Work Design.

From Functional Linearity To Virtual Complexity

Report for D3
State-of-the-art on work design

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José João Sampaio

IET-Research Centre on Enterprise and Work Innovation

FCT-UNL

jjs@fct.unl.pt

Abstract

1. - Setting the Scene.

Traditional work design has been functionally-based and framed on a well defined task definition, according to the main functions performed by the organization and supported on specialized departments allowing a permanent and effective work definition, implementation and control.

In the last twenty years, following technologic developments and competition for innovation, this functional tayloristic approach to work organisation, has evolved to cope with the growth of complexity in global markets and with the need to balance technological development and product oriented work design. According to Hansen et al (1997) different research (Garnsey & Wright, 1990, Hill, 1988, Markides, 1995) has shown that some approaches to work design, like the matrix structure or the multidivisional organizational form, which have been experienced to overcome the functional structure rigidities and to reach the necessary flexibility to develop a product oriented work organization, have proved inefficient.

Yet, market competition, increasing customers demand and technological development had a major changing role on product life cycle, which, in turn, induced new developments on task performance and work design trough the implementation of cross-functional teams (Hansen et al, *Op. Cit*).

This strategy towards a process oriented structure intends to eliminate functional discrepancies in work development and to foster greater response flexibility to environment changes. In this context, work design includes multiple functional areas and may extend beyond the firm's boundaries, to include customers and suppliers (*Idem*). The organization and the work process become than a complex open system, which interacts dynamically with its environment.

2. - The Self Organization. A Conceptual Framework

Following Maturana and Varela's Autopoiesis, self organizing systems develop a synergetic attitude of information exchange with its external environment, resulting in a continuous adaptation to external changes, but maintaining its internal identity. In a contingent perspective of organizational behavior, this results in an adaptation strategy that goes beyond the ability to react against turbulent and instable environments, implying the all productive process to be assumed as being, itself, intrinsically instable and turbulent.

The adaptation is than performed trough a selection process of the different produced varieties, keeping only those which better fulfill the *fitness* objective, aiming to reduce organizational disorder or entropy.

The self organization may then be assumed trough a) greater interaction levels among actors, promoting the emergence of catalytic synergies of new opportunities and b) identifying and assuming internal divergences (disorder) as the source of learning processes, innovation and creativity, resulting in the definition and implementation of a new working organization.

In fact, this is an autocatalytic phenomenon, from which the interaction between agents or entities, creates new entities which reinforce mutually. In this way, self-organization and autocatalytic phenomena among social actors, allow the achievement of results different than those each of the actors would expect to obtain acting independently. On the other hand, political and economic scenarios, imply organizational structures that need to incorporate a great amount of knowledge, allowing themselves an autopöietic and dissipative self-organizing attitude, meaning the existence of a core identity cooping with total flexibility of its adaptive components, until a certain critic dimension from which adaptation is no more possible and evolution is needed.

According to Bauer (1999), an autopöietic system is able to identify, on itself, the resources needed to its evolution seeking to update its identity, according to external changes, trough creativity and innovation. In consequence, productive structure evolves to flexibility supported on sophisticated interaction schema between economic actors, which, trough a productive and commercial network, assume the growing complexity of the productive systems. Finally, modern society's internationalization implies the adoption of integrative and diversifying strategies, in a *fit* perspective, corresponding to a growth of qualitative and quantitative interactions (among different critical environments) on the social, economic and cultural dimensions, which, in turn, are coherent with the critical evolutive and adaptive necessities to the system survival.

Thietart (2000) notes that, according to the Santa Fe Institute nomenclature, an adaptive system is composed of several interacting entities or agents, acting in accordance with local rules and not following a pre-established and coordinated plan. Among the combinations resulting from the multiple interactions, some will be retained and will lead to the emergence of a certain order, following a pre-established logic. So, according to the theory, adaptive behaviour results from a physical subjacent mechanism and focus on multiple entities or agents that modify its behaviour according to simple rules. Only the dynamic process of multiple interactions is a complex one (*Idem*). In complex working systems, this complexity tends to evolve to productive structures, where the technologic innovation and the interaction among the different sub-systems is assumed in a complete different way from other work environments, mainly mass production of simple products or with little technological incorporation.

Continuous development, learning, ability to adapt and creativity become than the main stream of the organization strategy trough the regeneration of human and social resources, including skills, knowledge, co-operation and trust, motivation, employability and constructive industrial relations, as critical dimensions for sustainable working conditions, achieved trough a) the development of a company capability to continuously regenerate resources; b) the design of mechanisms to support self - designed work and organization; c) the extension of democratic and integrative principles for work design and d) the development of network-based mechanisms to generate development resources for small and medium-sized companies (Backström et al, 2002).

3. - Technology and Work Design

These dimensions require active experimentation and the development of learning mechanisms (Shani & Docherty 2003) that facilitate the evolution to self organization processes through the continuous adjustment of values, norms, relations and routines in the daily interaction between all members of the organization (Backström et al, *Op. Cit.).* Also, Gustavsen (1992) emphasizes the key point is that every one concerned at the workplace ought to be encouraged to elaborate its values, together in a developmental process including both the culture and work-based knowledge formation, meaning they are at the same time independent actors and interdependent parts of a complex working system.

As we said before, in complex systems, the adaptation is performed trough a selection process of the different produced varieties, keeping only those which better fulfill the *fitness* objective, aiming to reduce disorder or entropy. In a complex work organization process, this selection requires the development of a professional knowledge based on improved techniques of measurement and experimentation. Pavitt (1997) refers that specialized bodies of technological knowledge have become useful as products incorporate a growing number of technologies. Referring to Gambardella and Torrisi (1997) research findings, Pavitt notes that the most successful electronics firms during the 1990's have been those that have simultaneously broadened their technological focus and narrowed their product focus.

This leads us to the necessary balance between technologic and human agents in a work design process. Borgman (1996) questions the possibility to establish a definition of technology that could demonstrate its power and, simultaneously encompass human responsibility: *"What is our involvement with technological standardization? Shall we revalue, modify or strength our commitment in technology? Is there another way?* "

Whatever the answers could be to these questions, we may easily agree that the concept of technology goes beyond the simple conception and use of tolls and machines. In fact, technology means the use of different techniques in a systemic and integrative perspective. This means that technological dependent work design shall be balance between human and technological agents involved, including a deep knowledge of their potentialities as well as their most vulnerable characteristics. But, the truth is that work design as been mostly supported in a human factors development perspective, meaning the design, development and implementation of “intelligent” work systems and environments, capable to integrate the most intrinsic characteristics of human and social behaviour. This “artificial intelligence” encompasses work design during late 80’s and supports the emergence of a new ergonomic research area called *cognitive ergonomics*, as well as *cognitive engineering* corresponding to its industrial field of application (Bannon e Karsenty, 1997).

Yet, besides these developments, work design in a Human/Machine Interface basis has shown to be problematic, taking into account the social nature of human agents, which being not compatible to any behavior determinism, calls for a change on work design either at conceptual level or at the methodological one. On this purpose, Thomas & Kellog (1989), referred by Bannon e Karsenty, (*Op. Cit*) identified the existence of a ecological *gap* in traditional work design methodologies, consisting in the development of laboratorial tests, most of the times in the absence of important elements which can only be tested in real work. The necessity to approach the operational reality as been well demonstrated by Rasmussen, Hollnagel and Woods work (Bannon & Karsenty, *Op. Cit.).*

But, this approach to operational reality can not resume itself to the identification of a set of human nature characteristics and to the tentative to integrate it in complex work systems, trough a more or less sophisticated interface design. Most of the times, this procedure will lead to operator cognitive absence and loss of working functionalities awareness. In fact, work design is more than the specification of a set of rules and/or functionalities, supported by complex technological systems. Hoc (1997) refers the Joint Cognitive System concept introduced by Holnagel &Woods (1983) meaning task distantiation from a strictly technocentric perspective and the integration of Human dimensions in work design, this way preventing human agents from being reduced to a residual role in the whole human/machine system.

4. - Operational Requirements

Confirming these concerns, there is a consensual agreement that work design shall integrate a strong operational component, trough the participation of the final user in the conceptual as well as the design and implementation phases, this procedure being determinant to the definition of the operational specifications that will support the new working system (Amalberti, 1998; Billings, 1997; Parasuraman, Sheridan e Wickens, 2000).

Traditionally, user participation in work design was restricted to the initial phase of the whole process, trough the evaluation of current operational activity and future operational needs, performed by system analysts, which both constitute the basis of the future working system (Bannon 1990). Yet, the truth shows that this approach has revealed a great weakness in the necessary adaptation of technological dependent work systems to the future users’ operational needs. Even the submission of the operational specifications to the evaluation of operational users, has proved to be unproductive as these specifications were, in many cases, of difficult interpretation and comprehension, possibly leading to the limit situation of *automating a fiction* (Sheil, 1983).

An alternative to this methodology is the so called “cooperative design” consisting in the participation of future users during the whole system design phase, assuming that operational people have normally a great difficulty in describing its own work, mainly when some kind of modeling needs to be established. Thus, integrating users in design and development phases requires the definition and implementation of new prospective and evaluation tools, like workshops, simulations, etc, allowing future users to test the benefits and disadvantages of different work design and operational environments.

These tools will be assumed as a kind of future work system prototype (Bannon, *Op. Cit*) representing as they are described by Bødker & Grønbæk (1991) the so called systemic involvement “scandinavian model” where future users are assumed to be fundamental partners in the design and implementation of technological dependent work systems. In this approach, workers are given skill-enhancing computerized tools and methods (Ehn and Kyng, 1987) that allow them to envision future work situations, anticipate potential problems and contribute for the re-design of the planed working system (Bannon, *Op. Cit*). In this perspective, Cooperative Design means that Human/Machine Interaction can no longer be reduced to technocentric or anthropocentric determinisms, as modern working contexts integrate a large number of human and technological agents that need to understand each other structural dimensions. Finally, this cooperation represents a decisive step to free Human/Machine Interaction from an understanding where human nature is considered as a constraint to systemic development and, on that perspective, solvable by technological means, like any other operational problem (Sampaio 2005).

An important issue that needs to be addresses in cooperative design relates to the capacity of designers and users to understand each other. Talking about “language games”, (Ehn, 1992) identifies some lessons on design, skill and participation, learned from UTOPIA and DEMOS projects:

General lessons on work-oriented design include:

> *- Understanding design as a process of creating new language-games that have family resemblance with the language-games of both users and designers gives us an orientation for doing work-oriented design through skill-based participation--a way of doing design that may help us transcend some of the limits of formalization. Setting up these design language-games is a new role for the designer.*
>
> *- Traditional "systems descriptions" are not sufficient in a skill-based participatory design approach. Design artefacts should not be seen primarily as means for creating true "pictures of reality," but as means to help users and designers discuss and experience current situations and envision future ones.*
>
> *- "Design-by-doing" design approaches such as the use of mockups and other prototyping design artifacts make it possible for ordinary users to use their practical skill when participating in the design process.*

Lessons on skill in the design of computer-based systems include:

- Participatory design is a learning process in which designers and users learn from each other.

- Besides propositional knowledge, practical understanding is a type of skill that should be taken seriously in a design language-game since the most important rules we follow in skillful performance are embedded in practice and defy formalization.

- Creativity depends on the open-textured character of rule-following behavior, hence a focus on traditional skill is not a drawback to creative transcendence but a necessary condition. Supporting the dialectics between tradition and transcendence is the heart of design.

Lessons on participation in design of computer-based systems include:

- Really participatory design requires a shared form of life--a shared social and cultural background and a shared language. Hence, participatory design means not only users participating in design but also designers participating in use. The professional designer will try to share practice with the users.

- To make real user participation possible, a design language-game must be set up in such a way that it has a family resemblance to language-games the users have participated in before. Hence, the creative designer should be concerned with the practice of the users in organizing the design process, and understand that every new design language-game is a unique situated design experience. There is, however paradoxical it may sound, no requirement that the design language-game make the same sense to users and designers. There is only requirement that the designer set the stage for a design language-game in which participation makes sense to all participants.

These results show that cooperative design strategy while prioritizing the work process and allowing future system users to acquire a more consistent adaptation and comprehension of the technological work procedures involved (Ehn And Kyng, 1987) also requires an high level of users and system designers integration, who must identify each own competencies for the construction of a common dialogue. This will be the basis for work design evolution towards a prospective concept, where future users will participate in the design and implementation of the operational system modifications. Cooperative design evolves than from a methodology, towards an objective to be achieved in a joint process between system designers and operational people (*idem*).

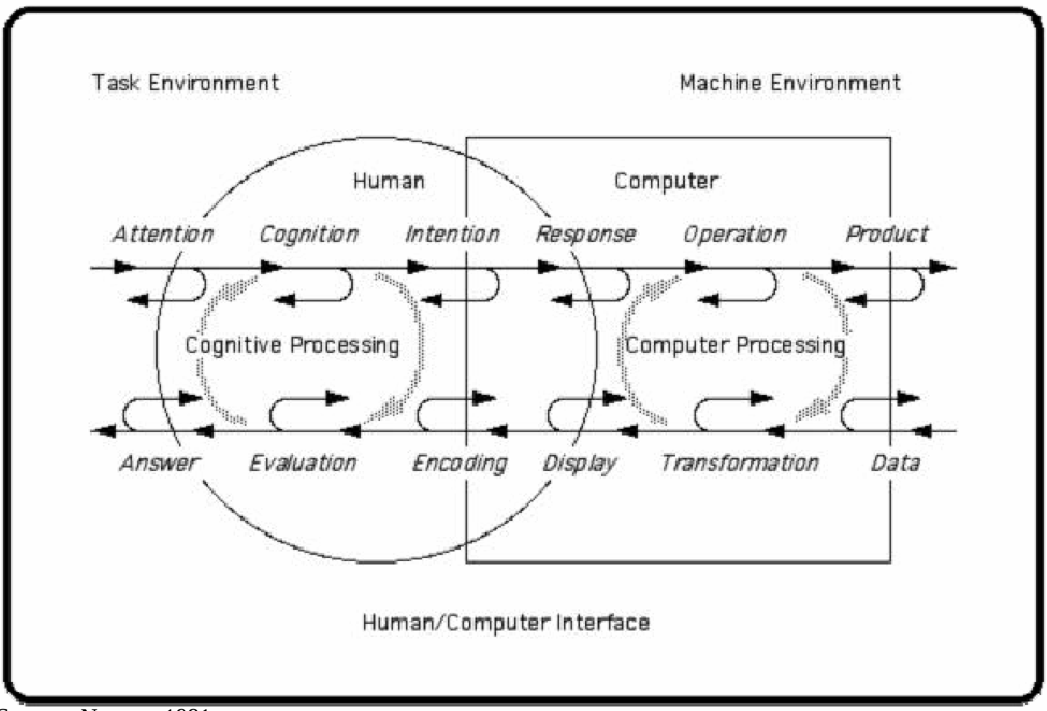
In a Human centered approach, technological integration in work design shall be developed to support human agents and not just because it is available (Billings, 1997). As stated by Hopkin, (1988) and Garland & Hopkin (1994), to reduce human agent operational involvement in a complex working environment, may lead to a significant reduction of performance capabilities, when they are most needed, i. e. in emergency situations or to solve unexpected operational problems (Ahlstrom et al. 2002).

5. - The Interface

Our previous discussion shows that the simple consideration of human characteristics in working systems design and implementation may not result in a human centered approach. Also the study and development of sophisticated interface systems between human and technological agents, aiming to reproduce human nature and motivations, will, frequently, end up on too heavy and difficult to operate systems (several modes and systemic functions) resulting in the perverse effect of de-motivation of the human element in the whole system. Thus, it is assumed to be of paramount importance the study of the physical and conceptual frontier between the operational user and the input and output systems and sub-systems. It is trough this frontier or interface that human agents give instructions, inputs data and collects the correspondent feed-back which permits to maintain the whole system under control (Norman, 2001).

In a traditional and simplistic perspective of Human/Machine relationship, interface is assumed as being essentially operational and corresponding to the necessary balance between system design and human response capability presenting information in predetermined zones (Shneiderman, 1998) and with a layout which is consistent with user expectancies (Billings, 1991, 1996). We are talking about an instrumental and mechanized use of the technological systems, resulting in the isolation of each other in its specific field. Nowadays it is possible to identify a new approach towards a multidisciplinary cooperation between social and system development scientists, fostering the question of how human and technological agent's behavior must be reciprocally understood, as a set of cognitive and computational processes – see fig. 1.

Figure 1. The human/computer interface as a set of cognitive and computational processes

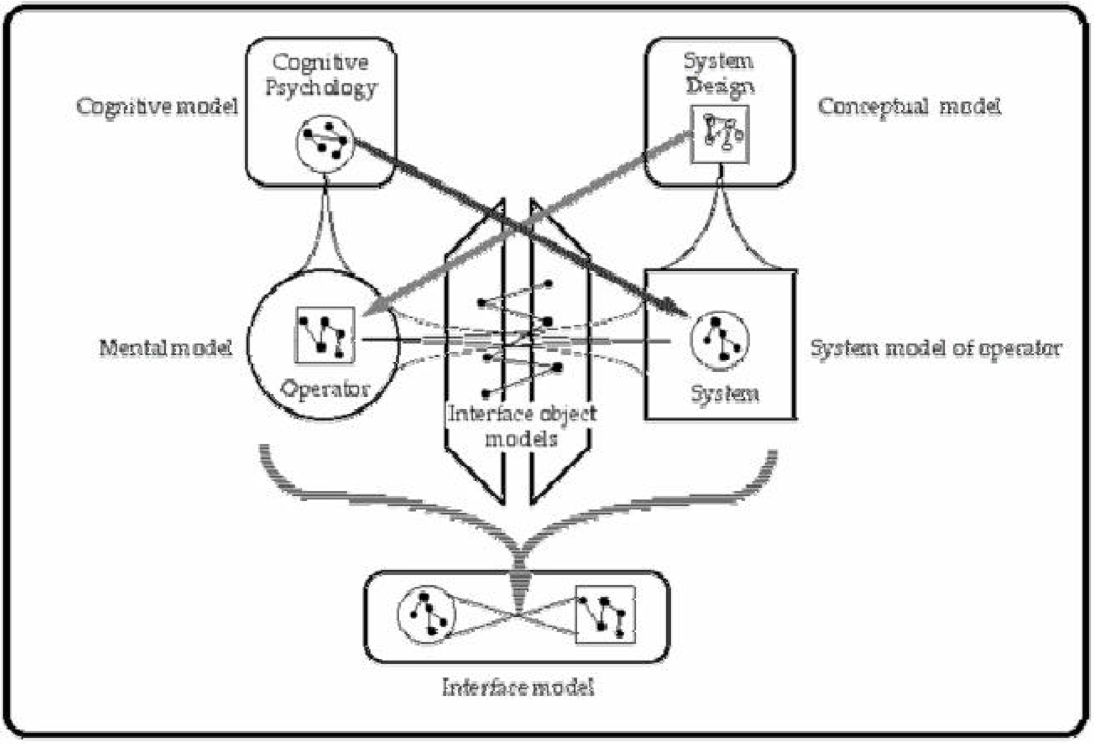


Source : Norman 1991

As referred by Norman (1991) human/computer interface assumes a task context (operational) and is identified as the overlapping portion of the areas representing human activities (circle) and technological/automated processes (square).

Figure 2 shows that Human/Machine interface normally results from a set of psychological / cognitive models.

Figure 2. Models involved in the human/computer interface



Source : Norman 1991

Norman explains each of these models:

- Interface model determines high level functions which correspond to human and technologic sub-systems. As an example we may take air traffic control, where some tasks are allocated to the air traffic controller (radio-telephony, operation decision and clearance deliveries, etc.) while other tasks are of technical system "responsibility" as target distance and trajectory calculation, or alerting advisory.
- The operator cognitive model is determined by the psychologist. It is the result of theoretic and empiric research on the operator's information processing limits and capacities.
- The systemic operator model represents the way the operator is expected to react. The equipment will anticipate user's behaviour in order to exclude possible ambiguities and formatting data in a comprehensive way. As an example if the operator inputs http:/www.fct.unnl.pt, the systemic operator model may correct it to input http:/www.fct.unl.pt. Also some actions may be inhibited or forced by the system.

- Conceptual model of the operator is a system representation, which is formulated by the system designer and delivered to the operator to help him understand and use it. This model is assimilated by the user trough documentation and operational training, i. e., trough professional training aiming to adapt him to the conception and functionalities of the technological system.

- Mental model of the operator is a cognitive internal representation of how the system works. For example, the operator may assume a word processor like a type writer machine…

- Object interface model consists on graphical representations or symbolic objects, like buttons, switches and other objects to be represented on an automated system display.

These explanations suggest that, no matter what the considered dimensions are – sociological, psychological, ergonomic, system designs – there is a general agreement that the results obtained from a strictly technological dimension of work design and Human/Machine integration, have not corresponded to the initial expectations. In fact, as the result of operational complexity promoted and sustained by ICTs, system design can't cope anymore with the isolation of scientific disciplines, meaning the necessity to promote a multiple approach that will adapt available technology to the characteristics of future user population. In this context sociological competencies like group awareness, structures and data collection and analysis tools, are becoming a demanding challenge to engineering professionals, towards a better and faster integration in multidisciplinary teams Moniz (2002). This integrated approach to system design, will allow organisations to be structured in a "strategic intelligence" direction as well as a better understanding and development of concepts such as simultaneous engineering, converging engineering and flexible production (*Idem*).

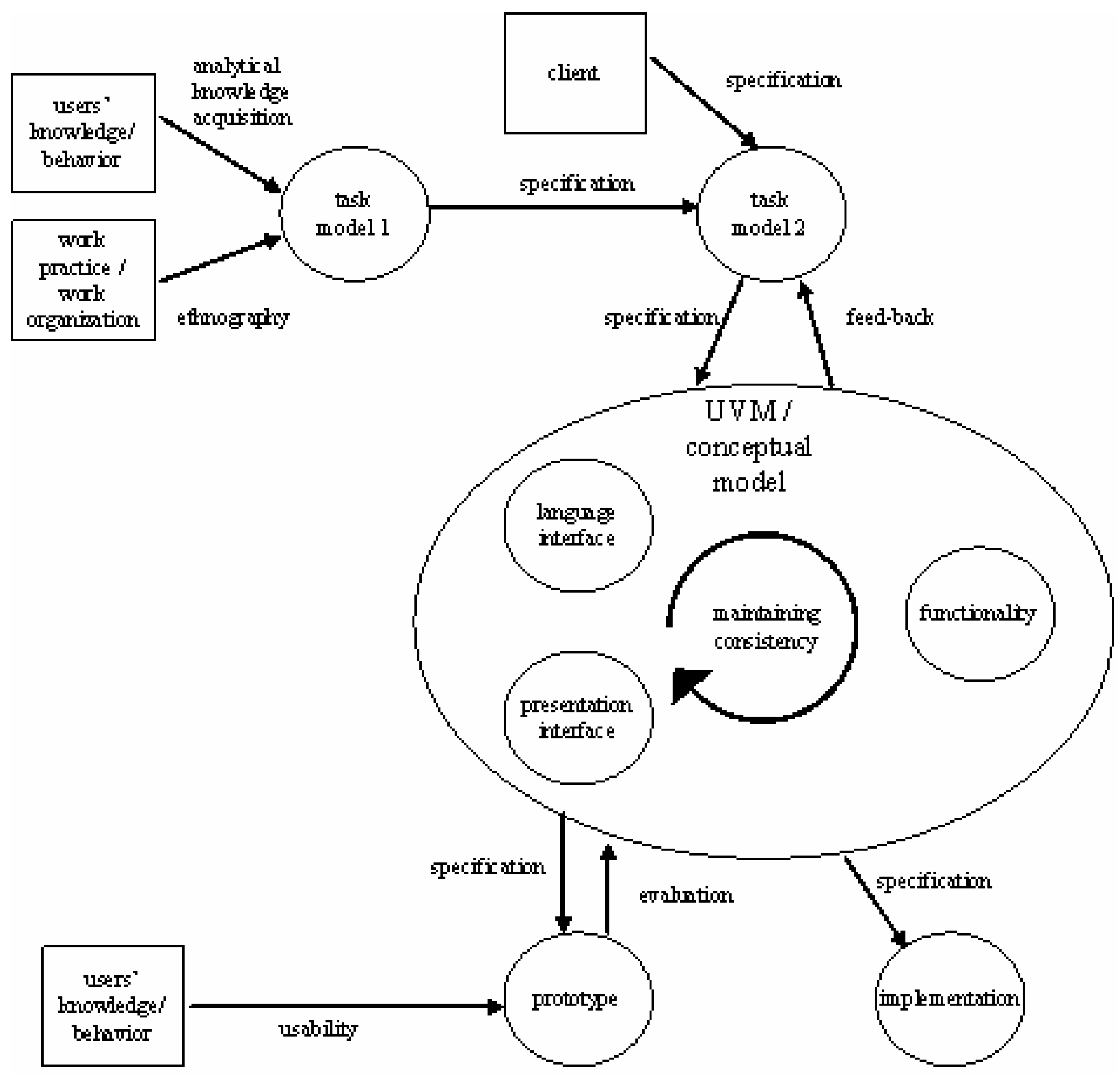
6. - Complex Work Systems Design

The late suggests that integrated approach to system design will not be effective if it is not viewed as a structure of activities, where both future clients (people or organisations that pay for the design or acquisition of the systems) and users (the people or groups that apply the systems as part of their daily work) have an important role to play, as they may have different or even contradictory knowledge about task domain and, consequently, different goals regarding the system to be developed (Gerrit C. & al., 1995). Also, end-user groups may have, as a group, knowledge or a view on the task domain that may not be equivalent to the (average or aggregated) knowledge and views of the individuals (*Idem*) making the design process, a problem solving activity in a recursive trial and error process. That is why the development of a suitable team structure of activities model is very important for the design process.

Figure 3 shows Gerrit C. & al. (1995) team design model, where a) task model 1 is developed on the basis of knowledge acquisition activities; b) task model 2 is the result of analysing task model 1 as a specification activity, taking account of the clients' request and relevant knowledge of state of the art technology; c) UVM (User Virtual

Machine) in a feed-back interactive process with task model 2 ; d) prototyping is based on specifications emerging during design decisions on the UVM and will return evaluation to the mentioned modelling activities; e) implementation based on the specifications that eventually result from the UVM when evaluation has been satisfactory; f) management and coordination, including specification feedback control, of the various transfers among activity clusters.

Figure 3 - Design team, structure of activities



Source : Gerrit C. & al., 1995

Designing a complex work system represents, thus, a great challenge usually including several subsystems and a complex interaction network as well as requiring continuous maintenance and development in an evolving perspective of new technologies and functionalities incorporation, following new operational requirements.

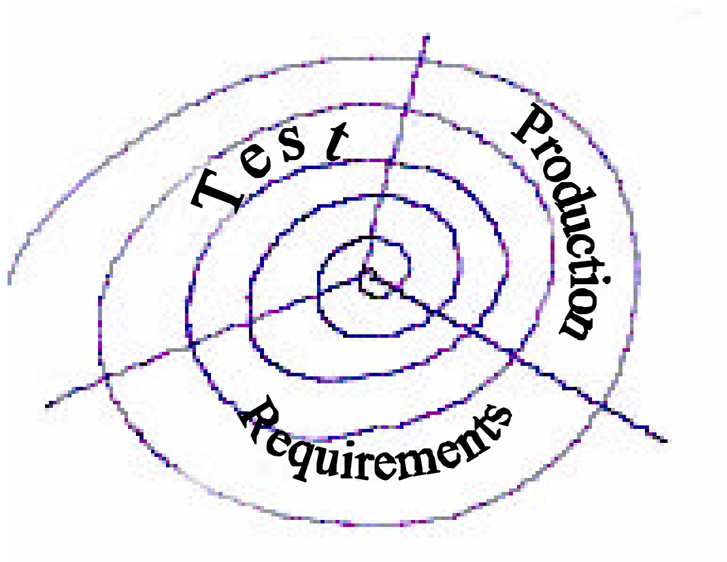
Also, this evolving strategy creates the necessity to aggregate, in the same system, technologies of different generation and nature, while assuring the efficacy of the final result, reason why system designers opt frequently to maintain, in a new working environment, some old but well tested components of previous system generations (Sampaio, 2005).

Our research showed clearly that teams including different generations of end-users and system designers result in a better understanding of operational requirements and technological potentialities and/or constraints, as a consequence of the accumulated experiences, either at system generation level or at operational needs. Although with different levels of involvement, this collaboration as shown to be fruitful in all phases, including initial requirements, development and final testing, with more incidence at initial and final phases of the designing process.

As shown on figure 3, complex work systems design is not a sequential process, where specifications, production and integration phases succeed in time and space on a chronological and foreseeable way. It is rather a recursive process where feedback is fundamental for the necessary fitness of each design phase to the end-user needs – fig. 4.

The result is the production of a document that is structured into three parts that constitute a) a first high level approach to the foreseeable objectives of the work system; b) detailed description of the new component or functionality to be introduced in the existent work system and c) detail of consolidated requirements that will frame and support the production/development phase.

Figure 4 - Complex System Design Process. A Simplified Diagram

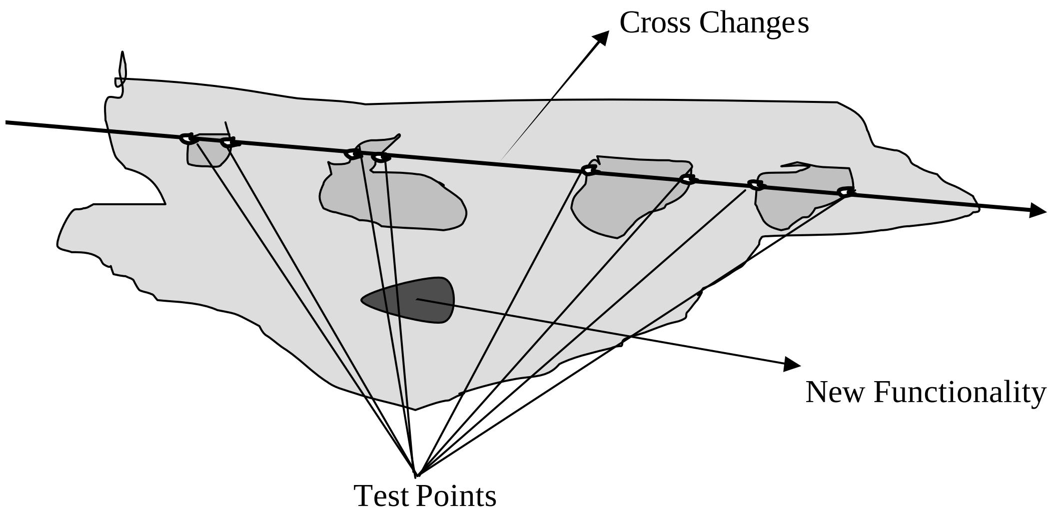


Source : Sampaio, 2005

REQUIREMENTS phase is a critical one and must be projected to the development/production phase, in its most relevant aspects. The resulting document shall than include all relevant information needed to the understanding of the solutions found as well as documentation related to the actions developed, from prototyping, meeting reports, diagrams to “brain storming” conclusions.

PRODUCTION/DEVELOPMENT phase shall initiate from the solid knowledge of existing systems and/or functionalities. This is done by, disaggregating the existing system on which a new product is to be included, while considering all components, functionalities and interfaces. This way it is possible to identify and evaluate possible constraints that might emerge from the new components interaction. For example, if a system is operationally stable, it is important to understand that any new component to be introduced will become an eventual destabilizing factor and that adequate procedures shall be addressed to minimize the risk. This means that available technology and development procedures must be integrated without any constraint in the existing systems. As we said before, this is the job of a multidisciplinary team, which work is developed across all the productive process and shall validate the coherence and integrity of the resulting working system – fig. 5.

Figure 5 – Identification of Changes Introduced in an Existent System



Source : Sampaio, 2005

INTEGRATION phase consists in the process of putting together all the components that have been autonomously developed inside the system. This is initially done on a test system that replicates operational system, or trough a shadow operation procedure, maintaining high safety standards for the normal operation, like the rollback possibility. During this process the new design is followed up and logging, exceptions and profiling information is collected for system evaluation and eventual detection of anomalies. These procedures may finally end up into new functional or corrective requirements, which will restart the whole process.

7. - Virtual Organizations Work Design

We said before that designing a complex work system represents a great challenge usually including several subsystems and a complex interaction network. During the last decade, when such a complex work system is supported by information technology in an open (boundless) organisation, it has been identified as a virtual organisation work system (Jarvenpaa and Leidner, 1998).

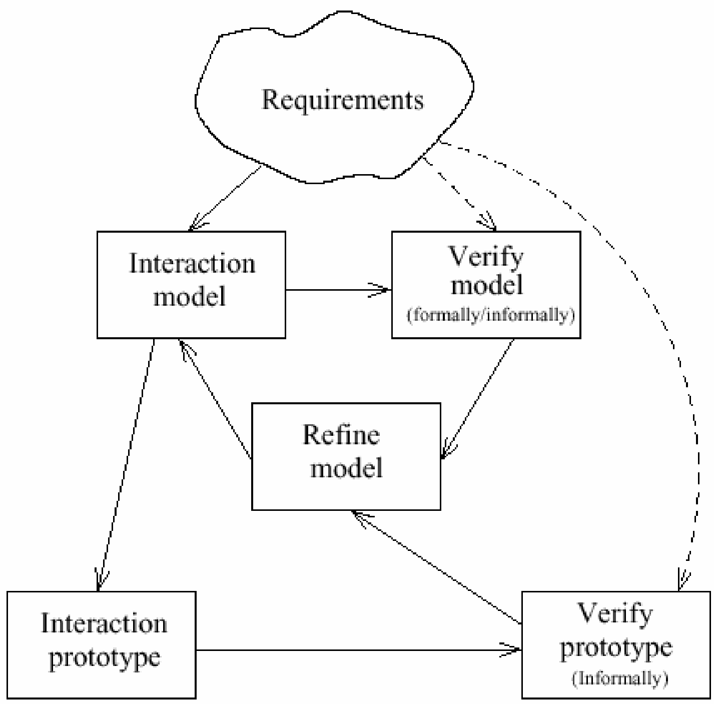
The concept of virtual organisation (VO) appears thus, as the emergence of a new form of work organisation and design, enabled by technological progress, which complements the physically bounded and centralised traditional work place. Yet, this conceptualisation needs to be discussed against the complexity of virtual reality itself, as a set of interconnected networks, electronically linked by a complex technological system. These networks may as well be individuals, groups, or different organisations, in a web of cross relations that lacking the traditional hierarchical structure, result in a powerful networked virtual organisation in terms of focus, access of information and flexibility (Alexander, 1997). In this context and following Dutton (1999) in Hemingway & Breu (2003), the process of virtualisation may be seen to entail three interdependent activities, as networking, restructuring and building a learning organisation culture.

Also Timothy et al. (2004) refer VOs as being composed of a number of semi-independent autonomous entities (representing different individuals, departments and organisations) each of which has a range of problem solving capabilities and resources at their disposal. These entities co-exist and sometimes compete with one another in a ubiquitous virtual marketplace, until one or more of these entities perceive the opportunity of pooling each other capabilities (complementary or competitive), in order to exploit a market niche, forming a new VO. In this context, VOs are conceptualised as continuous flows of information that, fostering work cooperation, differentiate and select new working segments and nodes, in a complex work dynamic, where discontinuity and temporality seem to be the main characteristics (Dibben. & Panteli, 2000) ensuring that they are both agile and resilient (Timothy et al. , *Op. Cit*).

Virtual environments (VE) play, than, an important role in representing a three-dimensional real-life or abstract space, although much care need to be addressed in its design, to avoid user disorientation, loss of situation awareness and/or perceptual misjudgements, as well as difficulty in understanding available interactions. Because these constraints may, finally, end up into user low usability and acceptability, the context of use assumes, like functionality and structure, a great importance in VE design. However, as referred by Turner and Turner (2002) attention has concentrated primarily on the technical challenges of representing complex spaces, actors, movement and communication, as well as focussing on the usability of the environment for individuals or collaborating groups. As noted by Kaur et al. (1996) in Willans & Harrison (1999), only a few system developers are aware of this class of interactive system and whereas there is much software available which facilitates the prototyping and refinement of the environment, the corresponding facilities for the development of interaction techniques are weak. It is than important that methods (and tools to support the methods) by which the interaction techniques can be systematically designed, tested and refined, are present in VE development (*Idem*).

Loking for a solution to this problem, Willans & Harrison (*Op. Cit*), are concerned to identify which techniques developed for interactive systems in general, can be applied to virtual environments and which characteristics of the behaviour of virtual environments distinguish them from other interactive systems. Integrating prototyping of interaction techniques into the development cycle of virtual environments the authors conclude that behavioural specification is a good starting point for such a prototype because it allows the developer to consider the requirements in a user centred, rather than implementation centred, manner. Following this idea, the design of a prototype will require a behavioural specification (what the user can do and in what sequence) and the response of the system to the user interaction (*Idem*). This procedure allows the specification to be used in verification before prototype development figure 4.

Figure 4: A proposed structure to the specification-prototype method of verifying behaviour



Source: Willans & Harrison (1999),

As we said before, VOs consist of networks of workers and organisational units, linked by information technology in order to coordinate their activities, combining their skills and resources, in order to achieve common goals. As a consequence, "virtual teamwork" emerges as the natural work organisation, arguing Maher & Gu (2002) that VE design should stimulate the development of cognitive maps to orient, work, collaborate and navigate in the respective spaces. Looking at the incorporation of rational agents to represent the behaviours of the objects, Maher & Gu focus on the use and extension of a virtual world platform supporting pre-programmed behaviours, called Active Worlds, and its relationship to architectural design.

This characteristic identified as virtual architecture, considers the design of VEs as places in some ways similar to places created through architectural design (*Idem*). Finally, the authors identified three major conclusions from their research :

1. **Beyond being there**: these kinds of place environments demonstrate their potential when we can create places that go “beyond being there”. This is possible because the world is a virtual world and not constrained by the physical, but also because we can ascribe behaviours to objects in the world that are relevant to being in a virtual place.

2. **A new set of design principles** can be developed that consider requirements that are associated with the experience of virtual presence as well as the way in which a person interacts with a world through the input devices of a keyboard and mouse. These principles are only starting to be realized and each designer will develop their own design style based on how the designer interprets virtual presence.

3. **Metaphorical design** is an important consideration in the design of virtual worlds. Until there are enough examples of virtual worlds so that we can develop an intuition on how to interact and behave in these new worlds, there needs to be a clear reference to the physical world. This provides a comfort zone for people interacting with each other and the virtual world.

These conclusions lead us to the understanding of “virtual teamwork”. As referred by Lau (1997) Groupware (coined in 1978) and Computer-Supported Cooperative Work (CSCW) appeared in 1984, are the most common designations for the technological tools supporting teamwork. Applied to VOs the term groupware may as well designate e-mail, bulletin boards, group calendars, real-time conferencing systems, office automation software, 'room based' decision support systems or GDSS, workflow management systems, text or document based conferencing systems, as, more recently, internet based applications (*Idem*). Anyway and besides VOs being adequate for the deployment of such products (O’Leary, 1997) the real use of this impressive amount of software development, does not meet IT vendor expectancies or are, in many cases, used in a limited fashion (Bullen, 1990; Schal, 1996).

This gap between the product and its usability calls for a deeper insight of human issues in work design and consequent product development, i. e. in the understanding of both functions provided and user-requirements, as well as the “nature” of human and technological agents (Sampaio 2005). In a VE, teamwork organisation and design must try to understand the more subtle requirements for its effective support. As argued by Ramesh & Dennis (2002) it seems that the most evident characteristic of virtual teams is the need to find new forms of work coordination that replace the traditional face-to-face meetings. To support this argument, the authors outline the main characteristics of two communication and coordination forms observed in virtual team organisation, which they termed as “Integrated Team” (improves communication and coordination by tightly integrating team members through information rich media) and "Objected-Oriented Team," (many of its characteristics have parallels in the object-oriented world) concluding that the challenge for virtual teams work design is to understand when each form of team is appropriate, speculating that the object-oriented team model may be most appropriate for large and complex projects, while the integrated team model may be most appropriate for smaller and less complex projects (*Idem*).

8. - Conclusions

9. - Bibliography

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