

6 SOCIO-ORGANIZATIONAL REQUIREMENTS FOR A VE

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The virtual enterprise (VE) concept presents new challenges to the industrial sociology. The work organization and technology design requires a balanced framework pointing to the unification between technology and people. The proposal of social and organizational recommendations aims to contribute to the development of the base technology according to the socio-technical and anthropocentric theories. For those involved in technology implementation, strategic guidelines are presented, aiming to avoid unemployment and productivity dysfunction as consequence of an incorrect application of the technology.

INTRODUCTION

The last developments in information and communication technologies (ICT) have created a new space for enterprise innovation. Nevertheless, most of the times the innovation involves the implementation of new tools leading to process changes, difficult to understand and accept by the workers. The right strategy points to the involvement of workers since the beginning, participating together with the technology designers and developers in the definition of the best paths to innovation. This chapter aims to present the work done in the PRODNET project to establish a framework proposing the right mechanisms/implementation strategy to create a socio-technical VE infrastructure.

The Internet infrastructure represents a technological change with strong sociological aspects, where co-operation between entities was difficult and that now can increasingly be done via very cheap shareware tools, electronic mail, videoconferences, etc. There are significant research outputs addressing the analysis of groupware tools to support co-operative activities; some of them can be found in the context of CSCW (Computer Support Co-operative Work) concepts. However, these innovations are not disseminated at a significant level, especially in SMEs.

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The original version of this chapter was revised: The copyright line was incorrect. This has been corrected. The Erratum to this chapter is available at DOI: [10.1007/978-0-387-35577-1_37](https://doi.org/10.1007/978-0-387-35577-1_37)

The technical approach of industrial sociology regarding the work organizations and technology developments has to overcome a set of new challenges in order to clarify the behavioral changes resulting from this new “virtual enterprise” concept. A virtual enterprise can also be understood as a structure, organized around multicultural and “multilingual”¹ wide working groups (technicians, operators, office workers, managers, engineers, etc.). These heterogeneous cultures need to cooperate in order to achieve convergent goals. This is valid for all organizational structures (virtual or not). But factors like different contractual rules for new products, different rules inside enterprise nodes, different management structures, and the resulting decision-making shortening, are only a few examples of the complexities that this new concept has to deal with.

Like in other changes that happened during the past industrial manufacturing technological evolution, the success of the introduction of the virtual enterprise paradigm is also strongly dependent on the workers commitment.

However the complexity of social dependencies beyond internal enterprise borders brings new challenges. It is necessary to define a new social framework model, including all the characteristics of an effective co-operation among persons belonging to different firms, different organizational structures and, maybe located in different countries. This new framework brings a new set of demands at societal level, e.g., at organizations. Even for each social actor, the necessity to incorporate a “network” culture, that is not exclusively technological but has strong social and cultural implications, is becoming more and more evident.

The sociological contribution to this project aims to define a set of recommendations that will guide the implementation of the new emergent Virtual Enterprise concept. It is expected that those recommendations contribute to the development of the supporting technology according to the socio-technical and anthropocentric theories and also guide those involved in its implementation, preventing productivity reduction and unemployment, consequences of an incorrect application of the technologies and re-structuring strategies.

Considering that the new concepts and technologies that are developed inside the PRODNET II (Camarinha-Matos et al., 1998) project may not have an a-priori precise picture of the consequences they will provoke in the enterprises, it was necessary to resort to the enterprises’ experiences as a referential to begin this study. The strategy followed by this study was to start by the evaluation of an end-user, in this case the Portuguese partner, focusing the analysis on aspects that could be more directly related with the technology in consideration. Thus, this document is centered on the characterization of the proposed technology, evidencing changing aspects in order to characterize the set of variables that will lead the implantation process.

SOCIOLOGICAL VIEW OF THE “VIRTUAL ENTERPRISE” CONCEPT

The term Virtual Enterprises is being used to classify a new emergent approach to the organization of enterprise networks. Most of the products are not any more

¹ In the sense of different technical “languages”, concepts, sets of references.

exclusively produced in one physical enterprise. Subcontracting is intensively used to get market opportunities, minimizing the investments that are necessary to completely fulfil the development and production needs.

“Virtual” in this context means something that is real, but implemented by some strategy or system that provides a simulated unified reality based on a distributed network of components. Based on this assumption it is possible to say that a product that has many contributions from many real enterprises was manufactured/produced in a Virtual Enterprise. Therefore a Virtual Enterprise is an association of a distributed set of production/development resources. These resources are managed by real enterprises connected by a co-operation facilitator that can go from weak connections like route, surface mail, etc. to electronic connections building intra- and inter-enterprise electronic communication networks. In fact, enterprise networks exist since long ago, however co-operation has been bounded to restricted areas until the last developments of information and communication technologies.

Limited co-operation areas like the northern Italian “industrial districts”, the Basque Mondragón case, or the Ruhr valley networks, from many other examples, are even today positive examples of local co-operation among enterprises joining synergies. Internet, as an infrastructure to support co-operation, is an emergent technology that is receiving much attention and it is being transformed into a mass media mechanism for exchange and sharing of information. It is possible to see Internet as an information and communication technology facilitator of a global co-operation.

As Lucas and Baroudi (1994) wrote, “the new IT-enabled variables may be totally distinct from traditional design variables, as it is the case when virtual corporations are compared with traditional organizational sub-units. IT-enabled variables may also be an extension of traditional variables, as in the case of developing linking mechanisms”.

Complex enterprise arrangements and/or agreements are being established to easily get market opportunities. This kind of arrangements is always fired by a business opportunity, and it usually has a co-ordinator at the enterprise that manages such goal. It can rely on the production of a product by a group of enterprises, but it is transparent to the end-user how the production runs. Therefore, from this distributed production perspective, it is possible to say that a Virtual Enterprise has produced a product.

The enterprise co-operation arrangements can take many organizational forms. It is possible to find structures from completely dependent sub-contracting enterprises, most common in automotive industry, to more independent enterprises playing the role of sub-contractors, but always directing their productive resources to alternative markets. It is not possible to find, in most of the cases, a specific behavioral pattern neither at regional level nor dependant of the industrial sector. The enterprise independence is more dependent on the entrepreneur capacity to increase the flexibility of his/her enterprise, when belonging to a virtual enterprise. As a matter of fact it is possible to say that a virtual enterprise is grounded on a diversity of organizational models, those of each enterprise member.

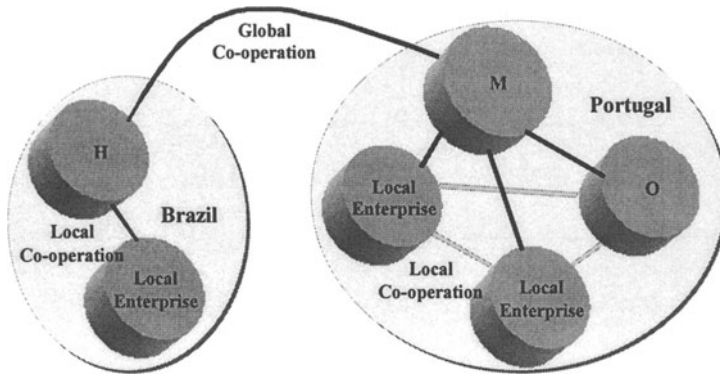


Figure 1 – Co-operation among enterprises

The concept of virtual enterprise follows all theories around network of enterprises. The main difference that emerges from this new concept is the availability of an infrastructure able to provide enterprises equal opportunities. The information and communication technologies associated to the new computational infrastructures, promoting a flexible co-operation among enterprises, plays the role of a democratization movement. The subcontracted enterprises are able to easily access other contractors, access to innovation knowledge, make new relationships with other enterprises operating in the same sector, etc. The Internet is playing a key role based on its low cost and because it is easy to install and use. A domain until now reserved to large enterprises, the intensive utilization of information of technologies, is being extended to SME's. As an example, the electronic information interchange of the commercial information in EDI is until now *quasi* exclusively implemented in large enterprises.

As Gurstein says, *“one intriguing possibility is that in the future there may be significant readjustments in how information intensive activities may be distributed (...). Emerging business functionalities supported by ICT present significant opportunities and even advantages to local enterprises. At least these functionalities reduce distance barriers and location, and give argument to the inevitability of urbanization as a necessary accompaniment of globalization”* (GURSTEIN, 1999).

Nevertheless, a long way needs to be transposed before an effective virtual enterprise can be established. There are many constraints conditioning such tendency:

- Lack of an integrating infrastructure guaranteeing a global interoperability among SMEs
- Reengineering of the internal enterprises business processes in order to deal, naturally, with the virtual enterprise
- Reorganization of the social and organizational structures again to fulfil the virtual enterprise requirements.

As it happens with the networks emerged from direct contact, deeply supported on mutual trust relation, the virtual enterprises crossing the physical accessible borders need also to get such confidence from entrepreneurs. It is not easy to

overcome the absence of a physical presence. When people are face to face, many informal and symbolic information items are exchanged or acquired by each interlocutor. It is not an easy task to model such ancestral confidence relations by using the new information and communication tools. The sociological intervention is essential to guide the changes referred to integrate organizations into a cooperative world. The complexity of the necessary changes advises a step by step movement from the "AS-IS" organizational structures to the "WOULD-BE" foreseen organization toward the virtual enterprise requirements.

As some authors point out, the new organizational design variables made possible through information technology are the following (LUCAS, BAROUDI: 1994):

- 1 Structural variables
 - 1.1 Virtual components
 - 1.2 Electronic linking
 - 1.3 Technological leveling
- 2 Work process variables
 - 2.1 Production automation
 - 2.2 Electronic workflow
- 3 Communicational variables
 - 3.1 Electronic communications
 - 3.2 Technological matrixing
- 4 Inter organizational relations variable
 - 4.1 Electronic customer/supplier relationships

In fact the virtual organization creates new management and coordination challenges. In most cases, traditional organizations are using technology to make partial changes in their structure without making major modifications to the entire organization. For example, electronic or metal engineering manufacturers can set up just in time EDI links with parts suppliers, changing just one component of the organization. At the same time, the supplier can then be viewed as part of the manufacturer's raw material inventory. Nevertheless, the organizational design variables should be the same as those mentioned above usually applied to more advance virtual enterprise concepts.

In what human resources are concerned there are two main drawbacks: on one hand the technology evolves on a small step by step basis; on the other hand the persons inside the organizations are only able to make changes also in a step by step basis. These two vectors - technologists on one hand and human resources (at different levels, from management, consulting, engineering, production, etc.) on the other hand, all of them need to be involved in the movement of the changes. To get their adherence they must be informed about the changes and more than that, they must be considered as active contributors to the changes.

These constraints can be observed from another level - the technology design point of view. In fact, there are two main approaches: the technocentric, exclusively centered on technological aspects without considering sociological constraints and the anthropocentric that brings to the conception phase the sociological constraints. The technocentric strategy is focused on technical and technological issues. Instead, in the anthropocentric approach, the technological conceptions toward enterprise

innovations shall involve organizational and social constraints, in order to allow a better integration between the technical and human aspects. *“The anthropocentric option involves on the development of systems based on specific architectures conceived according to the human factor valorization and new organizational principles such as: autonomy, creativity, participation, co-operation, decentralization and professional skills”* (KOVÁCS, 1993).

Therefore, the virtual enterprise is to some extent the conceptualization of a production system based on a set of distributed enterprises following some coordination enterprise node to realize some business goal. Geographic distribution, different cultures (organization, language, processes, etc.), flexible communication, and co-operation mechanisms, privacy integrity and authentication, are some of the issues that need further research to achieve a reliable network of enterprises as the basis to create many virtual enterprises.

Another perspective of the problem is on the design of the technological solutions to support many of the enterprise functional needs. Information computational tools tend to be general, to cover an increasing number of the enterprise needs. However this generality implies on some changes into the enterprises adopting the technology. These changes sometimes don't follow the most advised path and as a consequence, they are classified as the main negative contributions to the innovation failure. This is a complex subject mainly for SME's those that cannot support internal developments, to customize the ICT tools to the reality of the enterprises. For large enterprises the situation does not apply because they usually have their own internal development departments or at least they have internal capacity and power to customize the new tools they are adopting.

CHARACTERIZATION OF THE INNOVATION PROCESS IN VE

Considering that the introduction of an infrastructure to support the participation of an enterprise into a virtual enterprise involves technological innovation and process reengineering, a parallel comparison can be traced between this and similar studies made about innovation in SMEs. There is however a relevant aspect that characterizes this innovation: it points to an extended co-operation among enterprises located in different regions, countries or even continents, what presents a cultural differentiation challenge.

Wang (1997) underlines the fact that *“the immediate benefits of inter-organizational networks are the efficiency and cost saving in transactions related to the participant organizations in the networks. An apparent change in the participant organizations of inter-organizational networks is the phenomenon that cooperative task teams cross over the boundaries of individual organizations. A long-term effect of inter-organizational networks is the strategic alliance between the participant organizations. An organization migrates to the business alliance link stage once the inter-organizational networks become a strategic necessity”*.

However, like a classical innovation process, the key for the success is in people with their interest and beliefs on the changes. To easily define the requirements, guaranteeing that an enterprise follows a safe innovation path to the virtual

enterprise world, this chapter aims to clarify the new relevant aspects of the enterprise participation in a co-operation network.

From the answers given by PRODNET II technological partners (academic and software houses) it is possible to find some common sentences pointing to different views of the expected changes and preventive actions. Some have stated that “it is important to stress the necessity of a new generation of employees with a deeper knowledge of the overall processes” [software house partner]. Others that “most of the technologies used in PRODNET, are more or less already used in some companies, but with no connection between them. The automated relations between companies are in a relation one to one. PRODNET brings the concept of the company relationship as a global entity” [software house partner].

But the partners stressed even the organizational model issue when they mention that “in the VE environment supported by PRODNET, the organizational and management structures should be based on a triadic model, taking into account the organizational-social-technological view” [university], or that “the main objectives of PRODNET are to provide tools that increase the reactivity, the quality and the security of the manufacturing process and the production & commercial relationship of the company” [university].

A software house partner mentioned that “new information management tools will be available to follow flow control and co-ordinate commercial and technical information exchanges”, and another one pointed out that “a firm that used to process received faxes or to execute a well defined set of activities has now a powerful set of tools doing most of the activities in an automated way”.

All these features require that “a high level of openness to innovation and doing new and more interesting tasks is much more important in our opinion”, as mentioned by another software house partner of the PRODNET II project. Even if the answers evidence partial aspects of the expected changes, all answers give a significant contribution to two evaluation perspectives: the technical and the human views, even if the answers were given by technologists.

It is a common belief that most of the documents hand-handled will be substituted by electronic equivalents. This new set of documents will be mainly handled by interfacing with specialized computer applications. As an example, an order received by fax and later introduced into the enterprise information system through a dedicated computer application can now be automatically transferred to the enterprise information system. Depending on the internal processing of the received electronic information (possibly in EDI format), the order may be sent to a user’s mailbox to be processed or either to be processed by an enterprise application to deal with orders (PPC). These aspects are mainly related to the internal information flows and information processing. However, one important aspect of the proposed changes is the convergence toward a paperless enterprise by the emergence of computer based document processing.

Based on the demonstration scenario it is possible to anticipate some changes. Let us consider, for instance, an order received at H (Brazilian enterprise) from M (Portuguese enterprise). The order is received by the PRODNET infrastructure and stored directly into the enterprise information system. Based on the workflow plan, the electronically received order will be processed by all predefined computational components (enterprise applications). As an example, a received order goes first to

the mailbox of a responsible user to check new received orders and later included into PPC application to be processed. As soon as the production of all ordered items is complete, an accounting application receives partial information from that order to be processed. This is only a short example of a few steps an order can follow inside the enterprise.

From this scenario it is possible to infer that people start to deal with information not following the former paper based way but accessing a set of enterprise application tools. From the experience of adopting electronic information processing tools one of the main concerns is to provide a sustainable adoption of this new culture inside the enterprise.

Another aspect is related to the fact that the integration of an enterprise into a virtual enterprise-supporting infrastructure creates many changes to the enterprise organization and operation. It is expected that an increasing set of sub-systems would support the automatic information processing into different contexts. One of the main problems the enterprise faces is the need to integrate different technologies to automate partial enterprise processes.

SOME VARIABLES GROUNDING THE PRODNET INNOVATION

The Information and Communication Technology (ICT), is being the catalytic agent of a set of new changes in the entrepreneurial world. As defined before, these changes are taking many forms, some of them unstructured, but always centered on the need to join production / services and knowledge resources to gain competitiveness beyond other social-economical reasons. As a matter of fact, the electronic communications and information sharing among distributed sites, plays the role of facilitator to this tendency. Enterprises can now exchange information based on automatic systems, making transparent to the users its complexity and increasing the quality of co-operation mechanisms. From the technological point of view it is expected that most of the information exchanges using phone, fax and surface mail, will move fast to an increased automation levels. The question is how to model the changes in order to understand the new environment where people have to deal with advanced information technological tools to realize their activities. Some aspects to take into account include:

- response time
- importance of information content
- repetitive procedures/situations shown to users to be applied to similar cases
- classification of procedures according to repetitiveness and its relation to decision risk
- new partners in the network
- information origin and relevancy classification
- maintenance of inter-department information relations and consistency
- classification of information novelty
- network decision nodes.

About response time the question is how to model the new information flows based on electronic tools. The expectation of people to get an answer to a question depends on the knowledge he/she has about the efficiency of the communication channel. Consider the example of sending an order to an enterprise directed to some known internal user. If the delivering order system gives the sender an indication of the reception of such order, the answer time will start to count. Unlike using surface-mail or even fax, here the sender knows definitely that the receiver has the message in his/her hands. This virtual proximity among co-operating people, would make visible the efficiency with which each intervening actor executes his/her activities. The co-ordination of the work done by distributed and heterogeneous people, involving the co-ordination of different cultures, represents an example of a problem.

Information contents represent another challenge to the enterprise users. The information integration creates new and more complex information views. Enterprise users will face more complex tools browsing more interrelated information. Even if graphical presentations and intelligent assistants can help on information interpretation, the enterprise users need to improve their global information knowledge. Another aspect is related to the information and classification according to its importance. Depending on the automation level, the users may have to face situations where decisions have to be taken. These decisions depend on the enterprise size and the activity assignments related with its internal organizational structure. For a small enterprise it is expected that a worker would have to deal with a wider spectrum of information and therefore that needs an extended knowledge of an expected number of running processes.

Other aspects like the repetitive procedures/situations should lead to some effort in order to provide workers with mechanisms for them to learn from past experiences. The ICT tools can also contribute to rearrange the responsibility assigned to each worker based on the novelty of the situations. The classification of the procedures can be done according to repetitiveness and its relation to decision risk. For instance the entrance of a new partner in the network may involve an upper decision level, based on the assumption that this decision can create future commitments, what makes it a strategic decision. On the other hand, another transaction with an enterprise with a past history in the network may not need a more complex decision making than that performed autonomously by the workers.

Another aspect to consider is related to the evaluation of the information origin, relevancy and its classification. Again the ICT tools can contribute to give workers decision-making facilities based on the enterprise information system.

The networks of enterprises are always based on unbalanced relations with one or more decision nodes guiding all relational process. The information technology can move these networks from these unbalanced relations to a more democratic infrastructure, based on an equal access to information sources by all enterprises belonging to the network. However the information access is not enough, it is also necessary that enterprise people have access to a set of tools providing them with decision capacity.

REQUIREMENTS FOR THE TECHNOLOGICAL INNOVATION PROCESS

The lack of *a priori* knowledge about the new functionalities proposed by the PRODNET II project, and knowledge about the process reengineering needs resulting from the effective application of the PRODNET II achievements, creates some difficulties on the establishment of such requirements. The definition of a general set of guidelines to be followed by technologists is mainly centered on the sociological experience from the application of innovation to SMEs taking into account the complexity and the diversity of human behavior.

One of the main factors to get the confidence of the SME workers is to make them feel that they are an integral part of the productive system. This implies a deep change in the employees' view and also in the strategies of the human resources management. As Wang refers, "*the success of a cross-organizational team depends not only on the group members, but also on the commitment of corresponding top management*". Any change on the workplaces must receive the understanding of the motivations for the changes and at least a strategic agreement of the involved workers.

This interactive / participative innovation process would avoid misunderstandings between the workers view of the changes and the view of the technologists that develop and customize/install the new technologies. Most of the times these misunderstandings are originated on conservative attitudes. Workers that for long time execute a set of activities using a restricted set of tools tend to acquire habits and to protect their acquired experience against changes. Often the new tools, software tools, or other human aided resources don't bring much more advantages to the executed processes.

The reasons are diversified, some originated on the lack of tool functionalities, but most of the times due to a weak adoption of the tools by the workers what leads to less productive situations. This weak adoption is originated mainly on a misunderstanding between the former processes executed by the experienced workers and the advantages, for them, when adopting the new technologies. Therefore, some of the reasons for a problematic adoption of a new technology by an SME may be:

- Technology may not evidence a real advantage in comparison with the former process execution;
- The new tools are too general and complex to use. Their application creates functional gaps when not customized to fulfill the specificity of the adopting enterprise;
- The new tools are felt as interesting but they don't fit well with the legated systems and culture. It is frequent the generation of innovation islands along the enterprise based on the lack of an enterprise-integrated view (organizational, functional, and information);
- The introduction of the new tools is not accompanied by a reengineering process and the needed organizational adjustment;
- Workers are not involved in the reengineering process; they are ordered to change their habits by adopting the new processes and tools;

- An important part of knowledge gathered by workers from their daily experience is not incorporated into the innovation process, what generates de-motivation and knowledge waste;
- Workers are not prepared to deal with the new technologies: lack of ground knowledge; unknown vision of the changes; they do not understand the adopted new technologies. Summarizing they are not prepared to deal with the new situation involving the new tools, new procedures, new information, too many things are new.

From these reasons it emerges a need to include into the innovation process all intervening actors providing a sustainable conception and adoption of the new technology. To achieve a better understanding of the complexity on how to define the requirements for the proposed innovation, three analysis perspectives were considered: the technologists, the management, and the workers view.

From the technologists point of view the aspects related with the technology itself and its customization considering the legated culture are emphasized. From the management point of view the most important is the introduction of new or reshaped processes, deeply grounded on the information technologies. But it will require a new behavior from the decision infrastructure. From the workers view, the success of any process reengineering relies on the involvement level of the enterprise intervening workers. The changes should get a consensus and participation willingness from all interlocutors of the change.

The following subtopics intend to contribute to detail some of the above concerns, pointing to some guidelines for the technologists, and administration, as the main responsible on how the changes might be oriented.

GUIDELINES FOR TECHNOLOGISTS

The technology makers play a key role in all the innovation process. First of all they should understand the enterprise requirements and plan the innovation, guaranteeing that the enterprises really achieve the expected results without the creation of undesirable side effects. As a matter of fact one of the main problems in the innovation process is the difficulty to think on innovation from a global perspective.

The complexity of an enterprise operation, involving a large number of subsystems compromised with the execution of complex operations, makes any initiative to promote a global transformation into a very difficult task. Therefore any enterprise change should take into account the legated systems and processes, trying to establish smooth changes, providing that the new technologies inter-operate with the existing sub-systems.

The requirements for technologists are not easy to characterize because they depend on complex technologies and the perception the technologists have from the enterprise reality. The requirements for technologists are related to the global automation infrastructure and to the structure of the workplaces. To divide this complex problem into tackled ones, lets consider first the aspects related to the workplaces and later the integration perspective.

The workplace, as a connection point between workers and the information technology system, needs a special attention from the technologists. The following

enumeration of requirements aims to contribute to establish a better interaction between persons and the workplace tools/resources:

- informal information sharing: a new generation of collaborative tools should allow workers to share their knowledge and questions;
- new information technology solutions tend to create automation islands: the new infrastructures and tools should inter-operate with the legated infrastructures and tools;
- emergence of new bottlenecks on the decision framework: the electronic information flows should incorporate a reorganized decision framework, including the availability of the needed decisional information into the workplaces;
- loss of the empirical experiences and tacit knowledge will reduce workers involvement and motivation, so the new generation of tools should create spaces for workers to interact during its operation and configuration.

All enterprises have a legated internal organization and stable information flows, understood by all workers. The information (documents) flows along the enterprise, collecting all the necessary contributions/validations, depend on the implemented decision schemas that sometimes are too flexible/complex (informal) to be moved to a complete automated information environment. Often the decision making is not really exclusively centered on the workers formally mandated to do that. It is common to find workers responsible to make decisions using informal mechanisms to access decisional information from colleagues. In some sense, the informal relations generated by the written document flows influence them on their decisions. Based on the written information the workers have time enough to share decision concerns with other colleagues maintaining always their decisional position. Many contributions to the decision making are collected in an informal way giving the idea that the final decision was taken by the formal decision-makers (some workers).

The lack of such informal information sharing mechanisms advises the creation of an alternative. When accessing an electronic document, the workers should be able to access information sources and be able to inquire other colleagues using some specialized groupware tool. It is expected that workers will have to decide on the fly most of the time without an opportunity to ask for help from a colleague. Therefore, such required groupware set of tools might create a space similar to the former informal co-operation space. Following this direction, the very rich informal relations among workers can be integrated into the new infrastructure.

The proposed movement, toward electronic information flows, creates many changes in almost all enterprise departments. This global influence can create difficulties to the integration of legated technologies and methodologies. The workers not directly involved with the new technologies can create many difficulties if they are not informed about the changes, even if they are not direct actors of those changes. As an example, the workers responsible for the accounting system, using a legated technology to process orders and invoices can create bottlenecks delaying document processing. These bottlenecks can be originated by lack of clarification about the change on the innovated area, like the change of a document format, resulted from the elimination of information items considered wasteful into the innovated environment.

The proposed innovation infrastructures and tools should incorporate all the legated sub-systems, offering to all enterprise workers the opportunity to be part of the changes. Before changing the information flows and their contents, a relation between the legated system and the new proposed one should be generated. This ahead planning is able to detect the necessary customization work to prevent a perfect integration with the legated systems.

The decision-making framework is deeply related to the amount of information available on each work place and how easily it flows along the enterprise. One explanation for the complex decision making frameworks based on manual documents relies on the need that decision-makers have to collect information along the enterprise. With the information technology, workers and managers have extended information into their working places and at any moment all relevant decisional information can be accessed. As an example, the introduction of the PPC makes possible to the worker interacting with the sub-contraction management to select suppliers (inside the country) without the intervention of the administration board. The PPC manages a list of suppliers, classified according their service quality, what facilitates the delegation of decision-making responsibilities about this issue. As a matter of fact, with the introduction of ICT tools for managing the enterprise information system, the decision framework tends to be more flexible. On one hand the workers have more local decisional information and on the other hand managers can access, any time, the decisional information they need.

Based on the availability of the enterprise information from any work place, the decision framework can be deeply centered on the decisional information available at each work place. Depending on the ICT tools, each workplace can have decisional information conditioned by the enterprise strategy. This infrastructure gives to each worker a greater flexibility to deal with complex situations without the need to wait long times for a confirmation from the administration.

The movement toward fully automated systems creates work places with different human intervention requirements. Some systems tend to reduce the human intervention by automating all the operations. This leads to a very powerful system when everything runs without problems and, in this normal situation, the intervention of the workers is very reduced. However this kind of work places can create on workers a dangerous distance from its operation, reducing their interest on the system and, as a consequence, provoking a reduction of their capacity to deal with exceptional situations.

As an example we can use a worker operating an automated CNC machine tool (with automatic feeding) to produce some part. Hypothetically we can imagine a worker deeply believing on the CNC machine technology and relaxing his skill on how to solve exceptional situations, normally solved by the automatic embedded systems. If the worker does not understand enough all the features of the system in the case of a failure, even if it is a small problem, the operation can be compromised, with visible effects on delivery schedules, quality control, production management, and so forth.

The automation tools must evidence all the operating processes in order that workers understand what the automation system is doing for them. With the new ICT facilities it is easier to provide workers information into the workplaces, providing a continuous acquisition of expertise knowledge about technology and

processes. On the other hand, the automated systems should incorporate into their operation the need for the intervention of the operator, even if an ICT solution exists to avoid it. This anthropocentric approach to systems automation guarantees a higher level of human intervention, giving the enterprise skilled workers the opportunity to be always aware of how to solve complex situations using their acquired tacit knowledge.

When the information flows are centered on electronic documents it is expected that the information exchanged will become more restricted, e.g. centered exclusively on those items necessary for the running operations. Workers tend to be centered on enterprise applications operation with a significant reduction of the utilization of the natural language. This can lead to a reduction of the exchanged information quality.

The creation of an interesting co-operation environment among the different departments of the enterprise could be a way to increase the exchange of information beyond that strictly necessary. The information technologies should fulfil the absence of paper documents flowing among departments and the trust relation created by them.

When the direct dialog is reduced, workers tend to reduce their systemic perspective of the enterprise. If they only get information related to their activities, if the direct communication is reduced, and if the presented electronic documents have only restricted information, the global vision is lost.

The information about the systemic perspective of the enterprise should be available either through written documents (paper), or through specialized tools, providing enterprise workers with strategic enterprise information and with initiatives leading to the exchange of experiences among workers, creating a global team.

GUIDELINES FOR THE ADMINISTRATION

A key to the success of the integration of an enterprise into the virtual enterprise world is the commitment of the administration. Another important aspect is the conscientiousness of the administration about the extent and limitations of the technology in addition to the social and organizational aspects involved when the enterprise joins a virtual enterprise.

A decentralized decision making process should be considered in the implementation of a technological system with the characteristics of PRODNET. If the enterprise reproduces the traditional centralized system, it would be difficult to establish a more efficient decision structure necessary to fulfil the new requirements of the virtual environment. On a distributed system the different actors need to access decisional information otherwise too many bottlenecks can be generated disturbing the normal enterprise business.

In the virtual enterprise scenario the information flows are faster (electronic flows) and, in consequence, each workplace has to deal with more differentiated information in large numbers. As an example, when hundreds of invoices are received from suppliers belonging to different virtual enterprises, the workplace

dealing with the received electronic messages may have to make many decisions about them.

The implementation of the new information and communication system must be accompanied by the decentralization of the decision making process in order to obtain the advantages from all characteristics of the new technology and avoid the bottlenecks generated by the traditional decision systems. The management level has to re-think the strategy of decision making in order to generate a faster way of being into the market. The characteristics of the technical tools should help the enterprise to increase performance in what answers to the customers and suppliers are concerned; the organizational structure must be redefined in order to avoid the delays originated by a slow decision process. The proximity to the customers depends not only on the technology but also on the decision-making framework. It is necessary to think the technology inside the work environment and not in an abstract way where the functionality does not have social and organizational constraints. Some of the obstacles to the innovation process are originated on individual attitudes, such as:

- desire to continue in a familiar environment which is well known;
- lack of information about the foreseen changes into workplaces;
- fear of not having all the information about what is going to happen;
- fear of loosing the job;
- fear of being considered de-skilled when performing the new required tasks;
- fear of failing in the new work situations.

To guarantee that all workers are able to deal with the new scenario it is necessary to inform them about the foreseen changes and involve the different professional teams through some consulting mechanism, making them feeling that they are an integral part of the innovation process. Many of the technological and organizational innovation experiences in other enterprises show the advantages of the participation of people in the conceptual and implementation phases of the changes.

One of the main problems on new technology adoption is the lack of time to digest the new involved concepts and processes. Often there is no time enough to prepare the workers to deal with the new technology through a well-structured vocational training program.

The innovation process should be adopted taking into account the time needed to be understood by all the workers. It is not easy to move from a not automated co-operation with customers and suppliers to an environment where many electronic information transactions may occur in the context of some virtual enterprises. Therefore the virtual enterprise culture must be incorporated on a step by step basis, starting from the administration to all remaining levels of the enterprise. Furthermore, the adoption of a set of new tools, very different from the ones the workers are using, requires time to acquire the new knowledge necessary to understand the tools and the involved processes.

A well structured vocational training program on contents, time schedule, and knowledge transfer methodology, is essential in order to guarantee that all workers are involved and an effective practical result is reflected on the operation of the new enterprise resources and re-engineered processes. Besides technology, the operation on a virtual enterprise environment requires the understanding of the co-operation

culture based on the fact that the enterprise maintains relations with other enterprises from the same region or from other countries or continents.

Significant changes on workplaces content can lead to the integration of difficulties based on conflicts resulting from a different understanding that both technologists and workers have about the new functions. Given the complexity of the enterprise activities, the innovations can lead to functional inconsistencies or even to new processes difficult to be incorporated by workers as they involve new concepts without a clear mapping from the former workplace contents.

It is advisable to define an adoption/implementation cycle considering the need for the necessary interactions involving the refinement of the new reengineered processes, incorporating changes emerged from the interaction with the workers. Technologists without a deep understanding of the workers experience do the technological innovation. Workers tend to refine the way they execute activities. With time, some planned processes would be refined based on workers experience or even based on a collective understanding of the needed changes. The technological innovation should include a phase to consider the adoption of such experienced knowledge, incorporating changes conducting to a better worker satisfaction. This interactive process can be emphasized during the implementation phase considering the possibility to make technological changes following the workers recommendations considered as pertinent.

WORKERS ROLE IN THE INNOVATION PROCESS

The integration of the enterprise into a network supported by the PRODNET system introduces important questions about technical and social skills. On one hand there are technical demands related to the characteristics of the system and on the other hand there are new demands inherent to the new logic of working into the enterprise, from the internal and external points of view. People must develop social skills that enable them to interact in multi-disciplinary teams that often include people from other organizations and where differences must be accommodated and co-operation expanded to achieve common goals.

The functionality of the PRODNET system, presents some new aspects, and introduces significant changes in the information/communication flows, raising new demands from the workers competencies, as the technical skills, and the social, organizational, and cultural skills.

The technical skills can be understood as the technical knowledge of the system functionality, the capacity to interpret a large amount of information, the abstract work resorting to symbols and codes and the interactive vision of the information system. The adaptability to new markets, customers and technologies, the global understanding of the work process of the enterprise, the capacity to deal with new situations, the large knowledge about the products and markets, the capacity of a systemic thinking, and the large technological knowledge, are also considered as technical skills.

Some relevant social, organizational and cultural skills are:

- behavior according to the cultural context;
- permanent interface with customers and colleagues;

- capacity of assuming responsibility and decision-making in ambiguous situations;
- capacity of team work;
- capacity of co-operation;
- capacity to share information.

The development of social and technical vocational training is a crucial point in the process of technological innovation. The work has a new rationality, which implies the incorporation of different attitudes from the behavioral and technical point of view, where the vocational training has an important role to play.

The technical training dimension for workers is based on the knowledge of the basic concepts involved in their activities, the operational features of the tools they use to perform their activities, and the knowledge about the products and the markets.

The social and organizational dimension is related with basic concepts of teamwork, communication skills, cooperation involving heterogeneous teams, and the self-initiative and decision-making.

The specificity of the function of the information systems managers requires new expertise knowledge, as a deep knowledge of the enterprise processes, the extended knowledge about the adopted technologies, and a good state of the art on the enterprise emergent technologies. The social and organizational dimensions are the social principles related to the work, the team working, and the co-operation culture.

The industrial environments are very complex and often-experienced workers execute a large group of complex activities. Most of the times there is a lack of written information about the processes that they execute. The accumulated knowledge acquired along the years with a continuous improvement of the involved processes is very important to the enterprise operation. In the Portuguese 'end-user' it is also possible to find such workplaces, where a few workers behold significant strategic information and who, in general, resist to the adoption of a system that contributes to structure their workplaces, giving them the feeling that they no longer maintain such power. As their participation is strategic for the changing process they should be involved into the innovation process creating discussing spaces where their knowledge can be incorporated into the new reengineered processes.

CONCLUSIONS

There is an increasing conscientiousness about the need for the contribution from the sociology since the very beginning of the development of information and communication tools and systems. However this joint effort is not always pursued because it is not easy to join interdisciplinary efforts to solve a common complex goal. It was stated that the technological developments are themselves social constructions constrained by such social forces. Therefore the technology conception shall have, since the beginning, the contribution from the sociologists in order to guide the developments toward the best unification between people and technology.

The evolution toward the globalization centered on the information and communication technologies is a reality complex enough to require further efforts to

understand better the characteristics emerging from the new relations and the guiding actions that better conduct the virtual enterprise paradigm. A virtual enterprise involves people interacting with the new technology that need to decide faster and base their decisions on wider information knowledge. An enhanced decision structure to deal with the dynamism imposed by electronic controlled workflow and document flows is also required. The involved multicultural relation is also a challenge that this new enterprise arrangement needs to face. Based on this complexity a first approach was done with a set of recommendations targeted to technologists, entrepreneurs and other enterprise responsible workers. The presented problems and corresponding recommendations are not a complete solution to the adoption of the virtual enterprise concept/implementing technologies. They must be considered as a contribution to the definition of a model, characterizing all the relevant aspects of the technological changes and considering all the social and organizational constraints.

Acknowledgment

The authors would like to thank the Esprit project 22647 PRODNET-II for the financial support. The authors thank also the contributions from the consortium partners: CSIN (P), ESTEC (P), HERTEN (BR), LICHEN Informatique (F), MIRALAGO (P), ProSTEP (D), University of Amsterdam (NL), UNINOVA (P), Universidade Federal de Santa Catarina (BR), Universidade Nova de Lisboa (P).

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