Information technologies can modify design procedures, increasing the number of participants in the phase of problem definition and analysis, and also allowing more extensive participation in decision-making. There may be considerable variation in the degree of involvement, up to and including the social level, with reference to the users and public decision-makers.

The collaborative and participative functions present in the computer transposition of the "group" concept may be employed for educational purposes. The teaching of design may usefully exploit the analysis and exploration of problems according to this scheme: Questions, Suggestions, Arguments. This method is preparatory to a group design methodology, and its employment across a LAN makes it possible to break the constraints of time and place typical of traditional teaching methods.

Collaborative and Participative Design

Most of us think of a computer as an information-processing machine, but it would be truer to say that it is the most powerful instrument of communication ever invented. Any task carried out by a computer may be interpreted as activating and enriching the communicative process.

Yet the myth of a communicative revolution has much less to do with technology than with interpersonal relations. Think, for example, of the effect of a different orientation of communications on the organization of the design process.

In design organization, large-scale, precise management of communications implies the possibility of sharing information more extensively. Greater sharing of information should encourage collaboration and individual participation in the analysis and decision processes intended to design choices.

At present, there are substantially two different philosophies to encourage participants' creative involvement in a design, called respectively Collaborative Design (C.D.) and Participative Design (P.D.), both of which presuppose prompt circulation of information and greater individual participation in the design process. The essential difference between these two philosophies is the degree of involvement in decisions and the number of decision-makers referred to: in some cases the decision-making process may even involve the users of the design at the end of the line.

By means of a large number of experiments carried out in Europe, the U.S.A. and Australia, a scale of assignment of decision-making responsibilities has been defined (Figure 1) [Mumford 1981]:

- **Collaborative Design** leaves decision-making power untouched; the participants are merely sources of information, with little or no participation in decisions;
- **Representative Design** involves a limited number of participants in design formulation and decision-making process;
- **Participative Design** assigns responsibility for the design to all those participants, who are intensely involved in the design formulation.
Overall Quality

Greater individual involvement in productive choices is one of the routes towards the much-sought-after total quality. Those methods which pursue total quality require not merely the reorganization of production factors in the interests of increased efficiency and productivity, but a complete rethinking of procedure organization: from design to production, and to sales. In this context it is crucial to rethink the role of the actors in the productive process: what is required is individual participation in and agreement with the company’s overall choices.

The approach to quality is not just a theoretical review of a problem already faced in other ways: participation in projects and contracts in Europe ever more frequently involves acceptance of the ISO 9000 standards, which set down exact criteria for quality assurance in the building trade. The idea is that the customer should document the fulfillment of specifications. But, in contrast to traditional methodologies, supervision is not limited to the work itself, but also covers documentation and the procedures adopted. Documentation and drawings become an integral part of quality control, together with the procedure and coordination of work. The checking of total quality results from the pursuit of partially defined objectives, documented by means of periodic quality inspections, for each of which certification is issued, showing whether or not requirements have been met (Figure 2). Should the result be unsatisfactory, a Non-conformity report is produced; this, in addition to documenting deviations from the established procedures, may lead to a Modification of requirements, requesting modification of the planned procedure/design.

Acceptance of the ISO standards demands rethinking of the entire process from design to production. The scale of the project, that is of the operation, of the design, or of the site, determine the degree of complexity of the reorganization.

However, the complexity cannot be measured exclusively in terms of the size of the project: we must think of complexity in a broader sense, in terms not only of scale, but of the competences brought into play, and of the social and economic actors involved. Even in relatively small-scale designs it may be necessary to coordinate miscellaneous competency, differing in formation, role, experience and geographical location. We may think, for example, of the growing sensitivity to ecological problems and of the resultant problems of environmental contracting, or of the need to coordinate design decisions according to technical analysis on the one hand, and to different social requirements, or opinions expressed by users, on the other.

The Organization Paradigm

The design process can be represented as a network whose nodes are the participants, interconnected by means of edges: the flow of information. This flow is composed of reports, conversations, sketches, drawings, photographs, etc. Since the number of connections tends towards the square of the number of nodes, an increase in the
number of participants tends to bring the communication and decision systems into a critical state.

Hierarchy is one of the systems adopted in order to manage a large number of flows, in that individual members can access only part of the information and only the decision-maker takes a global overview (Figure 3). In practice, however, increased complication of the problems may overload the decision-making vertex with information, so that it cannot work rapidly, or it may regard crucial aspects as secondary.

![Diagram](Image)

**Figure 3:** Organizational structures.

It was first Weaver [1948] and then Morin [1977] who employed the fruitful concept of organization to deal with complex problems without oversimplifying or mutilating them. The designer has available the Organization paradigm: the pattern of complexity is taken for the intelligence of the active, organizing complexity, which itself produces its own intelligibility without limiting itself in terms of space or time. “Although paradigm is an overused and often misused term, here it is employed in its strictest sense to mean a model that embodies a set of underlying and generally implicit assumptions through which the world is interpreted (...). An organizational paradigm is, thus, both a standard or model for an organization and a world view, a way to make sense of organizational reality” [Constantine 1993].

The transposition of the Organization paradigm into a design methodology may require extension of the decision-making base by means of reorganization of the information flow. In C.D. this flow tends in a single direction towards the decision-making vertex; in P.D. no exact direction of the flow can be defined in advance because the decision-making vertex tends to be expanded (Figure 4).

![Diagram](Image)

**Figure 4:** The Organization paradigm among reference working structures.

The aim is to pursue a more flexible decision-making and organizational structure, in which working teams are flexibly organized to meet a variety of problems. In place of a rigid hierarchical subdivision, we propose working teams based on the coming together of creative, organizational skills and energies in accordance with the needs and aims being pursued. The organizational structure of the group is modeled by the problems it must face, and not vice versa.

In the case of both C.D. and P.D., what is required is a reorganization of the Information System [Simon 1969] in terms both of the flow, improving information distribution, and of the direction, rethinking the how and why of the participative moments necessary to decision-making. The “communicative revolution” brought about by computers can supply the necessary facilities for this change: computer networks make it possible to identify skills within the design and to coordinate participation in decision-making, even from remote geographical locations.

**Education**

Can a change in communication organization be of direct interest in education, and specifically in the teaching of architectural design?

It is impossible to formulate an unambiguous answer, since the innovations introduced in computer technologies in communication are so recent. It is my belief that one of the cornerstones of education...
innovation is network interconnections which permit more extensive access and improved sharing of individual knowledge — among teachers — and collective knowledge among groups. This concept of group, defined as “groupware” in computer terminology, corresponds to the “Laboratorio” (workshops) in the new Regulations for Italian Schools of Architecture.

Teaching methods based on extensive access to personal computers closely linked across networks should allow us to set aside the unities of time and place demanded by traditional teaching methodologies which impose the simultaneous presence of students and teachers. It is clear from experiments in the field of C.D. and P.D. that heterogeneous competencies can be made to interact and can at the same time be shared among a much larger number of participants (Figure 5). But while decision-making is the direct, explicit purpose of C.D. and P.D., this aim is less clear in teaching.

![Figure 5: The Organization paradigm among reference teaching structures.](image)

An Educative Application

The application of the Organization paradigm to the design process means educating students in its use: the purpose of instruction is organized knowledge, and this is also the purpose of design education. According to Jerome Bruner’s pedagogy, the aim of teaching is to make the transition from mere learning to logical use, systematic connection, translation into structural terms of what is learned [Bruner 1960]. In this sense C.D. and P.D. methods are propaedeutic, since through them we acquire and wield the information, concepts and experience necessary to facilitate group design work.

It is not so much a matter of instruction in C.D. and P.D. methods applied to design, as of supplying the means by which the student can become an active part of a group and profitably support the solution to a design problem. The school’s task is to supply the student with those methodological tools and critical capabilities which will enable him/her to actively interpret the design and hence the infinite number of cases and problems met with in exercising his/her profession.

The “Laboratorio” is the academic structure in which the collective didactic experiment is carried out, in which a design topic is outlined and dealt with in accordance with the group’s skills. In practice, what happens is that a specific design problem is posed, which the students analyze, explore and discuss, offering their own contributions according to:

- Questions
- Suggestions
- Arguments
- Reports
- Decisions.

The structured nature of this method aids the organization of thought and encourages clearer communication of ideas. In contrast with unstructured discussions, this method facilitates the analysis and communication of problems and makes it possible to deal with the complexity arising from multiple participation.

This method can be applied to a discussion by means of traditional tools, commonly used in P.D. projects: blackboards, large display boards, colored pens, story boards, flow charts, cards, etc. It is also possible to implement this method in a software, to translate it into a “groupware”. The students perceive the structure of the method in the simplicity of interaction with the software and, more generally, with the computer.
An Example

Let us suppose that the students in a workshop are asked to analyze the requirements for a new office building. The question "Function Requirements?" is the initial Question node of the new graph, called "New Office Building" (Figure 6). This node becomes the root of the design problem, visible and accessible to whoever links to the network with his/her computer. Obviously, the graph could cover other different problems: "The Environmental Impact of the Shopping Mall on..." or "Restoring the Plastering of...". Participants in the discussion can add nodes to the graph displayed on the monitor by linking them to other nodes which are held to be semantically close to them. Each participant can add Suggestions nodes to Questions nodes to offer possible solutions and opinions, setting up a link of the "answer to" type, indicated on the monitor by an arrow between the two nodes. Arguments nodes are added in the same way. An Argument can motivate (pros and cons), explain, or deepen a Suggestion node.

![Figure 6: Graph "New Office Building."](image)

The graph is also defined as a tree because of the analogy with the plant whose branches (the connections between the nodes) and leaves (the actual nodes) "grow" from the central trunk (the initial problem).

In an architectural design graphical information has a prominent communicative role. In the tree, the graphics can be used to support and integrate the Suggestions and Arguments nodes. Reference can be made in the single nodes to both external (on traditional media) and internal graphic information, immediately accessible on the monitor. In order to share internal documents Report nodes can be inserted, which visualize in a window CAD drawings, digitized sketches and photographs, animations, videos. The use of Report nodes makes it possible to set aside the format, or the information medium, in view of the choice to give more importance to the content than to the representation of communication [van Bakergem 1993].

Decision nodes are added to the graph to reduce the size of the tree, which would otherwise tend to expand indefinitely. A decision-making process, in contrast with an open discussion (which may never converge towards a common position), must tend either towards the dialectic synthesis of the individual positions, or at least to the predominance of one suggestion over the others, in view of the operative goal. The aim of Decision nodes is to provide operative tools to "prune" the tree. Decision nodes enable students to formulate qualitative or quantitative judgments regarding a group of Suggestions nodes. Qualitative judgements are best, better, equivalent, worse, worst, while quantitative judgments demand the attribution of a ranking to the nodes.

Implementation

The implementation of the method is based on the Client-Server communications system. The Client is resident on the user's computer, and presides over communications between the network and the application processes. These applications are the monitors for the visualization of the "tree" and of the individual nodes, including those containing graphic documents (the Report nodes), and the tools for adding new nodes to the graph. On the remote computer the Server oversees communications between the individual Clients and the applications designated first to recognize the users and subsequently to allow them access to the files. Each Client may access the overall graph and the content of
each node for reading only. Thus the Clients may not
modify the content of the nodes, but may simply read
them and add new nodes. Client access to the node
content means that it can be imported on to the local
computer, while the creation of a new node means
exporting the local data onto the Server.

The communication model adopted is
asynchronous distributed. It is asynchronous because
the individual Clients can access the Server at different
times: the existence of a single database, resident on the
Server, inquired and updated by the various users,
guarantees the coherence of the information provided to
the individuals. It is distributed because access to the
Server is ensured for users in different locations, linked
to the local area network (LAN) and also, thanks to
high-speed bridges (2MB), to users of other remote
LANs.

The Design Tree

Graphic representation of decisions should
offer a visual synthesis of the evolution of a design. The
tree graph provides this synthesis of the discussion,
making it possible to interpret the dynamics of the
debate at a glance.

The extension over space of the tree, the
convergence, or, alternatively, the divergence of the
nodes, represents the emergence and distinction of
various positions. The spatial distribution of the
Suggestion nodes around a Decision node visualizes the
degree of synthesis achieved, or, in other words, the
convergence of different positions in the direction of
one or more decisions. By observing the tree the
participants can form an idea of the design and at the
same time each one can go back over the stages of the
development, reviewing the problems and topics
previously met with.

From the educational point of view it is a
simple matter to evaluate the degree of individual
participation in the development of the design. As a
basis for judgment it is sufficient to point out the nodes
inserted by each student:
* the number and position of Suggestions nodes
inserted in the tree provides a parameter of the

accuracy and diligence, or perseverance,
committed during the decision-making process;
* the graphic relationship between the Suggestions
and Decisions nodes, evaluated in the light of the
decisions made, or the prevalence of certain
positions over others, makes it possible to bring out
the importance of the individual contributions, and
if there is a high degree of participation in the
debate, this may be a valuable indication of the
individual quality of the contributors.

Time and Place

Translating the method into a software which
manages asynchronous and distributed communications
makes it possible to free the discussion from the
constraints of time and place.

In terms of place, the physical location of the
user is no longer relevant thanks to the speed of the
computers and networks: the ideas travel, and the
people stay still. If the method proves fruitful, this
opens the way to the possibility of comparing diverse
experiences and at the same time sharing individual
competence. This can never, of course, be comparable
to a course of study in which the whole individual is
assessed in terms of the cultural environment in which
s/he is inserted. Nevertheless I believe that it can open
up new possibilities for communication and offer a
different approach to education.

In terms of time, the point is that the
organization of the debate does not demand the
simultaneous, face-to-face, presence of two or more
interlocutors. Access to the tree is available round the
clock: a node inserted in the morning can be examined
by others at any time.

We cannot suppose, for the moment, that
network communications will one day be a real
alternative to direct interpersonal relations; computer-
mediated communication means the irreversible loss
of many circumstances and communicative phenomena
which would be facilitated by a direct relationship.

*Often, in an intimate dialogue between human beings,
hand gestures may carry a different message from the
text. Customs contain cultural information: the Arabs
use their noses, the Japanese nod their heads” [Negroponte 1972]. In contrast, a decision-making system which uses computer networks to share and coordinate individual opinions depends essentially on written texts, sketches, drawings, digitized video and audio. Experimental research [Garlegher 1990] has shown that if the initial phase of approach to the media is overcome, communication across networks proves to be an effective incentive to synthesis and a stimulus to the incisive formulation of ideas, rendering them more readily communicable. I am not aware of experimentation in the field of design education which would support this thesis, but one may suppose that P.D. and C.D. systems, and hence their use on networks, spur students to greater concern with communicability, above all with graphics, and help to improve synthesis and logic during design process.

Problems Raised

Numerous problems are raised by educative use of the system. I should like to draw attention to two of these, regarding graphic communications across the network and the role of teaching staff.

Report nodes make it possible to share freehand sketches which have been scanned. If they are to be legible, high resolutions are essential, but with current technology transmission speed is limited, especially across Wide Area Networks, while display resolution is poor. It is extremely frustrating to wait for several minutes to access a sketch and then to be obliged to visualize it moving a window across a higher-resolution image. This process imposes an intrinsic limitation on the communicative function of the design drawing, built up around cross references, both within the drawing itself, and outwardly towards other drawings, even on different scales.

As regards the role of teaching staff, if students are to have free access to discussion and hence to personal computers, what is the role of the teachers in this context? Or, in other words, should the system tend more towards C.D. or towards P.D.? On the one hand, teachers can participate jointly in decisions; on the other, control of the Decision nodes might be assigned to the teachers as supervisors of the debate.

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