we analyse knowledge transfer strategy based on knowledge codification using knowledge engineering methods.

3.2 Knowledge transfer models

We present here two theoretical models with distinct perspectives. These models bring a conceptual framework for many knowledge transfer processes. They have been reviewed and discussed by academics and practitioners (Dalkir 2011, Harrison and Hu 2012).

These two models give us a better understanding of knowledge codification role in knowledge transfer process.

- SECI model

The SECI model of Nonaka and Takeuchi has proven to be one of the more robust in the field of KM. this model focuses on the knowledge conversion between tacit and explicit knowledge. It describes how knowledge is

accumulated and transferred in organizations following four modes: socialization, Externalization, Combination and Internalization.

Socialization is the sharing of tacit knowledge through social interactions such as face to face.

Externalization is the process of converting tacit knowledge in a visible form: explicit knowledge. It is a way, for organizations, to make knowledge tangible and store it in manuals, databases in order to be easily shared. In this mode, knowledge engineering methods are useful.

Combination is the process through which discrete pieces of explicit knowledge are recombined into a new form.

Internalization is the last conversion process (from explicit knowledge to tacit knowledge) where knowledge is converted into personal mental models and then can be used in an optimal way to achieve tasks.

- BOISOT I-Space KM Model

BOISOT KM model is a conceptual framework incorporating a theoretical foundation of social learning. Boisot (1998) suggested that knowledge is structured, understood and transferred through three dimensions: codification, abstraction and diffusion.

Codification refers to the degree to which knowledge can be encoded (even if the receiver does not have the facility to understand it) while abstraction refers to a low level of knowledge contextualization (easy to be generalized to other contexts).

The assumption is that well codified and abstract knowledge is much easier to understand than highly contextual knowledge.

Consequently, for tacit knowledge with high contextual level (high degree of specificity), there is a risk of loss of context due to codification which is a barrier for knowledge transfer. That is one of the limits of knowledge transfer process relying on organizational memories built with knowledge codified principally using knowledge engineering techniques.

Highly contextual knowledge need a shared context for its interpretation and that implies face-to-face interaction and in a general way a socialization approach as in the SECI model of Nonaka and Takeuchi (1995).

In this model, codification and abstraction work together and facilitate the knowledge diffusion and transfer.

4. Codifying with knowledge engineering methods: Barriers for knowledge transfer

Understandability and diffusibility of codified knowledge with knowledge engineering techniques depend on many factors:

- accessibility and readability of used formalisms for the knowledge receivers (Dalkir 2011)
- knowledge receivers' profiles (background, context of knowledge use, preferences for logical structuring and understanding' profiles) (Tounkara and al 2002)
- level of description of complex and specific knowledge
- exchange channels between Knowledge sources (experts or specialists) and potential future users

4.1 Multiplicity of formalisms

Knowledge engineering methods lead to a set of models and each of them correspond to a specific type of knowledge. For example the Common KADS methodology proposes five types of models (Dieng and al 2000):

- Task model of the business process of the organization
- Agent model of the use of knowledge by executors to carry out the various tasks in the organization
- Knowledge Model that explains in detail the knowledge structures and types requires for performing tasks
- Communication model that represents the communicative transactions between agents

- Design model that specifies the architectures and technical requirements needed to implement a system including functions detailed by the knowledge and communication models

So, expertise is codified through formalisms (which are often diagrams) depending on the type of knowledge.

We can point out many difficulties associated with the multiplicity of models: Accessibility, readability and understandability/intelligibility. The profile of knowledge receivers can accentuate those barriers: are they familiar to the use of models? What about their cognitive preferences of apprenticeship: are they more textual than visual?

Knowledge engineering methods only focus on the codification of the tacit knowledge of knowledgeable staff (experts or specialists) but they do not take into account appropriation and organizational learning capabilities of readers (potential future users).

4.2 Heterogeneity of readers profiles

In an Organization, readers do not have the same level of expertise and their profiles can be heterogeneous (background, contexts of knowledge use, preferences for logical structuring, understanding profile, familiarity with models, etc.)

However, the logical structuring and the presentation of the tacit knowledge codified are not guided by learning levels of future readers but only by the concepts tackled when interviewing experts/specialists and by the models structure.

4.3 Background

A knowledge receiver with important prior knowledge (related to the knowledge domain) and familiar to the use of models may have a greater absorptive capacity. It may be easier for such receiver to decode and assimilate knowledge with high level of complexity.

4.4 Contexts of use

More the distance between the receiver's context of use and the described one is important, more the knowledge receiver will make important cognitive efforts to adapt knowledge. This case happens when the codified knowledge is very specific to the knowledge source's context.

4.5 Preferences for logical structuring and understanding profile

Preferences for logical structuring depend on the learning level of knowledge receiver. For a novice, understanding concepts before procedural tasks could be more logic. On the other hand, an expert would perhaps prefer a structuring guided by problems solving.

Understanding profile can be assimilated to the cognitive preferences of the reader when learning: textual and/or visual preferences.

When knowledge domain is codified taken into account logical structuring and cognitive preferences of the reader, knowledge transfer can be accelerated because the knowledge receiver makes less cognitive effort.

4.6 Level of description of complex knowledge

More the knowledge is complex more its transfer can be difficult.
To reduce complexity, we propose complementary activities to enrich codified knowledge referential:

- Identifying sets of complex knowledge already codified
- Describing and illustrating routines in which identified complex knowledge is embedded
- Organizing exchange (with adequate knowledge transfer channels: informal or formal) between experts and users to help them build a shared context for interpretation.

4.7 Level of description of specific knowledge

It may be difficult for experts to explicit some sets of knowledge without strong link to situations they experienced. For those sets of knowledge with high degree of specificity, knowledge receiver has to make an important cognitive effort to generalize (abstract) the knowledge and to re-contextualize it for his personal use.

We propose three activities to facilitate this abstraction step:

- Identifying sets of specific knowledge already codified
- Eliciting with experts general principles which guide the use of identified specific knowledge
- Identifying and illustrating with experts other possible contexts of use

4.8 Exchange channels to increase diffusion/transfer

Communication and transmission channels are necessary to accelerate knowledge transfer. They are an important basis for:

- Elaboration of a shared context for interpretation
- Legitimization of captured knowledge as best practice
- Evolution of codified knowledge through social interactions.

In the grid below, we synthesise key points to analyse for codified knowledge transfer efficiency.

Table 1: Analysis grid for codified knowledge transfer

	Activities for efficiency of codified Knowledge transfer
Codified knowledge	**Complex knowledge** identify sets of knowledge with high level of complexity explicit and illustrate associated routines create a shared context for interpretation (develop interactions between experts and knowledge receivers)
	Specific knowledge Identify sets of knowledge with high degree of dependence with the knowledge source's context of use. Explicit general principles associated to specific knowledge Identify and illustrate other possible contexts of use
Reader's profiles	**Background** Professional background level of expertise of the reader in the knowledge domain degree of familiarity with knowledge engineering models
	Contexts of use - Identify various work situations where the codified knowledge would be useful for the reader.
	Define preferences for logical structuring
	Define preferences for his understanding profile Visual representation of knowledge? Textual representation of knowledge? Audio preference (multimedia)? Illustration with concrete case studies?
Exchange channels	Identify existing communication and transmission channels Stimulate social interactions between knowledge sources (experts) and readers

5. Methodology for knowledge transfer efficiency

We propose, here, an empirical methodology for transfer and appropriation of codified knowledge referential at individual and organizational levels. It is a two steps approache (re-writing and sharing), guided by the previous analysis grid (§ table 1) and supported by a set of methodological tools tested in several companies and in various contexts with the "Knowledge Management Club", in France.

Executing these two steps transfer methodology supposes, first, that identification and codification of tacit knowledge are well performed.

5.1 From knowledge mapping to tacit knowledge codification

We identify tacit knowledge to capture using a cartographic approach to analyse knowledge areas in the firm. Then, with knowledge engineering techniques, we capture and codify tacit knowledge.

5.1.1 Mapping and Evaluation of knowledge domains

We refer to the definition of knowledge cartography given by (Speel 1999): "knowledge mapping is defined as the process, methods and tools for analyzing knowledge areas in order to discover features or meaning and to visualize them in a comprehensive, transparent form such that the business-relevant features are clearly highlighted".

We have a "Domain" oriented approach: we make an analysis from a mass of information in order to organize it in logic different from the functional approach. In fact, the goal is to ignore the functional structure of the firm, grouping activities into knowledge domains. This task demands an important capacity of analysis because it's not a natural process.

Knowledge domains map is a visual representation by operational actors of knowledge domains they consider essential for their activities. They are grouped according to a common finality on the same theme of knowledge. According to the precision required, a domain can be divided into sub-domains and a theme into sub-themes.
For each knowledge domain, we make a synthesis of the collective perception (of operational actors) about the knowledge domain criticality. It is the result of a qualitative (collected arguments) and quantitative analysis relying on a Critical Knowledge factors grid (Tounkara, Isckia and Ermine 2009). This grid has been performed and validated in many French and Forein companies. The Critical Knowledge Factor grid contains 20 criteria regrouped in four thematic axes (§ **table 2**)

Table 2: The critical knowledge factors grid

Thematic axes	Criteria
Rarity	1. Number and availability of experts 2. Externalization 3. Leadership 4. Originality 5. Confidentiality
Utility	6. Adequacy with strategic objectives 7. Value creation 8. Emergence 9. Adaptability 10. Use
Difficulty to capture knowledge	11. identification of knowledge sources 12. Mobilization of networks 13. Tacit knowledge 14. Importance of tangible knowledge sources 15. Rapidity of obsolescence
Nature of knowledge	16. Depth 17. Complexity 18. Difficulty of appropriation 19. Importance of past experiences 20. Environment dependency

Each criterion is evaluated according to a scale composed of 4 levels, representing the degree of realization of the criterion. Each evaluation of a criterion is based on one question. Each level is expressed by a clear and synthetic sentence by avoiding the vague terms and which lead to confusion ("rating description")

Last, we list in a table, knowledge domains concerned by specificities it could be interesting to highlight when considering the operational actors points of view: domains with great expertise, domains to be valorised, very vulnerable domains or domains that need to improve/adapt methods for training courses and knowledge

transfer. This table is a basis for a more refined analysis and for identification of suitable knowledge management actions:

- "**Codification-transfer**" when it is about actions for acquisition, preservation or sharing
- "Organization" when it was managerial actions
- "Training-Recruitment" when actions are dealing with learning systems, recruitment for new competencies
- "Innovation" when actions are dealing with creativity, environment scanning, etc.

5.1.2 Capturing and codifying tacit knowledge domain

First we identify experts to interview for tacit knowledge capturing: they are knowledge sources and will be authors of the codified knowledge referential. We make individual interviews.

We define goal and scope of the codification sessions. During these 2 hours sessions, there are strong interactions with experts to identify and formalize the different types of tacit sets of knowledge. Using knowledge engineering techniques (as Common Kads, for example) and their associated knowledge models we codify tacit knowledge models (§ **4.1**)

The codified knowledge referential is then read by other experts who will add comments and then revalidated by authors (knowledge sources) of the codified knowledge referential.

The result is a codified knowledge referential:

- Reflecting the knowledge domain and the tacit experience of one or many experts;
- Structured into chapters corresponding to crucial tacit sets of knowledge identified with experts.

5.2 Adapting knowledge referential to readers (re-writing approach)

This approach relies on two steps:

- Characterisation of readers:

It is an important step for defining readers' profiles (Background, context of uses, preferences for logical structuring).

- Elaboration of specifications for re-writing

The goal, here, is to define:

- Additional contents for the description of highly complex and specific knowledge
- Additional illustrations (case studies, videos) to elaborate
- A logical structuring for the codified knowledge referential
- Re-writing and validation of the new knowledge referential

5.3 Sharing the knowledge referential (sharing approach)

Our sharing approach has one main goal: *create a shared context for knowledge interpretation* to make easier and accelerate organizational learning.

We rely on three principles:

- **A clear vision of actors involved in the process of transfer**

We can identify three groups of key actors:

- *Knowledge sources* who are experts or specialists interviewed to capture tacit knowledge; they are authors of the codified knowledge referential.
- Knowledge readers are knowledge receivers selected to contribute to the adaptation of the codified knowledge referential; they are a pool of re-writers.

- *Other knowledge receivers* who are potential future users (other team members, new employees, etc.)
- **An adequate structuring of exchanges between groups of actors**

The goal is to formalize situations of exchange which will lead to a collective good appropriation and a legitimization of captured knowledge.Clear and precise objectives must be defined for each formalized situation (§ **table 3**).

- **Using adequate channels in regard to the purpose of the knowledge transfer**

For each situation of exchange, we recommend to select the most suitable transmission channel (Informal or formal, personal or impersonal) to increase appropriation and transferability (§ **table 3**).

Table 3: Formalization of exchanges to develop a shared context for knowledge interpretation

Situation of exchange	Objectives	Transmission Channel
Presentation of the codified referential to knowledge readers	The goal is, for knowledge readers, to understand the objectives, scope and content of the captured knowledge. Knowledge sources (experts/specialists) present, comment the referential and clarify sets of complex/specific knowledge by giving examples and different contexts of use. This presentation initiates the process of elaboration of a "shared context for knowledge interpretation" and is important for its success. Many sessions can be useful to have a collective understanding of the codified referential.	- Formal seminars
Exchanges between knowledge readers to adapt the codified referential	Knowledge readers are involved in a collaborative work which will lead to the adaptation of the codified knowledge referential. Here, they identify complex and specific sets of knowledge and try to make them more explicit: - building case studies collectively - illustrating other contexts of use relying on their own experiences - changing the logical strutcturing of some chapters - etc.	- Formal seminars
Sharing the re-writed referential with potential future users	The goal is to share the re-writed and stabilized codified referential with other knowledge receivers who are potential future users. The pool of re-writers has to define apprenticeshep objectives and delimit the the appropriate sets of knowledge they will have to focus on. Training sessions can be appropriate to exchange with potential future users.	- Training sessions - Online training sessions
Sharing learned lessons when using of the codified referential	The objective is to faciltate future evolutions of the codified knowledge referential by capitalizing learned lessons of actors using it. Exhanges (even informal) between the different groups of actors must be organized periodically to identify: - new ways of doing more efficient (evolutions) - new applications/new contexts of use - difficulties met - etc.	-Informal seminars -Coffee break conversations - Online forums - Formal seminars

The below figure synthetises our two steps methodology for knowledge transfer efficiency.

6. Hydro Quebec case study

Hydro Quebec is one of the biggest electricity producer and distributor in North America. Hydro Quebec is a public company and his principal shareholder is the Quebec Government.

The Hydro Quebec study is part of a bigger project « support for critical knowledge capture » leaded by the Human Resources Department. The study lasted 2 months and concerned one operational unity. It was motivated by the future retirement of one of the unity's experts.

Interviewing this expert and using knowledge engineering techniques, a codified knowledge referential was elaborated in a first stage.

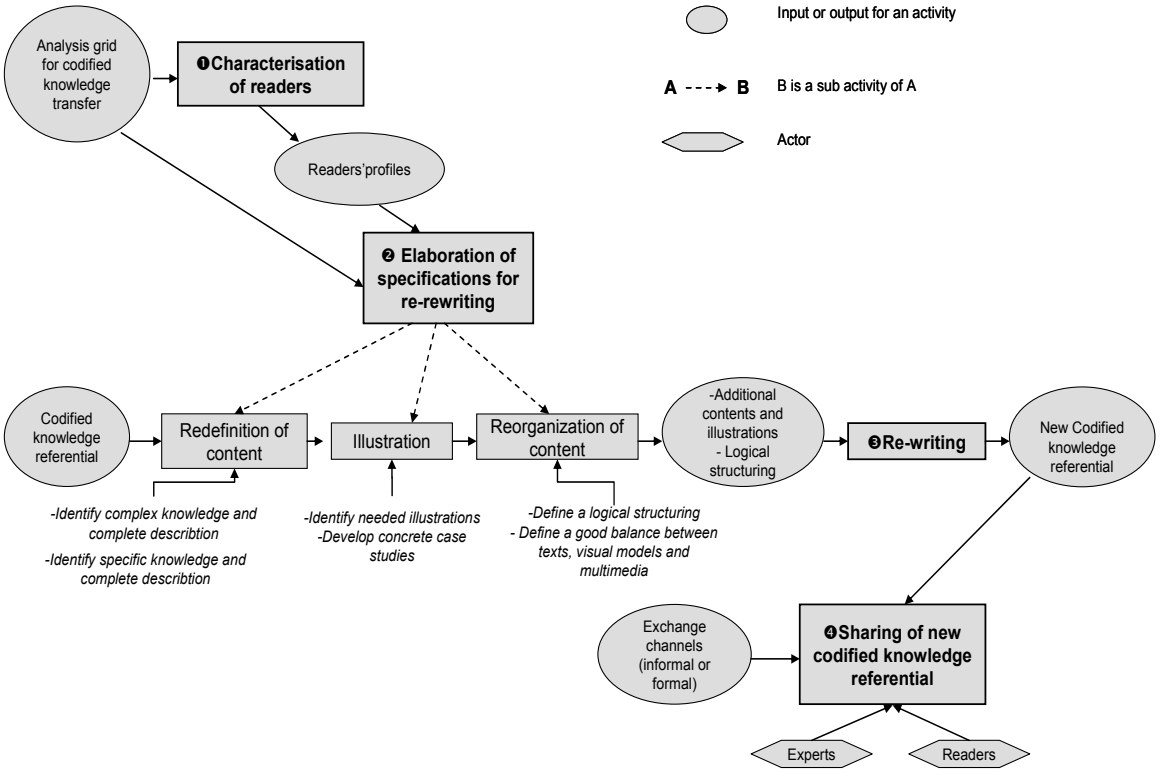

Figure 1: Methodology for codified knowledge transfer

Two objectives were assigned to our study:

- Optimise the use of the codified knowledge referential
- Accelerate the transfer of the knowledge referential to five future experts of the same unity

6.1 Approach

We mixed questionnaires and interviews to implement our knowledge transfer methodology.

Questionnaires were used with the 5 future experts (readers of the codified knowledge referential) to characterize their profiles (Professional and study Background, contexts of use of the referential, etc.). Four of them had a technical background and the fifth had a managerial background.

Interviewing the five future experts helped us identify additional needs for the codified knowledge referential more. Interviews were guided by our analysis grid for codified knowledge transfer.

6.2 Results

Our study leaded to new specifications for the codified knowledge referential to increase its transferability (§ **table 4**).

Table 4: Synthesis of new specifications for the codified knowledge referential

	New specifications for the codified knowledge referential
About the Content	a list of additional descriptions to write a list of missing critical knowledge to integrate in the referential (needing new interviews of the expert) a list of sets of knowledge to complete by concrete case studies
About the structuring	Despite the multiplicity of models in the codified knowledge referential, readers *find models readable* because each them was associated with a textual description. For the logical structuring of the referential, they preferred a *problem solving approach*.

	New specifications for the codified knowledge referential
About the new referential sharing	It was proposed: a *collective and collaborative re-writing* of the codified knowledge referential (with the expert); a "*Knowledge management facilitator"* who will drive the sharing step and coordinate the evolution of the referential.

The principal implication of Hydro Quebec Case Study is that the methodology for knowledge transfer must be performed as a collective and collaborative process which involves three categories of actors:

- knowledge sources (experts/specialists)
- knowledge management facilitators
- Knowledge readers

7. Conclusion

In our article, we first underlie factors which affect efficiency of codified knowledge transfer. Then we propose an operational methodology to optimize continuity between knowledge codification and knowledge transfer. This methodology relies on two robust theoretical frameworks: the SECI model of Nonaka and Takeuchi and the Boisot I-Space KM model (§ **3.2**).

Integrated with knowledge engineering techniques, the methodology can enhance knowledge codification by leading to the elaboration of a pertinent shared context for knowledge interpretation.

The Hydro Quebec case study highlights the importance of defining an appropriate organization to support the knowledge transfer process.

Economic aspect can be a limitation of the knowledge transfer model we propose. Implementing such a process transfer can be a heavy investment for companies:

- An organization (it can be a formal community) must be settled and this involves identifying actors and defining for them roles and responsbilities
- Actors must be available for the codification, the re-writing and the evolution of the knowledge referential.

In the next step of our research, we will focus on the evaluation of knowledge transfer efficiency after an implementation of the proposed methodology.

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