Knowledge Creation and Management in a SME Environment: a Practical Case

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Introduction: Knowledge Management, and the SME Environment, State of the Art

The academic literature on knowledge management, although extensive, is scarce in relation to the Small and Medium Enterprise (SME) environment. Recent publications have addressed this field [1]. Mostly the researchers and practitioners have focused their work in a closely related field: the understanding and practice of learning in small firms [2, 3, 4, 5, 6, 7][1]. Some of their conclusions will be applicable to our case, such as the SME need for just in time knowledge, the predominance of informal learning in the SME, the involvement and relevant role of the owner manager in the learning and training area, the motivation factors, the change resistance, etc. This paper intends to contribute to the understanding of knowledge management in the SME environment.

Organisational learning, as a discipline related to the collective capture, storage and reuse of the firm experience, has dealt with organisational change and is quite relevant to the SME experience. According to Argyris [8], "*the individual learning activities, in turn, are facilitated or inhibited by an ecological system of factors that may be called an organisational learning system.*"

Along this same line, Huber [9] points out that "*an entity only learns if, through its processing of information the range of its potential behaviours is changed.*" Weick [10] deals with knowledge about action-outcome and the effects of the firm environment. Senge [11] sets up his five components for the learning organisation of which team learning and mental models are elements core to the SME. Garvin [12] introduces the concept of knowledge management in the learning organisation defining it as that which is "*skilled at creating, acquiring and transferring knowledge and at modifying its behaviour to reflect knowledge and insights,*" pinpointing that learning implies a potential change in the organisation, as Argyris [13] has outlined in his double-loop learning model.

Ang & Damien [14] point out that organisational learning is the process, and the learning organisation, the structure supporting it. In this sense, Fahey and Prusak

[1] For the interested reader the web page of *The Marchmont Observatory* (www.lifelonglearning.ac.uk) refers an ample research experience.

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[15] quote that "*a deadly sin in knowledge management would be failing to create a shared context for it."*

Learning as systematic change has been proposed by Watkins [16]. The efficiency of the learning groups as cross-community organisations, formal groups, informal networks, etc. have also been discussed as Communities of Practice [17, 18, 19], Virtual Corporations [20, 21, 22], Networking Firms [23], etc. Clarke & Cooper [24] support the idea of knowledge management as a collaborative activity in order to create this mentioned "*shared context.*"
Finally, the use of software for organisational learning has been reported by various authors [25, 26, 27, etc.].

This paper will discuss the efforts of a group of small firms to develop an expert software application to optimise and manage a complicated printing process. This effort has been carried out through an R&D co-operative project (*Autogravure*), financed under the European Commission IV Frame Work R&D program. A printing firm led the project and five other *SMEs* participated in it. The firms belonged to different industries such as machine and material manufacturers, a technology user and manufacturer of sweets, and finally, two research institutes. These organisations were based in Spain, Italy and Germany. A mixture of industries and cultures involved in the project [28, P. 62].

The project pursued several objectives, which could be simplified by describing it as the development of a global Quality Function Deployment (QFD) model. As will be outlined later, the existing processes in the rotogravure printing industry resemble a kitchen factory, where the cook’s skills determine the final results. Furthermore, in this case there were a number of different "*cooks,"* speaking different languages, and possessing different cultures, such as artists (marketing publishers), mechanical engineers, production engineers, chemical engineers, software analysts, managers, etc.

If anything characterised this project, it was chaos and uncertainty. From the very beginning it was designed and planned without a clear idea of the processes governing variables. The initial hypothesis of the project appeared later to be misleading, which resulted in a project plan with an inadequate work breakdown schedule. Until halfway through the project life cycle, its objectives didn’t seem feasible -- even after holding a number of discussions and working through controversies between the project partners, and after a complete reorganisation of the project plans.

As the project approached its completion date it became apparent that it had become a knowledge management project. After analysing its development and difficulties the author became interested in studying it from a KM point of view. This paper is a reflection of the author's experience after maintaining various discussions and interviews with the different actors involved in the project.

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Process Workflow

As has been mentioned, the project objective was to develop a model and an expert system, which could allow the maintenance of a high, predictable and sustainable quality level that would satisfy the client' s requirements. Figure One shows the process's simplified *work flow*. In the first instance, the customer discusses his/her requirements, which have been reflected in some drawings or sketches by his/her creative publishing firm, with the press supplier-marketing department. After some extensive discussions, an agreement is reached in relation to price, delivery, quality and scope of work.

Once an order is produced the sketches are sent to the prepress department of the supplier which will develop the interface files for the printing process. Extensive work is required in this adaptation process since the client's requirements in the form of sketches, electronic drawings, etc. have to be transformed into electronic files which are compatible with the following processes.

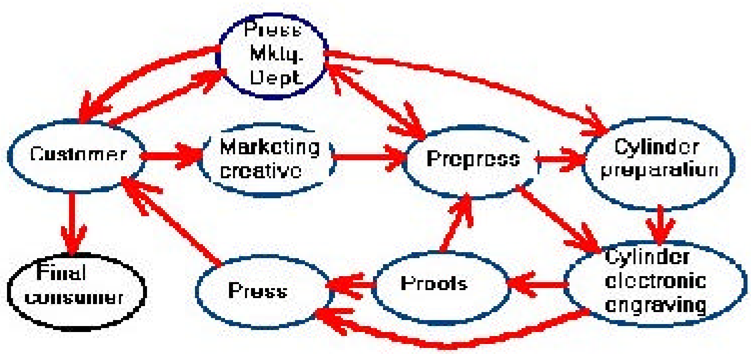

Figure One -- Process Flow

The rotogravure process utilises coppered cylinders (equivalent to the plate support in offset), one per colour, in which cells are dented in order to collect the different colour inks, and deposit the ink later into the material support surface, which has to be printed. These cylinders have to be prepared previously (and surface treated) depending on the conditions of the printing process in a complex galvano-technical independent process.

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The cylinder-engraving phase is also a complicated process, and the subject recently of a relevant technological evolution. Modern digitised processes with laser beams are substituting for electronic and electromechanical technologies.

The results of the engraving processes are checked with a proof press, before entering the production process, in order to control whether the quality levels have been reached. Again this phase will be made redundant by modern technologies. In the meantime, however, the printing inks are formulated in accordance with the work requirements.

Once, the cylinders are checked and conform to the work specifications, the final printing press production phase starts. The rotary press has to be regulated, and its main variables managed, in order to achieve the speed and quality required. The process finalises when the printed rolls have been cut and packaged.

Rotogravure printing has its origin in artisan work. Although technology has tended to substitute typical tacit knowledge (*cooking* know how) for more elaborate standards and norms, still the quality of most press shops, especially in the SME environment, depends on the skills of the machinists, engravers, operators, prepress artists, etc.

Due to this situation, and the fact that engraved cylinders are normally re-used due to their high cost, it becomes a difficult task to repeat a certain level of quality, the exact colour tonality, etc. when a certain order has to be processed again. The skills of all the process operators play a relevant role in the process and its control. This was emphasised during the interviews held by the author with managers in various industry firms. Quality requirements have exerted a strong demand on codifying tacit knowledge, as will be discussed later.

Working with Knowledge

Davenport [29] distinguishes between data, information and knowledge. We shall discuss how these concepts could be applied and analysed in relation to this project experience.

The project was confronted with a process composed of a number of phases (the workflow previously discussed), which the technical literature only covered partially and from a partitioned point of view. An extensive search of this literature showed how heavily industry *know-how* is based on dispersed knowledge. A visit to the Drupa fair in Dusseldorf (the largest world wide fair in the industry) and a number of conversations with specialists and suppliers confirmed this. A number of historical data points were collected through the process development for each order and with the objective of setting operating standards, etc. Except for some computerised operations (basically in the engraving process) most of the data was collected manually. Information, understood as contextualized and

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categorised data, was also collected and interchanged between the process operators and it was also managed in order to obtain certain desired results.

Knowledge as a mix of experience, contextual information, and expert discernment was brought to the project by specialists from the participant firms. Process operators, and workers seemed to be the most valuable asset. Knowledge could also be found in the process routines, in every day practices, and in norms prepared by suppliers.

Considering the process work flow as a value chain where the initial idea and wishes of the customer were pursued until a whole packaging product was produced, knowledge can be viewed as moving down the chain and returning information and data through the chain. The model to be developed had to make common sense out of this flow.

Experience provided a relevant source of dynamic knowledge acquired through a formal and informal learning process by operating the production process, learning from suppliers, technical fairs, symposiums, etc. Rules of thumb were developed between participants through learning and observations. It was thought that the model to be built would incorporate a number of these rules. It should then, be an intuition-based model compatible with a SME environment, where this type of compressed expertise [30] is widely utilised.

The spiral model shown in Figure Two can illustrate the learning model that helped to build knowledge in the participant organisations.

Figure Two - Knowledge Generating Spiral

The knowledge handled can be classified according to Polanyi [31, P. 27] as bi-dimensional: tacit and explicit knowledge. Tacit knowledge specific to context,

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personal and hard to formalise and communicate, predominated in those layers of the organisations closer to the operating environment and further away from automated areas. Explicit, codified knowledge, easier to communicate, predominated in management layers, and in those areas more prone to formalisation and automation.

Tacit knowledge, which was more elusive to grasp, proved, however, to be more critical and relevant to process control. And this is true in spite of the initial lack of emphasis on it from the specialists' side. According to Johnson Laird [32, P. 32], tacit knowledge includes cognitive elements, mental models that help individuals to define their environment, and technical elements such as crafts, skills and know-how. The former elements were found to predominate in the management layers while the latter prevailed in the operators' layers and were more difficult to formalise. Nevertheless, it has to be said that tacit knowledge made a strong contribution to process knowledge and challenged a number of theoretical assumptions that were part of the initial hypothesis.

Finally, the model proposed by Novins [33, P. 48] is useful to categorise knowledge. Here knowledge is classified in two basic dimensions. The first refers to its broad or narrow range of application, local versus global. In the former case, it would be applicable and would be dependent on a given set of conditions. It could be considered detailed knowledge (i.e. applicable to a certain process phase). At the other extreme, the knowledge would be global in nature, applying widely across the processes, the industry, technical and cultural borders (i.e. the case of colour standards).

The second dimension of knowledge would refer to its level of transferability. Explicit knowledge, rule-based, which can be stated simply and in definite terms could be considered easily transferable. At the opposite extreme, transferability is low when knowledge has a high tacit content, is judgement based, and has high sensitivity to the context (i.e. x = a+b, if... or x = c+d, when,...etc.). Therefore, according to its transferability the knowledge could be either programmable or unique.

Figure Three shows a matrix where knowledge has been classified according to those two dimensions. Four basic types of knowledge were found according to this matrix. *Quick access knowledge*, was easily managed by detail databases in the system utilised by various specialised departments. *Broad-based knowledge*, utilised by all the organisation was packaged in the software itself. The most difficult areas were those related to the unique dimension of knowledge and have been pointed out by a shadowed area.

Specialised and infrequent knowledge represents tacit knowledge utilised in some local areas containing relevant skills that are difficult to transfer. This knowledge had to be managed separately depending on its weight in the process

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output. *Complex knowledge* was broadly used and difficult to transfer. It meant knowledge arduous to communicate and based in generally recognised artisan skills. Here the approach was to develop general specifications and standards to handle it. A large amount of time and effort was required here and the process was based on trial and error procedures.

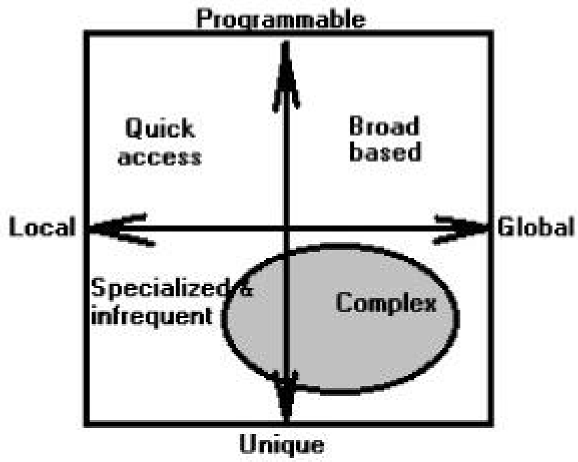

Figure Three -- Categories of Managed Knowledge (Based on [13], Modified by the Author)

The Process of Knowledge Creation and Management

The project development could be classified in four distinct and characteristic phases. These do not include the project definition phase, which had led to the initial proposal presented to the EC for funding.

The model guiding the project was conceived during phase I. Its development required an analysis of the workflow process. A systems thinking approach [11] was required to fully understand the process. Meetings were held with all participants in order to identify the critical elements and the interrelation between the different process phases. Here a pronounced interchange of tacit knowledge took place.

Concepts and experience were the drivers of the discussions between the experts taking part. Parts of the team (the equipment suppliers) contributed their skills and approaches to the understanding of the process. During these meetings the mutual practical experience of team members was interchanged. On these occasions, some of the technical myths, which had been supported until then by the technical managers, were abandoned. As mentioned earlier, tacit knowledge emerged as a critical element, especially due to the fact that all participants were SMEs.

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Phase II was related to the selection of what were thought (at that time) to be the critical process variables. These were independent or dependent relative to client order requirements. Brainstorming meetings took place with the assistance of engineers and operators. During this phase, and as a consequence of the effort made, part of the accumulated tacit knowledge became explicit in the form of concepts, rules of thumb, etc.

Its formalisation became a difficult task and led to the model structure. A special effort was required to select the quality parameters, which could define an acceptable standard of work quality and a measurable quality level. These quality parameters initially defined by experts tacitly, had to be converted to quantifiable concepts or variables. This stage involved a certain level of chaos and often the team didn't understand what needed to be done. At this stage the software experts started their project work.

During Phase III efforts were concentrated on the construction of the model knowledge system and its formalisation. The model and specification of its variables was refined and additional brainstorming meetings took place. These changed some model concepts substantially. Other variables were eliminated. As a result, a new body of explicit knowledge appeared which was more manageable. This phase seemed to develop more smoothly than earlier phases, and it seemed easier to manage explicit rather than tacit knowledge.

The tasks involved in Phase IV were related to the trial tests of the software model and its learning by the project team, plant operators and middle managers. The explicit knowledge created in the previous phase, in the form of a software model, had to be translated somehow to the plant operators' language. It had to again be transformed into tacit knowledge, in order to be assimilated by the intuitive plant environment.

The development of the project, as described above, can be explained by the knowledge spiral model proposed by Nonaka and Takeuchi [34] as shown in Figure Four below. The elaboration of the model in the testing phase, involved a great deal of complexity, especially in relation to the understanding of the system. Certain decisions took some time to make; mainly those related to quality levels and standards about when and how to judge: if a piece of work is acceptable, its quality level, and especially how to standardise it, and if the decisions about it are to be made into rules of thumb.

Actually, the project has finalised the construction of the model. Its situation could be defined, according to the Nonaka-Takeuchi model [34], as the cross-leveling phase of knowledge generation with the model (a tangible software package) as the built archetype. It is expected that it will constitute a learning tool since it has an algorithm building and input tool for that very purpose.

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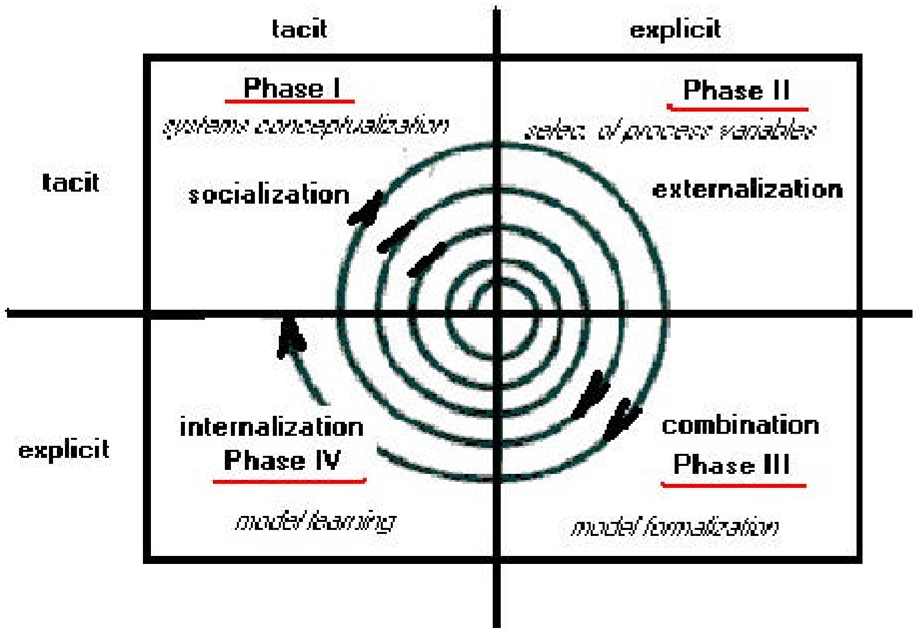

Figure Four -- Project Phases and Nonaka/Takeuchi [34] Knowledge Spiral Model

Barriers and Enablers for Organisational Knowledge Creation

The interviews with the actors and the experience of the project showed that certain elements or conditions acted as enablers and others as barriers in the knowledge creation process at the organisation level. The project took place at the group level of interaction but had effects at the individual level.

This project took place in an organisation network context, the individuals took part in an inter-firm project, and it was experienced in one of the firms. The process of organisational learning consisted partly in capturing, storing and reusing experiences and knowledge that were finally fed into a computer design for a software application. System rationality [35] and organisational memory [36] were important assets in program development. However, since it was formulated as a learning program, the Nonaka-Takeuchi model process was required to maintain the interest of its users and contributors, who had to store information they acquired and feed it back when the work context required it. Fischer [37] proposes that in these cases a virtuous circle has to be closed, whereas each participant needs to feel a personal benefit in order to be motivated to contribute.

Figure Five illustrates this circle which is based in the users perceived utility. Thus, this utility could be expressed as the following coefficient: *benefit / expended effort*. Logically the organisational memory will be activated if previous

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projects produced scarce benefits. Here the management of the project also had a relevant influence.

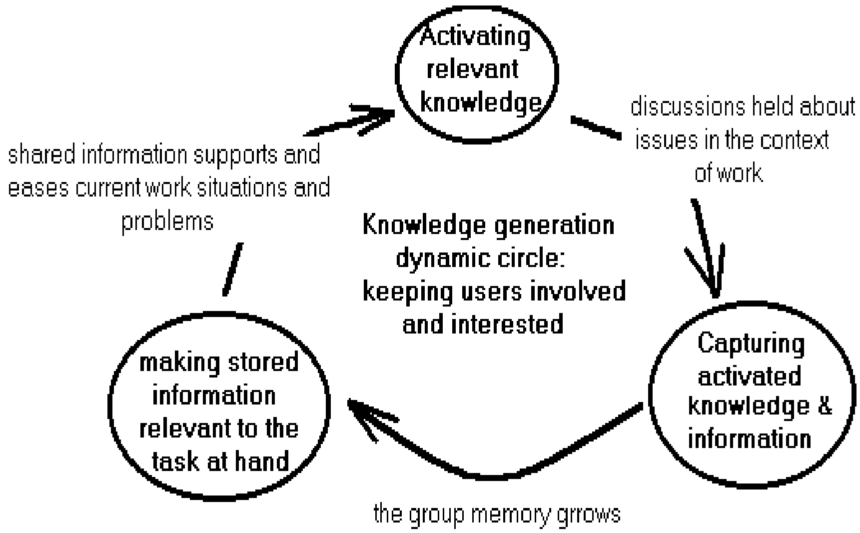

Figure Five -- The Virtuous Circle of Knowledge Generation (See [13])

As a consequence, motivation appears in the first place as an enabler, or alternatively, as a barrier when it is absent. When participation and communication were enhanced from the management side, it resulted in acceptance and a will to participate in the project actively. This was in direct proportion to the ability of management to link the project to the company's strategy and communicate it effectively. Nonaka and Takeuchi [34] defines such motivation as organisational intention, and Senge [11] includes it in the building of a vision.

Resistance to change was a barrier to the process. In some cases, knowledge sharing was a problem, since knowledge was utilised in some areas as a wall of defence and as a status preserver [38]. Dorothy Leonard-Barton [38, p. 54] writes about skills to which people bind up their sense of competence. They see a new knowledge generation tool as challenging them, and will resist innovation in that direction. This was the case in the area of computers and related skills. The author has often observed this situation. This reluctance to share knowledge required extra efforts from management to overcome it. Again, effective communication was a key factor.

Acting in the opposite direction was the need for information and knowledge. In some departments where data and information were lacking, many workers

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expressed a strong demand for more information to help them improve their work and reduce the uncertainty associated with various tasks. The new system made more evident the levels of quality attained in organisational performance, and this caused some restlessness in areas that were trying to rationalise performance problems. Transparency was a result of the new system.

Organisational culture was, as has been mentioned, a critical element. Knowledge sharing became difficult in instances of cultural mismatch [39]. This was the case with prepress operators, publicity designers, and printing specialists. On some occasions an excess of bureaucratic culture, placing emphasis on written memos, rather than on discussions and meetings, augmented velocity over viscosity, thus reducing the level of knowledge transfer [29]. In a SME environment, meetings are not well accepted for cultural reasons. If learning in SMEs became *double-looped* in Argyris's sense [13], these organisations would change with the same dynamism others that rely on meetings.

When the project made evident the need for training, that training became an enabler element, providing motivational drive by producing a virtuous circle of learning by problem solving and increasing the absorptive capacity of knowledge recipients [39, P. 5]. Informal communication lines between individuals acted as strong links for knowledge transfer when these lines were available [40, P. 27]. In many instances informal conversations and discussions over a cup of coffee or a long trip brought to light many clues for problem-solving difficult to arrive at through other than informal means.

The knowledge spiral was also promoted by the openness of the project. The fact that experts from other disciplines, countries and firms interchanged periodic visits and discussions with the project team had a positive punctual effect on its development. These contacts also provided redundant information, which granted extra room for discussion. Nonaka and Takeuchi [34] have reported both elements as enablers for the knowledge creation process.

The role of middle management as a hinge for the knowledge generating process in the project, and as a transfer medium between knowledge outcomes and the operating layer has to be outlined. As Nonaka and Takeuchi [34] point out, top management creates the vision, the dream, while middle management develops the concrete concepts that operators can understand and implement. This was especially evident during phases II and IV of the project when the basic task of middle management was to solve the contradiction between *what is* and *what ought to be*. They had a critical role in managing and translating tacit knowledge (balancing its mental and skills content) and later leading the internalisation phase. This role is more evident in a SME environment where top management may be a single manager or firm owner. Figure six below illustrates this relationship schematically.

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As this drawing shows, middle management communicates the effects of knowledge management to the external environment and to the operating layer, which, in turn, is a bottom-up source and test bed of knowledge. The role of the operating layer becomes fundamental in the knowledge production process, by questioning official explicit knowledge and contributing new tacit technical knowledge to the system.

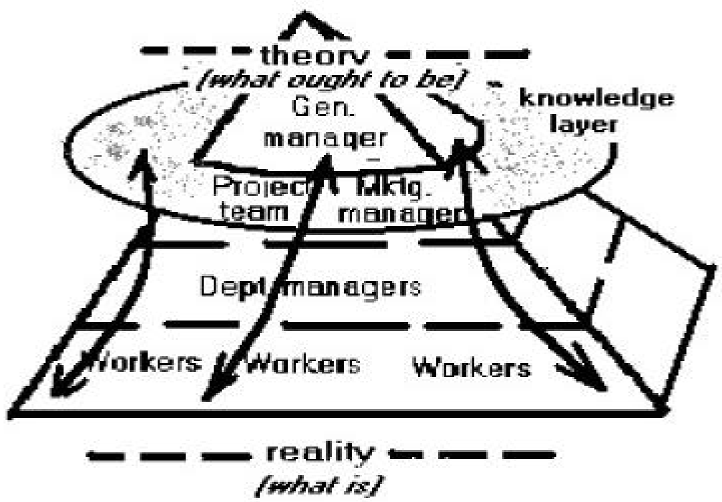

Figure Six -- Knowledge Action Layers

Conclusions

"The tacit dimension" plays a significant role in knowledge creation, especially in the SME environment. Contextualization of this tacit knowledge is difficult due to the disproportionate weights of cognitive (mental models) and technical (skills) in the management and operating layers of enterprises.

Knowledge creation and management is closely linked to the concept of a learning organisation, especially in a SME environment. The enablers of the learning organisation will allow a smoother process of knowledge generation. In the case described above systems thinking was fundamental to grasp the view of the process flow and its interrelations. Mental models allowed the transfer and handling of tacit knowledge and team learning was a basic tool for the development of the knowledge-generating tool. Finally, the building of a shared vision supports the leadership capacity that can keep the learning dynamism going in the future.

Human resources management plays a fundamental role in the whole process. In an entrepreneurial SME environment, the individual, the task (knowledge generation), and the organisational context are closely linked. As Kao [41, P. 15]

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points out, these three dimensions of the organisation will interact with its external environment. The environment will influence the organisation's strategy through the reaction it evokes in the organisation, In the case described above it had an important effect on the knowledge interactions. The human resource management of the firm will drive two dimensions: the individual and the organisational context. When the task (knowledge creation) has a creativity dimension it will present a management challenge to both the individual and the organisational contexts. This challenge will have to be met with an adequate human resource management system.

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Biography

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