An Integrated Framework for Office Information Systems Design and Management

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ABSTRACT

The complexity of Information Technologies is nothing compared with the one that arises when technology interacts with society. Office Automation has been traditionally considered as a technical field, but there is no way to find technical solutions when the problems are primarily social.

In particular, we need a better understanding between the managerial and technical world, offering a coherent, complete and integrated perspective of both. This is the basis for our model, developed as an unfolding of the complexity found in Information Technologies and a matching of these complexities with several levels considered within the Office, Office Automation and Human Factors dimensions. Each one of these domains is studied through a set of distinctions that create a new and powerful understanding of its reality. Using this model we build up a map of Office Automation to be used not only by managers but also by technicians because the primary advantage of such a framework is that it allows a comprehensive evaluation of technology without requiring extensive technical knowledge. Thus, the model can be seen as a principle for design and diagnosis of Office Automation and as a common reference for managers and specialists, avoiding the severe limitations arising from the language used by the last.

1. Introduction

Office Automation (OA) has become a very important application area of technology. We also would like to emphasize the key role the office plays in the development, evolution, competitiveness, and economics of an enterprise. The growing complexity of organizational environments; the trend towards an international market; the strength of regional differences; the need for a strong corporate identity; the capabilities required in order to survive in today's economy; these are only some of the factors which make Office Automation a basic strategic tool.

However, OA is still something fuzzy, unclear, and this prevents things from working as they should. Many managers are already aware of this, and it gives them reasons for fearing technology. OA is obviously necessary, at least as a partial solution to many problems in public and private organizations. Why, then, is it so difficult to implement technology in work environments and to achieve overall acceptance of the equipment? These and similar questions run counter to the traditional point of view, technology as the solution to all ills; nonetheless, they are questions frequently posed by managers, and there are no easy answers.

Problems of a social and human nature cannot be solved from a strictly technical point of view. But to adopt a strictly social perspective is also a mistake, since Office Automation is an applied field of Information Technologies. As a field of study, it requires the use of a conceptual framework for technological and organizational design embracing both social and technical aspects and establishing the appropriate relations giving a global perspective. The goal of our study is to develop a conceptual framework for managers that helps both users and producers to work with a common and integrated understanding of OA.

2. Office automation as a set of distinctions

If there is any application that can be considered to be a synthesis of Information Technologies, it is Office Automation. There is no better field for showing the need for a multidisciplinary, non-specialized and generalist approach. The complexity of Office Automation is obvious. And this is the reason why traditional technological and managerial methods alone are not enough.

Our proposal is to deal with Office Automation through a theory constructed as a set of distinctions. We use the concept of distinction in the sense of Winograd and Flores [31], i.e., as mechanisms within the language to create new domains of action and understanding in OA.

Within Office Automation many different distinctions coexist. At the same time, the perspective of each distinction must be related to the whole, in order to provide a richer and deeper picture of reality. The proper management of Office Automation begins with the recognition of its many facets and of the organization where it is going to be implemented.

We think the first step to a proper management of OA begins with the recognition of a general model as the one proposed here which is neither a methodology nor an implementation system, but rather a conceptual framework for action and interpretation.

3. Understand complexity

There are many reasons for considering technology a complex object. Any manager who keeps in touch with technology is aware of the facts: chaotic, ever changing and disorganized products in the marketplace; incompatible equipment; lack of standards; inadequate systems; lack of human resources to deal with that technology; changes in the organization's structure due to new technologies; lack of motivation to use the equipment, etc..

All this makes very difficult to take full advantage of technology. And since technology does not offer any help in solving problems, it is the user -- especially the manager -- who has to choose an approach that is relevant to the needs. In many cases, technology models the user's needs and not the other way around. The manager lacks the conceptual tools to evaluate technology, its potential and its subjective value, established according to the needs. To fill this gap we propose the first distinction: a hierarchy of levels of complexity.

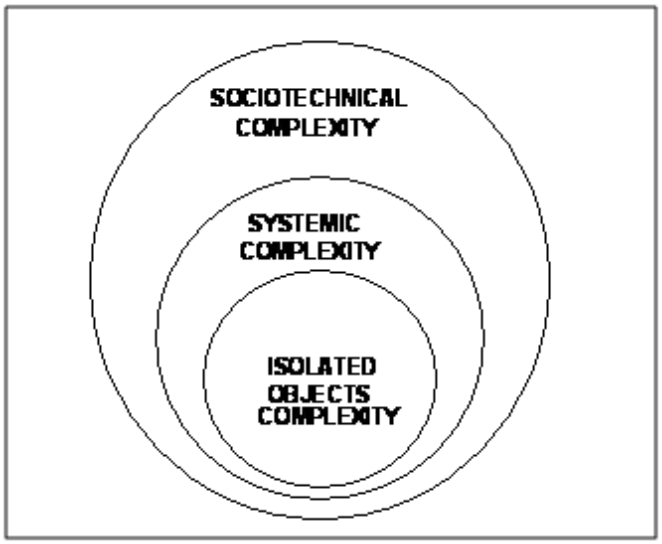


Fig. 1: 3L complexity model

The first level deals with isolated objects. Considered separately, programs and computers, oriented to a narrow application such as text processors, calculators, electronic agendas or electronic sheets,

comprise the first level of complexity. As far as the manager is concerned, these are applications with well defined goals.

When those isolated objects are linked together to build a system whose goal is not just text processing, for example, but to give support to some organizational functions, then systemic complexity arises. At this second level, we are dealing with a great number of technical connections and group activities. One example would be a set of computers running first level applications connected through a local network.

The last level stems from the interaction between technological systems and society, the sociotechnical complexity level. It is mainly at this level that the manager works, and it has many characteristics that differ radically from those of the others. Here, all the fuzziness, lack of definition, incongruence and irrationality introduced by human factors appears. Although strictly sociological in origin, this is the highest level and it includes the other two.

This model, which we call the 3-L (three level) model of complexity, was initially proposed by Sáez Vacas in [22]. A brief study of its application to Office Automation can be found in [26] and deeper ones in [1] and [27]. We will use this model as the basic construction for the framework presented in this paper.

3.1 Understand your own office ...

A basic step towards Office Automation is to decide which office tasks are to be automated. Text processing and decision making are certainly completely different activities but both are part of OA. Technology can only be correctly applied if there is a thorough knowledge of what is to be done. One of the initial mistakes of many implementations is to buy technology and then to try to find out what to do with it.

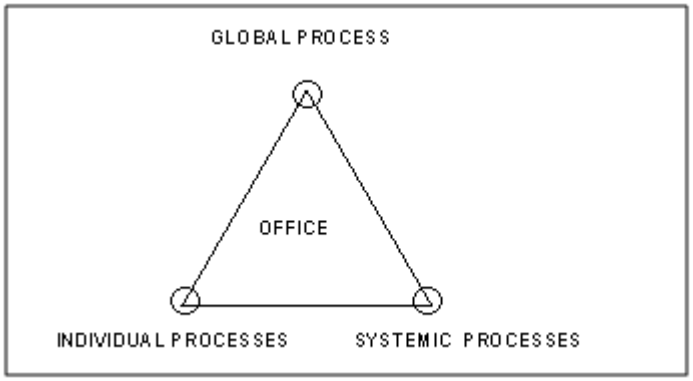


Fig. 2 The office decomposed in three complexity levels

There are many studies analyzing office tasks: reading, writing, making simple calculations, telephoning, mailing, meeting, filing and retrieving of information, etc. Nevertheless, the office is much more. When offices are conceived of only in terms of their manifest behaviour, the above mentioned activities, there is a dissonance between technology and reality, because reality is much richer and has much more variety.

Individual Processes are tasks carried out in an isolated way and without any significant meaning in terms of the organization. No enterprise defines its activity in terms of reading and writing, why, then, does technology do so? Managers must set their goals much higher.

Higher level activities provide meaning and coherence, establishing goals through office functions. These are Systemic Processes, composed of several individual activities, communicating with one

another, and connected to build processes within the organization: processing purchase orders, patents and financial reports, etc. Someone not familiar with these environments will just notice first level activities. Managers deal with Systemic Processes.

One step further, all those Systemic Processes must be coordinated to fulfill requirements that affect the organization as a whole. These requirements define higher level activities: the Global Process. This view of the office is our second distinction, depicted in figure 2 and with the same hierarchical meaning of figure 1.

3.2 Apply technology

Only with a thorough understanding of the way each office works can technology be correctly applied. Implemented technology must mirror, as far as possible, the environment's personality. Thus, with the office interpreted as a hierarchy of levels, Office Automation can be seen as having a similar structure. In the past, Office Automation practice has only recognized the lowest level and it is starting to become aware of the second one. Many tools are devoted to individual activities: text processors, electronic sheets, electronic agendas, graphic programs, laser printers, calculators, etc.

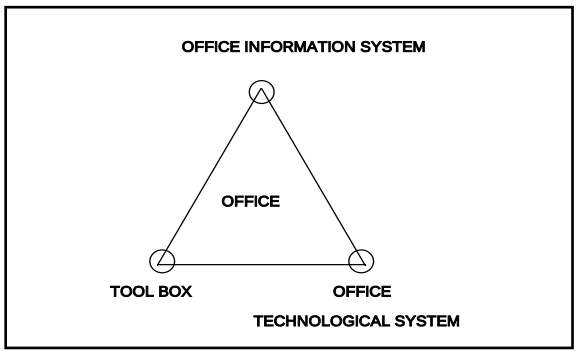


Fig.3 Office Automation seen through three complexity levels

All this technology is the Tool Box. It deals with very narrow problems and it is devoted to Individual Processes. As a consequence, the user sees technology as a partial solution to unrelated problems. We believe that much of current Office Automation is nothing more than a big tool box.

But Office Automation should be much more than a Tool Box. The next level must offer an Office Technological System in which different activities are grouped together into a meaningful process. There should also be a level in Office Automation for dealing with the Global Process. We call this level Office Information System. Nowadays, technology is far from this not only in technological terms but also in the organization's ability to understand this concept.

3.3 New Distinctions in Information Technologies

To say it in a few words, technology is anything but neutral. It creates an uncontrolled dynamic evolution which, if not channeled, can be a source of real trouble. Very often it goes beyond the users actual needs [14]. To some extent, there is a problem of technology in search of applications, which means an excess of power, low return on investment, lack of adaptation, unjustified difficulty of use and meager benefits from technology.

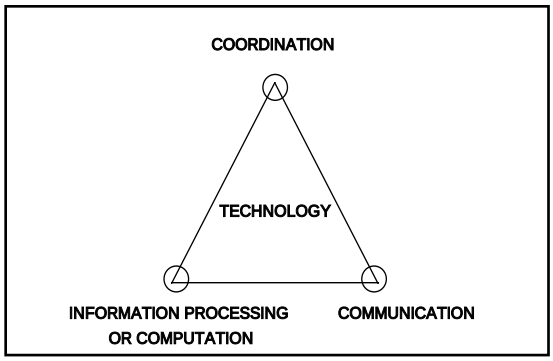


Fig. 4 A new perspective of technology through three complexity levels: the three C's

It is possible to classify technology into three groups and to relate them to the levels in Office and it is possible to classify technology into three groups and to relate them to the levels in Office and Office Automation. Information processing (or computation) is the first level and corresponds to Individual Processes and the Tool Box. This kind of technology can be generally found in Personal Computers and it is oriented towards individual applications.

Communication is the second level. When Individual Processes are combined to form Systemic Processes sufficient communication capabilities are required to integrate individual activities into larger processes. Thus, Communication is the basic component of Office Technological Systems. At this level, the office is a communication problem. Local Area Networks and Micro-Mainframe Links are examples of this type of technology.

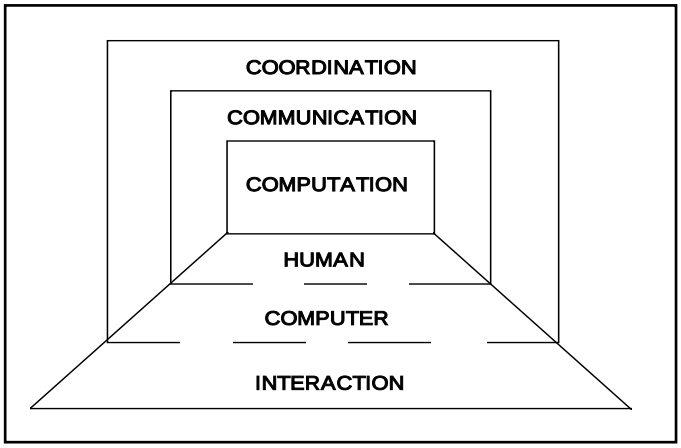


Fig. 5 A new and socially necessary technology: Conviviality, the fourth C.

Coordination belongs to the third level. Its function is to support the Global Process. The Office Information System must provide coordination facilities for orchestrating the two lower levels. Some products are starting to appear at this level or, at least, in the border between communication and coordination technologies: Coordinator, Information Lens, Chaos, etc. [27].

Humanization/Conviviality Technology -also known as Computer Human Interaction- deals with the human factor and with sociotechnical complexity. It is a fourth type of technology that makes the other three types usable and then viable.

From a more general point of view, we can consider technology as five types of abstract information processors: T (Information changing with Time), F (Format) and S (Space) [15, 27], M (Meaning) and H processors (Human processing). As we see it, Man-Machine interfaces work as H processors. Figure 6 illustrates this.

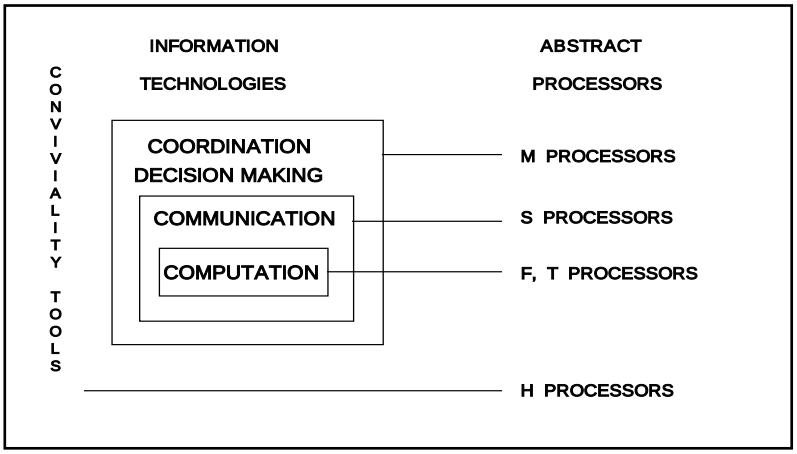


Fig. 6 Abstract processors related to Information Technologies levels

4. The office as a system ?

Currently, Office Automation ranks as one of the better resources for enhancing competitiveness. Technological innovation in businessis, in large part, based on Office Automation. But while the technical side is vital, computers are only facilitators: that networks carry meaningful messages and not just bit strings or that memories contain useful information can be seen as one of the key responsibilities of the manager.

There are no methods or methodologies for designing Office Automation. The proposed distinctions, ranging from complexity, office structure, and technology applications to technology, are intended to be the starting point of a conceptual framework used as a general principle for design and diagnosis of Office Automation. The goal is to give the managers a tool for bridging the gap between their interests and knowledge on one hand and pure technology on the other, providing them with capabilities for evaluating, comparing and choosing the right solution. In order to achieve these goals, these dimensions or distinctions have to be considered as a whole and understood in terms of the appropriate links among them.

4.1 From individual activities to Cooperative Work

Our model is shown in figure 7. Human factors, the fourth dimension, will always be placed as the highest vertex. At the base of the figure are the levels considered in Office, Office Automation and Technology.

Every system is composed of simple objects working together. In Office Automation, one must first surpass the Tool Box level in order to be able to deal with problems at the Systemic Processes and Office Technological System levels. Systemic Processes result from the integration of several individual activities (fig. 8). The number of lines written each day or the improvements achieved in the quality of graphics is of little importance.What really counts is in the number of useful reports produced; the number of patents processed; the speed in answering purchase or sales orders; that is, the overall system. This is the goal of operations research.

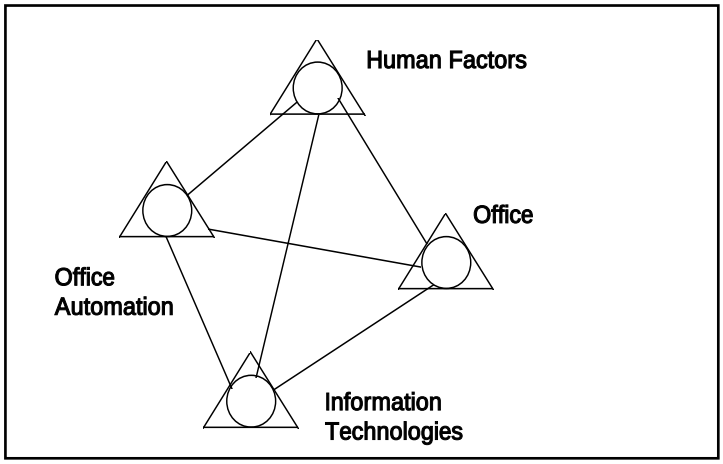


Fig. 7 The whole distinctions set

It becomes obvious that The Tool Box makes individual work easier, but it is not necessarily true that by improving the Tool Box the whole system will thereby improve. This second level can only be improved through the proper technology; through what we call the Office Technological System. The development of Integrated Software was a first step in this direction. Since then, several more applications have appeared which recognize the existence of this second level in the office and which provide methods for connecting individual tasks, addressing the true structure of Systemic Processes: Group Work (figure 9).

The state of the art of computer technology is quite advanced in general but according to our model, it is not so advanced from the office automation and users point of view. There is certain connectivity, as in networks, but: "How do we assure that this connectivity is paying off in productivity? how do we effectively apply these systems to the mission critical activities of the business?".

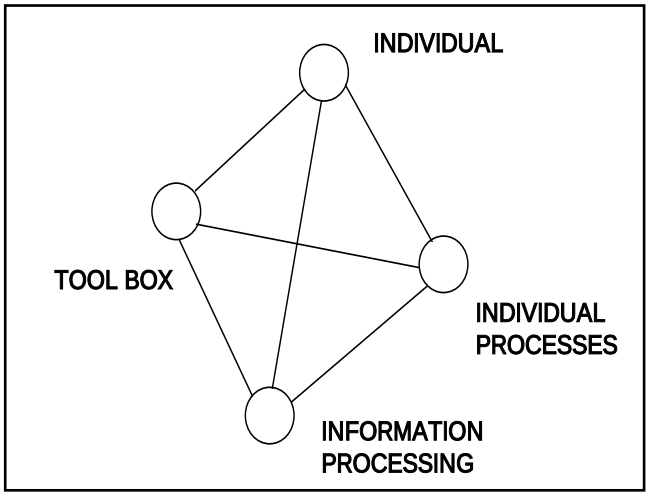
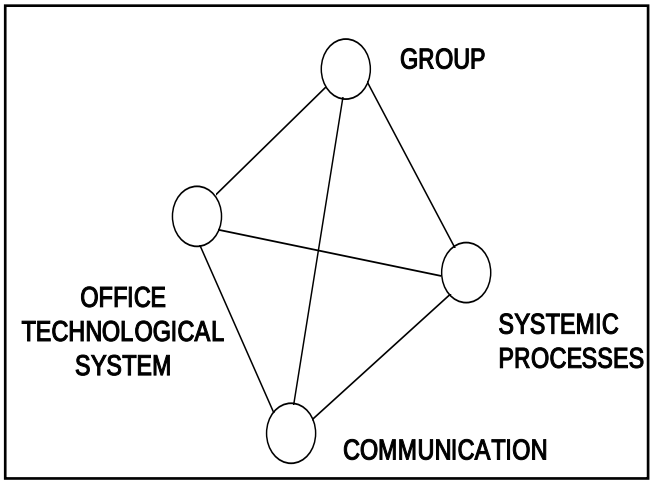


Fig. 8 The individual and his related complexity levels

And there are other authors that agree with our claim: "The personal computer came in to help people do their isolated stand-alone stuff, but the interoperability between them is in very bad shape", Engelbart said, [13]. "80 % of PC's today are involved in task automation, such as wordprocessing, spreadsheets, and bookkeeping ... the return on investment from PC's in task automation is a low 10 to 20 per cent" [Recent report by Nolan, Norton & Co]. "Here has been no measurable increase in productivity in the past decade. That's because personal computers in the Eighties mapped to the old way of working. To achieve the real payoff in the Nineties, computers have to force a complete reorganization of work", has claimed Apple CEO's Sculley [28].



FiFig. 9 The group and its related complexity leve

Following these ideas, we see a trend towards giving to systemic processes more importance, a tendency that technology will promptly follow. New terms, such as Business Process Re-Engineering [12,7], Business Process Management or Business Design Technology and Business Process Redesign [4] show the importance of the idea of systemic process. Many of these ideas can be applied in OA. Work-Flow Management Software is one of the first technologies supporting systemic processes [21]. Groupware is on the same line.

4.2 From Cooperative Work to Human Organizations

Our model provides a third level, Global Process, which defines true Office Automation. All functions have a meaning that goes beyond their results or how they work; over and above any other consideration, the office is a Human Activities System [3].

The meaning of Global Process may appear obvious, but it is not easy to apply to Office Automation. Over and above classical measures of performance, there are other considerations more relevant to the manager: changes in organizational structure -generally towards increasing decentralization- retraining of personnel, reinvestment of time, job satisfaction, acceptance of technology, evolution and growth of equipment along with the organization, etc. Finally, a human organization is a set of systems according to the different organization's images from the different agents [18]. This makes it more difficult to create a sociotechnical system and provides us with an idea of its complexity (figure 10).

All these points are related to the problem of corporate identity. For logical cost reasons, hardware and software are clearly on the path of increasing standardization. Technology thus becomes a very strong factor in the trend towards homogenization, against the equally strong trend towards self identity. In this way, we find a type of technology which, while implemented to improve the organization, ends up producing, as a side effect, a weaker organizational identity, an effect which is intensified when the Tool Box is used as if it were Office Automation.

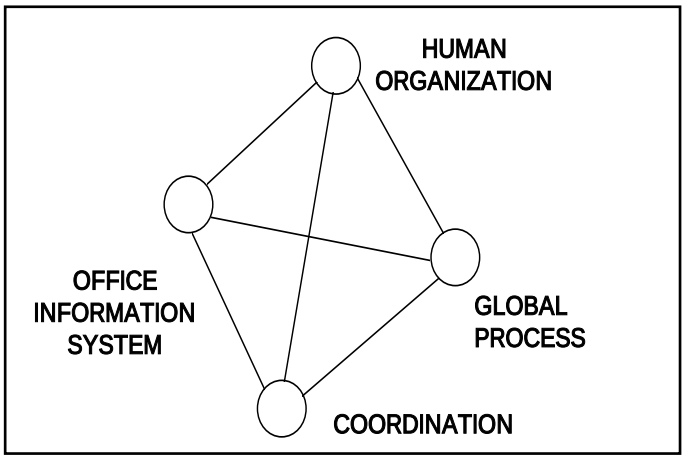


Fig. 10 The Global Process and its related complexity levels

There is some technology at this level. But, more important than that, there is an increase in the number of theories that will surely help to shorten the still long way that lays ahead. The works of Malone [17], Winograd and Flores [31] and Dunham, among others, are valid approaches to the second and third level of our model. Conversation Management and Workflow management will have to converge and produce an integrated theory. There is a fair amount of bibliography in this and related areas, [6] is an example. Our critics to these approaches are based on their failure to incorporate some dimensions of Office Automation (the systems structure, for example, and not only its processes) and Human Factors.

5. The Human Side: Conviviality, as a condition for technological innovation

All the concepts can be synthesized into the diagram shown in figure 11. This provides an ordered image of Office Automation and its related factors. Although the diagram may seem complicated, it is in no way arbitrary. It shows the aligned vertex forming the different distinctions which fall within the domain of the Office, the Office Automation and Information Technologies, with Human and Social Factors, these also include three different levels: individual, group and organization, each placed at the top vertex of its tetrahedron.

The third level of complexity arises with the development 'social factors': a consequence of the complex mesh between humans, office processes and technology in the Office Automation Axis.

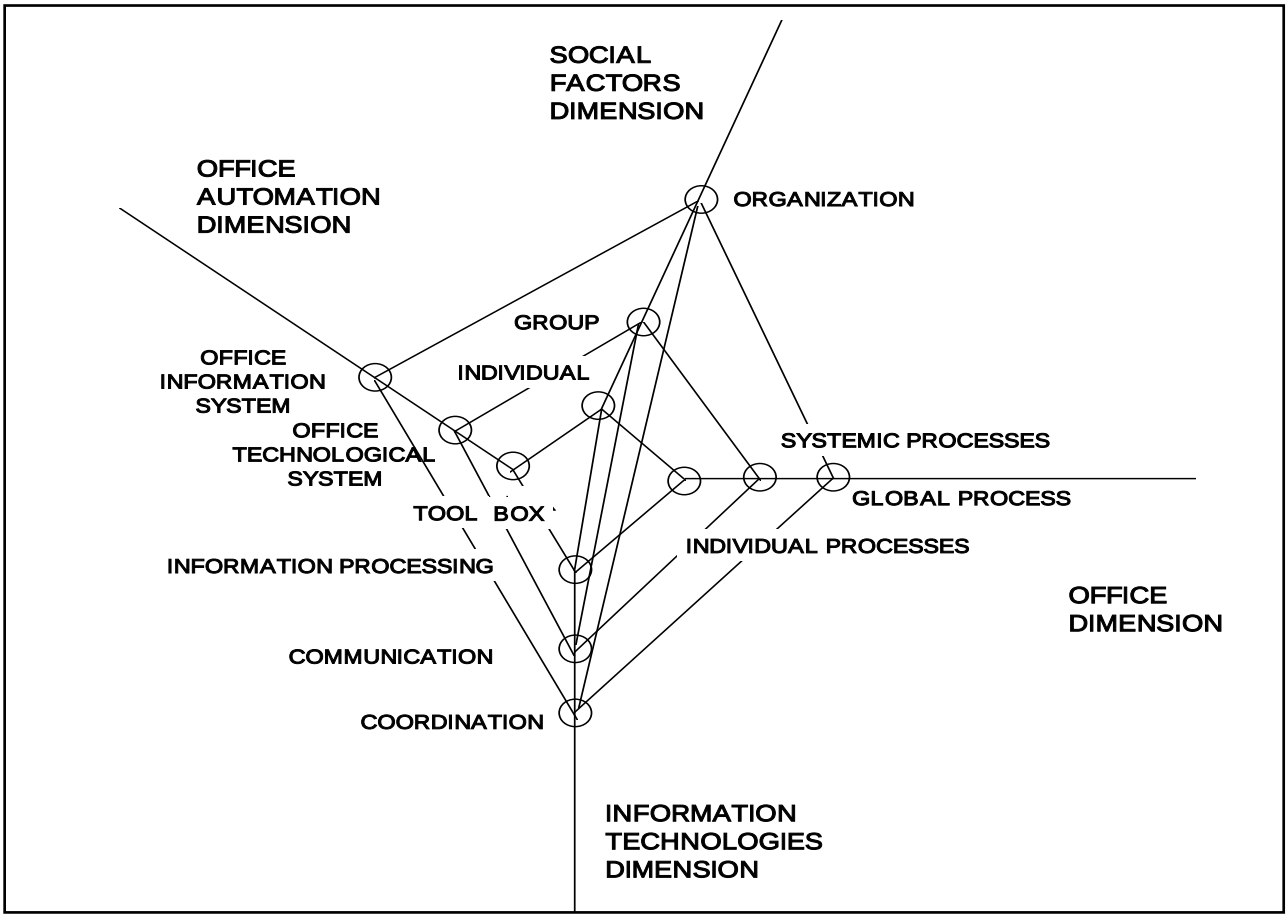


Fig. 11 Hierarchy of complexity levels as a new view of Office Automation

Expanding the personal radius of action can only be achieved if a tool works at the appropriate level. The radius of action of the work group is very different from that of the individual. If individual tools are used within the context of the work group, it will be at the individual level where they will have an impact but will not modify the group's radius of action. It can even happen that, rather than expanding, this radius actually diminishes due to the mismatch between what is expected and what is finally obtained.

Conviviality is the key to technological innovation itself and to the success of technology implementation in work environments. Two aspects of conviviality are user-friendly interfaces and ergonomics but Human Factors play a much richer role when people work in groups and organizations.

The third complexity level is that of sociotechnical complexity, which arises from the interaction between society and technology. It introduces a new domain completely different from the ones traditionally considered. Strassmann [30] states that between 1960 and 1985 approximately 95 % of the references about Office Automation dealt only with its technological side. Today things are different but it is also possible to go too far and put too much emphasis in human factors forgetting technology. Hirschheim's book [8] was an interesting change in focus and a good example of the remaining 5%. This kind of complexity can be seen as intrinsic to "human activity systems" , as Checkland defined them [3].

Global Processes involve different problems which can be grouped together under a new set of subdomains: a) complexity of technology, b) complexity in matching technology with organizations, and c) complexity in matching technology with humans. We represent these three subdomains by the schema of figure 12.

The subdomains affect the manager. Technology has reached an evolutionary stage where it can, and in fact does, deeply transform organizational structures and seriously affect human factors in work environments.

The growing interest in what has been called Human-Computer Interaction proves how important the human factor really is.

Top managers tend to see their organizations from a global perspective, human factors play only a minor role. This point of view, within the traditional organizational structure, would not necessarily have serious consequences but technology provides both individuals and work groups with a degree of power that makes the Human Factors concept very critical. This increased processing and communication power wielded by individuals and work groups represents a major change within the organization.

Psychological resistance on the part of human beings toward changing personal work habits and the fact that many technological tools are still unnecessarily complicated must be overcome. The existence of these barriers requires a thorough study of tool usability, in order to create a truly workable individual-tool interface.

When an organized entity faces/incorporates technology, many important changes result and they must be confronted in order to really reap the benefits of innovation. In the face of this complexity, many possible alternatives can be adopted. Usually, if the manager lacks experience with technology initial prejudice occurs and this may be a major handicap. But managers with at least some or even much experience with technology may also have a problem as well: a failure to take non-technical factors into account.

6. Users and Producers, Managers and Leaders

One of the main problems of technology is the inevitable gap it creates between users and producers. Such a gap is natural when one considers the different approaches toward the use and understanding of technology: to the user it is merely a tool but to the producer it represents a goal. However, such a gap ceases to be natural when it creates a pathological situation, as generally happens in organizations. In Office Automation this problem is exacerbated because there is an even wider gap between specialist and non-specialist. This is one of the main difficulties, found both in business design and information technology, as recently pointed by Keen [12, p.236]: "Today the IT field is at a pivot point. It comes out of a tradition of technocentered thinking, language, and methods and of poor mutual understanding between technical specialists and business managers".

Users are perfectly aware of the environment in which they work; their needs; their particular circumstances; their goals and objectives and their limitations. But, as general rule, they are not able to translate this knowledge into parameters related to technological innovation.

Producers, who create, produce, sell and maintain technology, are familiar with it and its applications, opportunities and advantages. They have worked long enough with technology to, at least, recognize that it poses some problems. But producers do not know details of the work environment and, thus, they can only offer generic products adapted to meet a global demand.

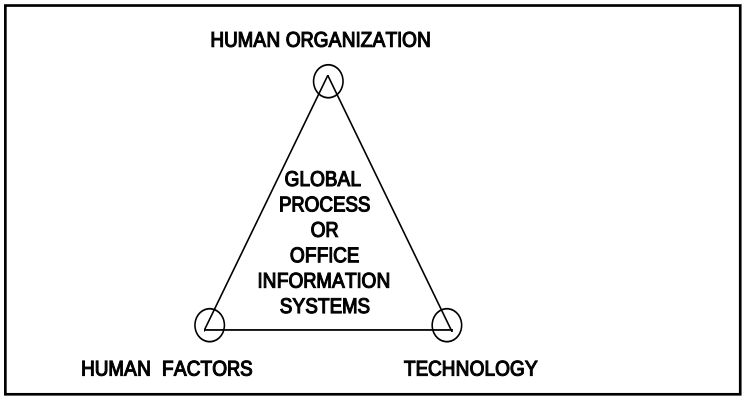


Fig.12 Third level complexity unfolded in three major fields

It could be argued that this gap is not a major problem. Applications such as text processors are general and sufficiently widespread to avoid the need for customization. But text processors are merely a component of the lowest level: the Tool Box. At this level there is enough generality to allow users and producers to coincide in supply and demand.

6.1 Top down / Bottom up

In reality, however, this coincidence is merely an illusion. To the user, what matters is the Global Process, much more than the Individual Process. If the user were capable of translating his needs into the corresponding technology, he would ask for an Office Information System, in the sense we are proposing, or, if not available, Office Technological Systems, not just a Tool Box. To him the hierarchy is top-down, with almost no relevance at the lowest levels.

To the producers it is just the other way round. Due to technological and market constraints, the producer gears his offer towards the Tool Box concept by means of generic applications having no technical or conceptual difficulties, in this way guaranteeing a wider market. Upper levels require a much more refined product; more knowledge about user needs is necessary, and the potential market is much narrower (the upper extreme would be custom design). The hierarchy as the producer perceives it is bottom-up, with Individual Processes as a first goal.

Our model of Office and Office Automation in effect moves these two perspectives closer together. With this model, the user can establish technological needs with specific reference to particular activity, while the producer can recognize the existence of upper levels in the demand and react accordingly.

6.2 Managing complexity

Many methodologies used to implement technology underscore the role played by the leader of technological innovation. The ultimate success of technology and future user satisfaction depend largely on the efforts of this person, who seldom has the resources necessary for achieving these goals. An implementation methodology can offer a more or less effective way to introduce technology in work environments; to plan the organization's evolution, or even take into account more advanced problems such as productivity measures or cost justification. But no methodology can say whether technology is applied at appropriate levels.

Managers interested in technology can read books and articles and find a "solution" to almost any kind of problem and, to a lesser extent, methodologies for implementing those "solutions". But in spite of that, the manager lacks the required reference point but based on needs and according to the characteristics of the organization. With our model, the manager has a very powerful conceptual framework for completing a sociotechnical design, as well a reference model upon which to map it. Managing Office Automation is equivalent to managing third level complexity. In general, technological innovation management is equivalent to complexity management.

Today's managers have become Information Systems Managers [10] and they must think in terms of this new role. Models such as the one proposed here facilitate this task by having a better understanding of the technical and managerial world, offering a coherent, complete and integrated perspective of both. Both, users and producers, can thereby have a shared understanding, with a common language to facilitate actions.

7. Conclusions

We have proposed a conceptual model for Office Information Systems, a model that evolves through three types of complexity to form a hierarchy. The model integrates four domains: information technologies, office processes, social factors and office systems. The result is a new and complete framework for the design and management of O.I.S.

The model has been presented in the form of a group of distinctions, at once powerful and easy to remember. To accentuate its dialectic character we have used as many graphic representations as possible. These figures can be summarized by Figure 11.

In [1] and [27] it has been shown that this conceptual model reflects the various possible perspectives of the office, as synthesized in [8]. In [27] the model has been analyzed as a tool for developing, in conjunction with cybernetics, a new vision of technological innovation in organizations through office automation.

7.1 A non-technical language for managers

The primary advantage of such a framework is that it allows a comprehensive evaluation of technology without requiring extensive technical knowledge. In other words, it provides a new and accurate language for expressing any kind of technological need posed by the organization, while avoiding the severe limitations arising from the language used by specialists.

By using the model, the manager can easily identify in which levels technology is to be applied, and always has at hand the references which make evolution possible; not only with technology but also coherently with corporate objectives. These three levels (Individual Processes, Systemic Processes and Global Process) constitute a step-by-step approach to Office Automation as well as a non-traumatic way for assimilating technology into work environments. At the same time, it permits managers to identify the most appropriate technology for each level, and to be guided by what it is actually done in the office, instead of what technology has to offer.

In this way, managers have a very powerful methodology for planning their technological strategies without having to face solely technical issues. As concerns technology, the model points out a very clear path for innovation and research. Once the first level (The Tool Box) is overcome, technology should concentrate on solving cooperation issues, integrating first level tools into full solutions to Systemic Process problems. This trend has already begun, as shown by the growing interest in Computer Supported Cooperative Work. But the fields where major research is still needed are basically Office Information Systems; the approach of technology to corporate activities; understanding the organization as a whole, and the study of implied factors (social, job satisfaction, organizational changes, corporate goals, evolution, competitiveness, etc.).

We would like to underscore the potential the model shows for serving as a common reference for the two major participants in Office Automation, users and producers, integrating both perspectives, top-down for the first, bottom-up for the latter, and opening new domains for action.

7.2 Opening new perspectives

A very important aspect of our study has been its focus on Office Automation from the point of view of complexity; in fact a very uncommon perspective in the fields of technological research and application. Unfortunately, studies about complexity, from the pioneer works of Simon [29] to the works of Morin [19] and Le Moigne [15] among others, are essentially unknown to managers.

We can feel justifiably hopeful about this last point, if books such as Pagels' [20], who recently passed away, can be seen as representing a new trend in the recognition of the complexity issue. In his study, he proclaims the computer to be the basic instrument of the science of complexity: "the great unexplored frontier is complexity" (p. 12); "I am convinced that the nations and people who master the new sciences of complexity will become the economic, cultural, and political superpowers of the next century" (p. 15).

We believe that, nowadays, the sciences of the artificial [29] are being replaced by the sciences of complexity, particularly when they include the human factor, as is underscored by the focus of the first Conference dealing with Critical Issues, which was held in November 1990, by the Association for Computing Machinery (ACM). There were two central subjects to debate: Managing Complexity and Modeling Reality. These two principles have guided our paper.

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