MEDIA in MEDIATION
Prospects for Computer Assisted Design Participation

Tom Maver, Jelena Petric
Strathclyde University

Abstract

One of the most consistent, powerful and philosophical ideas which has run like a silk thread through the short and erratic history of the development of computer aided architectural design is that of user participation in the design decision-making process. It is not an idea with which the architectural profession is particularly comfortable but it is, the authors claim, one which is central to the professional ethic and, therefore, to be its ultimate survival.

Design decision-making is, if addressed properly, a hugely, complex multi-variate, multi-person process on which precious little serious research has been focused. In the late 1960's the Design Methods Group in the USA and the Design Research Society in the UK formulated paper-based models of the design process and anticipated, in some regards with un-nerving accuracy, the way in which the application of information technologies would impinge beneficially on the process of design decision-making and, therefore, on the quality of the built environment.

One concept expressed at that time was as follows:

- *the application of computers to the modelling and prediction of the cost and performance behaviour of alternative design solutions allows subjective value judgements to be better informed and more explicitly audited, and that*

- *such subjective value judgements should be made by those most affected by them, i.e. the future owners and users of buildings.*

This paper is devoted to the critical re-examination of this concept, on the seminal research and development which has kept the notion alive over 30 years, and, how the current advances in multimedia, virtual reality and internet access make its ubiquitous adoption inevitable: in short, Media in Mediation.

1. DESIGN DECISION-MAKING

Architectural design is a multi-faceted occupation which requires, for its successful performance, a mixture of intuition, craft skills and detailed knowledge of a wide range of practical and theoretical matters. It is a cyclical process in which groups of people work towards a somewhat ill-defined goal in a series of successive approximations. There is no 'correct' method of designing and, although it is recognised that the process can be divided into separate phases, there is no generally accepted sequence of work that might guide design teams in the direction of achieving a satisfactory solution. Indeed, there are no solutions to design problems in the way that there are solutions to mathematical problems: the best that can be hoped for is an outcome which satisfies the maximum number of constraints which bound the area of concern. Furthermore, design is not an algorithmic process in which the desired conclusion can be reached by the application of step-by-step procedures - first finalising this aspect, then that. It is a fluid, holistic process wherein at any stage all the major parts have to be manipulated at once. In this sense, it is less like solving a logical puzzle and more like riding a bicycle, blindfold, whilst juggling.

Despite the complexity of the design decision-making process the emerging new generation of computer-based models is already having an impact on how design is performed and, hence, on the quality of design. The impact stems from the fact that the new models, as opposed to paper-based plans and elevations or other conventional forms, are predictive rather than descriptive; dynamic rather than static; explicit rather than implicit and, above all, permit a more-or-less continuous and interactive assessment of the effects of a developing design on cost and performance.

Evidence is growing of the advantages offered by the application of computers in design, and these can be summarised as follows:

1.1 Widening the Search for Solutions

Access to programs which dynamically predict the cost and performances characteristics of optional design proposals can increase the scope of search for good solutions by as much as ten-fold. Not only is the search coverage extended, it is also more purposefully directed because designers are able to compare the quality of any one tentative solution against the quality of all previous solutions.

1.2 Greater Integration in Decision-Making

In conventional working, a great deal of design time is lost as proposals are passed to and fro between the architect (who tends to be the originator) and the other specialist members of the design team (who tend to the "checkers"). Quite frequently the scheme on which the architect has lavished time and effort is found

by one or other of the specialists to be infeasible. With access to appropriate appraisal techniques embodied in computer programs, it is possible to check a proposal against a wide range of criteria from the outset of the design activity. Moreover, it is entirely practical (though not yet a widespread working method) for all members of the design team to have access to, and operate on, the common design model whether or not they share a design office. The models, then, can provide a strong integrating force in design team working.

1.3 Improving Design Insights

Apart from the use of appraisal programs to search for better designs, the programs can be used in a research and development context to provide insights into the way in which particular design decisions affect cost and performance. Typically, a designer working in this mode would select an existing building for study, then, keeping all other design variables constant (insofar as this is possible), systematically vary one factor while recording the cost/performance output from the program. In this manner, the architect can establish sets of causal relationships which provide powerful insights into structure of design decision-making.

1.4 Differentiation of Objective and Subjective Judgements

Contrary to the early fears of many architectural practitioners, the use of CAAD techniques focuses increased attention on subjective value judgements rather than less. As measurable attributes of optional designs are made more explicit, the necessary value judgements are forced to the surface of design activity and thereby, themselves become more explicit. The effect of this is to make it clear to designers and their clients, which judgements are based on quantifiable criteria and which on subjective and intuitive concepts.

Evidence of the degree to which computer-generated cost/performance information promotes effective value judgement, throws into sharp focus the crucial question: whose value judgement? This question was, for the first time, seriously addressed in the Design Participation Conference in Manchester in 1971 [1]. The issues raised (by such luminaries as Bill Mitchell, Chuck Eastman and Nicholas Negroponte) stimulated a decade of research into computer-aided design participation which is re-visited in the following three sections of the paper.

2. SOFTWARE FOR DESIGN PARTICIPATION

Software development within the ABACUS Group at the University of Strathclyde specific to the investigation of user participation in design centred on two programs: CUPID and PARTIAL. The following sub-sections describe these programs in general terms.

2.1 Computers for User Participation in Design (CUPID)

CUPID is one of a series of computer games developed by ABACUS to promote an understanding of multi-variate, multi-person decision situations which can be said to characterise participatory design [2]. Between two and eight players, each with a set of objectives generated by the computer, try in turn to manipulate geometrical shapes on a visual display screen in such a way as to satisfy not only their own individual objectives but also a meta-objective of minimum conflict between players. The board with sides labelled 1, 2, 3 and 4, is grid-marked into 64 cells. Players are given a number of 'blocks' to play with: six for 2,3 or 6 players; seven for 7 players; and eight for 4 or 8 players. Blocks can be any size but must be rectangular with a maximum length to breadth ratio of 2:1.

In turn the computer generates for each player a set of objectives for 'his/her' blocks (Figure 1). For example, Fred may be allocated blocks 2 and 5; block 5 must have a clear view of any one of the sides of the board, must be adjacent to blocks 2 and 6, and must not be adjacent to blocks 1 and 3; similar objectives hold for block 2. Objectives for any one player are revealed only to that player and not to the other participants in the game.
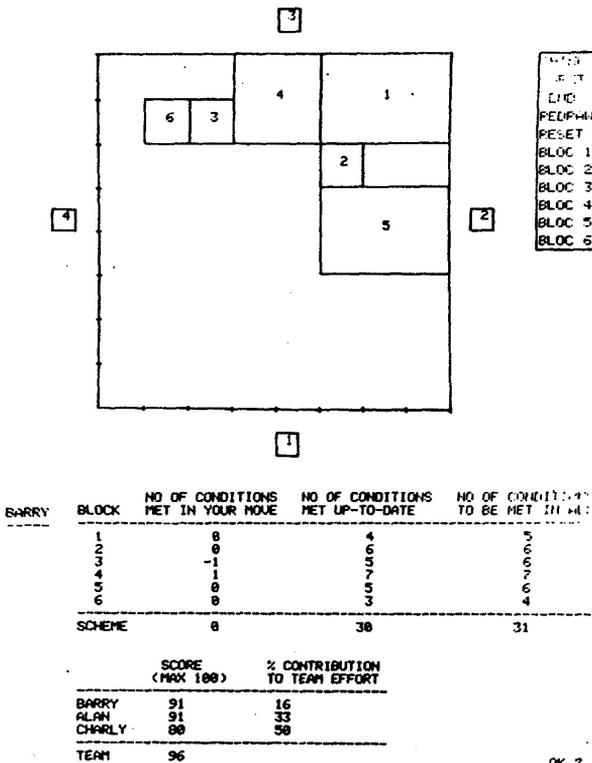

Figure 1

A play is made by pointing to a command on the menu In the first round, the number of moves each player can make is equal to the number of blocks he/she has been allocated. In subsequent rounds each player has an extra move to allow him/her, if desired, also to move blocks allocated to other players.

After each player has had a turn, the computer outputs a set of diagnostics, indicating those objectives relevant to all the players which have been satisfied or violated. An astute player can interpret some of the objectives of the other players by correctly interpreting these diagnostics. Following the diagnostics, the computer outputs a score card giving for each block, the objectives satisfied on the last play, the objectives satisfied to date and the total number of objectives requiring to be satisfied. The score card also gives, for each player, an 'Individual Score' (i.e. the degree to which his/her selfish objectives have been satisfied; maximum = 100) and a contribution to Team Score (i.e. the degree to which he/she has contributed to the achievement of all the objectives; maximum = 100). Additionally the Team Score is quoted; achievement of a team score of 100 indicates that the game may end.

Given the abstract nature of CUPID, no specific conclusions could be drawn as to the prospects of user participation in layout design. It was clear, however, from observation of many games that successful outcomes were increasingly achieved as players deduced the value criteria of other players and worked towards consensus solutions.

2.2 Participation in Architectural Layouts (PARTIAL)

The suite of programs known as PARTIAL has three modules which allow user participation in design to be studied [3].

Using PARTIAL1, the researcher is able:
- to select the schedule of accommodation and its associated 'space budget'.
- to define the geometry on any 'fixed elements', such as would be required in the case of building conversion. If there are any fixed parts of the design these can be input by the researcher using PARTIAL1 and will subsequently appear on the screen of the computer terminal when the participant uses the PARTIAL2 program.
- to select which performance measures will be used by the program to present appraisal information to the participant about the design.
- to select tutorial and advice options used by the program to comment on the participant's design.

After the researcher has finished using PARTIAL1 to create the control file which describes the design problem, the participants can use PARTIAL2 to build up the design on the screen of the computer terminal. The participant uses the graphic manipulation commands to select, place and shape the rooms, walls, doors, windows and partitions. The participant visually reads his/her drawing on the screen.

In a corresponding way the computer 'reads' the drawing by making a numeric description of the design as a data file.

The participant can evaluate his/her design according to his/her own criteria as an experienced user, by using subjective visual and spatial information from the plan. The computer, on the other hand, can evaluate his/her design with objective measures of performance such as indices of capital cost, energy cost, daylighting and planning efficiency. These measures are displayed to the participant in a simplified but unambiguous manner.

Using the graphic manipulation commands the participant can modify the design. He or she can add, shape, reposition or remove the rooms and the cladding elements. The computer redraws the modified design and always presents to the participant a tidy and accurate representation of current design. The computer can also re-evaluate the design after such a modification so that the participant can see if he/she has improved both the objective as well as the subjective qualities of his/her solution (Figures 2 and 3). The participant can continue the iterative process of modification and evaluation until a design evolves with what he/she considers to be the appropriate mixture of subjective qualities and objective properties.

PARTIAL3 allows a record to be kept over time of the participant's design activity;
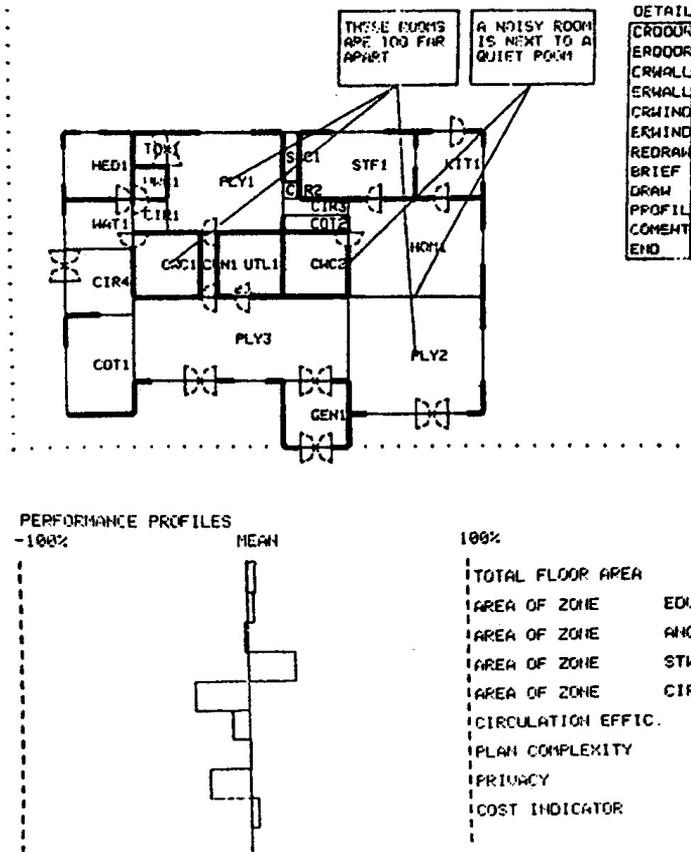

Figure 2 and 3.

this record can be subsequently interrogated by the researcher to establish the sequence of design actions and decision.

The PARTIAL suite of computer programs was rigorously tested and judged to be appropriate for a full scale experimental program funded by the Social Sciences Research Council (SSRC).

3. EXPERIMENTS IN DESIGN PARTICIPATION

Before the main research experiment using PARTIAL was undertaken (in which participants would generate design solutions), a study was undertaken of participants ability to reach consensus on the quality of previously generated design solutions.

3.1 Consensus on Previously Generated Design Solutions

The hypothesis which the series of studies [4] aimed to test was the level of agreement on selection of design alternatives at the early design stage varies as a function of

i) the amount and quality of the information given to the judges
ii) the professional training of the judges

Four groups of students, each group consisting of 15 students, engaged in the experiment. Groups 1 and 3 were made up exclusively of senior architectural students. Each group was presented with five sets of design drawings (site plans, floor plans, sections and elevations) each set corresponding to the design of a particular holiday house; additionally, Groups 3 and 4 were presented with cost and performance profiles for all five designs as generated by the computer program GOAL. Possible order effects were eliminated by randomising the sequence in which information was presented to group numbers.

Subjects were asked to make individual judgements (by rank ordering the designs on a like-dislike scale). No discussion was allowed until after the recording of the rank ordering, when informal discussion was encouraged and recorded.

Using the coefficient of concordance as a measure of consensus, the following conclusions were reached:

• given only drawings, non-architects enjoy a higher level of agreement with each other on the quality of design alternatives than do architects.
• given drawings and cost/performance profiles non-architects reach the same conclusion as architects on the quality of design alternatives.
• given drawings and cost/performance profiles, non-architects enjoy almost as much group agreement as do architects.

More generally it can be stated that:

- consensus on design quality depends more on the information available for comparative evaluation than on professional training.
- for architects and non-architects alike, an increase in the information available for comparative evaluation causes convergence of opinion.

3.2 Active Participation in the Generation of Design Solutions

This experiment assessed the feasibility of design of layouts by Headteachers for 80-place nursery schools and the usefulness of PARTIAL, compared with pencil-and-paper methods, in design synthesis [5]. Attempts were made to reduce or control possible conflict or variables present in the social definition of participation and the users' conceptions of what was important in the built environment by:

i)   defining the problem uniformly for all participants.
ii) adopting an 'experimental' or simulated study concerned with the production of designs which were unlikely to be implemented (hence the implications for practice were defined by the researchers).
iii) by using 'homogeneous' users.

The problem boundaries were embodied in the brief and performance profiles. The former was presented as a space budget, derived from Education Department guidelines; the latter represented the extent of deviation from the mean value of five recently-implemented designs for 80-place nursery schools.

The decision-making structure involved twelve headteachers producing their own solutions, then combining into groups of four to discuss and evaluate individual designs and produce collective solutions. Half of the individual designers used pencil-and-paper methods; half used PARTIAL. All groups used PARTIAL.

The strategy adopted a multi-method approach, including initial structured interviews on design objectives, the use of protocols from 'thinking aloud' by participants, quantitative ranking and rating methods for evaluating designs, and structured post-interviews. Independent 'judges' (12 headteachers and 6 architects) evaluated 'blind' the group designs in comparison with three most recently-built 80-place nurseries in Glasgow. The researchers adopted the idealised role of 'architect as enabler' and refrained from giving any directive aid on the decisions being made. The aim of the project was to explore the nature of the contribution brought to the design problem by headteachers, their usage of feedback on brief and performance, and the evaluation of designs by participants, non-participant headteachers and architects.

The major conclusions which emerge from this experiment are:

- Nursery school headteachers are capable of formulating design objectives and producing layout schemes for 80-place nursery schools which are con-

sidered to incorporate successfully the majority of these initial design objectives. These designs are considered by the participants themselves to be more acceptable than comparable architect-produced designs.

- Participants evaluate their own individual design more highly than other participants' individual designs. However, they are capable of cooperating to produce a collective nursery school design which is not only an improvement in building performance and space allocation terms upon the design from which it evolves, but is also evaluated more highly than the participants' individual designs.
- Further support for the feasibility of this type of involvement comes from the finding that not only do architects evaluate the participants' designs as highly as those of architects, but also they considered the group solutions to be an improvement over the individual solutions upon which they were based.

4. CASE STUDIES

Over the extended period of the investigation of computer aided user participation in design, two opportunities presented themselves to carry out "live" case studies [6].

4.1 Community Design Centre

In this project the researchers worked as architectural advisors to a steering committee from local housing groups, who were formulating an Urban Aid grant application for a community centre.

A decision-making strategy (within which the researchers would act as 'enablers') was developed which fitted the requirements of practice rather than experimental control, and monitoring the process was restricted to note-taking, tape-recording, and secondary information from the group's minutes. The research methodology was therefore based on participant observation.

The strategy developed was as follows: it represented a subdivision of the design problem, and was a basis for the decision-making procedure.

- Generate range of uses and approximate number of users.
- Define catchment area, possible sizes, cost constraints, 'computing' facilities.
- Decide which uses are most/least feasible, and most/least central to the building concept.
- Present background information (space standards, existing buildings).
- Decide which activities are compatible with the same space, and approximate timetabling.
- Decide on space required; numbers and sizes.

- Formulate space budget; modify after discussion.
- Define design objectives in general, layout objectives in particular.
- Generate, appraise and modify layout design.

Layout synthesis was carried out using PARTIAL, but problems over drawings strategies emerged from the outset, with disagreement over whether to design each phase in turn, or begin with the 'whole' building and subdivide it into phases. Some wished to remedy each 'mistake' as it occurred, others wished to see what the whole building looked like first. Communication appeared to be hampered by the size of the group (11 participants plus the researchers) and sub-groups began to form.

At the fifth meeting, the group discussed each plan, suggesting modifications, and selected one as a feasible basis for the design. This discussion was wide-ranging, covering suitability on functional, environmental, servicing and cost-related aspects, in addition to the practical feasibility of each as a phased building. The selected design was passed on to a professional architect with experience of phased buildings, who offered his assistance. After a final meeting in which modifications were finalised and costings estimated, the design was submitted with the Urban Aid application.

4.2 Nursery School Design Workshop

In this project, participation was being approached as a communication/learning process. The aim of the workshop, held during one evening, was firstly to enable criticisms of a standard design for 60-place nursery schools to be voiced by headteachers, and to use this standard design as a vehicle for describing general and specific requirements for nursery school design; secondly, it was aimed for architects to give users a clearer understanding of the design process and the complex range of inter-related objectives which the architect is expected to reconcile.

After an initial discussion on how the plan had evolved, how it was used by headteachers and its problems, the users and architects used PARTIAL to explore the consequences of introducing modifications.

The research methodology consisted of recording in note form the discussions between architects and participants, and structured questionnaires on the usefulness of the session. 8 nursery school headteachers, 4 of whom worked in a standard design, and 6 local authority architects took part together with the advisor on nursery education.

The replies from questionnaires issued after the session revealed that differing opinions on the evening were held by headteachers and architects. The headteachers considered that they had gained a clearer understanding of the design process, for example 'It confirmed my suspicions that schools are built down to price rather than on the basis of what is required'. This led also to increased sympathy with the architect.

The session as a whole, and PARTIAL in particular, had helped them to gain an

insight into the multivariate nature of design, for example 'I learned how cost, space, heating and efficiency are related and how these affect the final design'.

PARTIAL was also considered as a useful tool for the increased participation by users which headteachers proposed: 'It could be most useful and efficient for trying out different ideas on a basic plan and comparing the viability of changes relative to the mean', and 'Perhaps before a nursery plan was adopted, there could be a joint consultative meeting between architects, headteachers and education committee members, using the computer to explore all possibilities and suggestions'.

In contrast, the architects appeared to be less positive about the usefulness of the meeting. 'Usefulness' was considered to lie in establishing dialogue, educating users, and in formulating an initial agreed brief. No reference was made to more direct design participation, and the architects stated uncertainty about their role and suggested a more formal agenda (the participants had suggested a less formal setting would be appropriate).

5. NEW MEDIA IN SUPPORT OF PARTICIPATION

The software developments, experiments and case studies described in sections 2, 3 and 4 took place over a 10 year period, from 1972 to 1982. In 1985 the Design Methods Group of the Technical University of Eindhoven hosted an international conference on design participation entitled the Design Coalition Team [7] at which some 65 presentations were made - very few of which used information technology. Thereafter, regrettably in the authors view, the subject of computer aided design participation virtually disappeared from the scene for a decade.

There is hope for the future however, in the form of developments in multimedia, virtual reality and internet technologies. The relevance of these three technologies are discussed in the following sub-sections.

5.1 Virtual Reality in Support of Participation

To date, the application of Virtual Reality systems has been to provide immersive experience to designers of special worlds (e.g. hazardous, remote or non-existent). More recently, advanced virtual reality systems are being deployed to provide immersive experience of ordinary worlds to building users with special needs. Two major research projects are underway in this regard at the Strathclyde Virtual Environment Laboratory [8]:

  i) the construction and calibration of a wheelchair motion platform to drive those with and without mobility impairment through simulations of existing and pro posed buildings with the intention of improving access for the disabled.

  ii) the simulation of the prime characteristics and degrees of visual impairment as a means of improving the design of new buildings and the re-design of ex isting buildings.

In both these cases, design participation, via VR, is not just possible for the user

but wholly necessary. We are on the threshold of "experiential appraisal" antici-
pated as far back as the early 1980s (Figure 4).
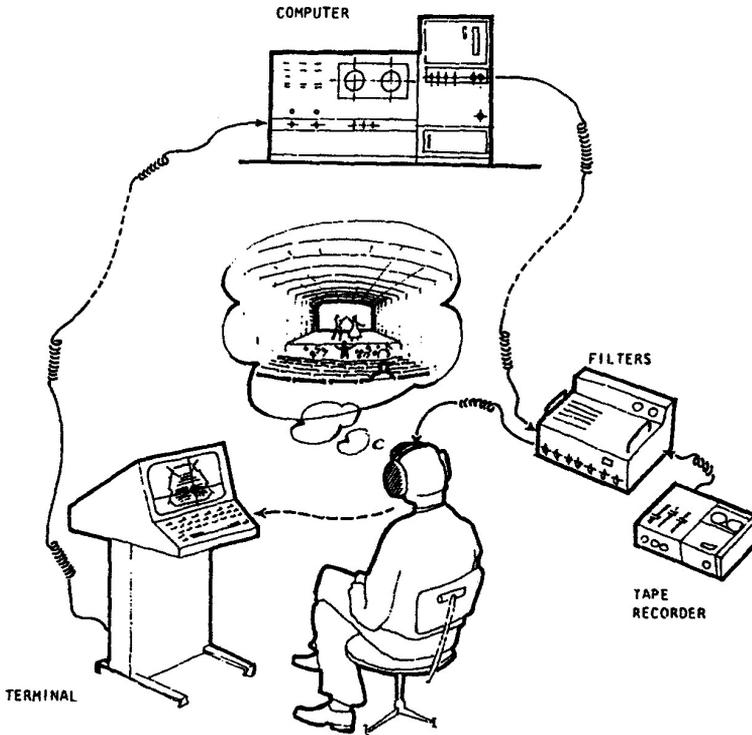

COMPUTER

FILTERS

TAPE
RECORDER

TERMINAL

Figure 4

5.2 The Internet in Support of Participation

Little needs to be said regarding the potential of the Internet for the involvement of
the public in all matters relating to the human condition. As the bandwidth of LANs,
MANs and WANs increases in inverse proportion to their cost-in-use, this tendency
will accelerate and precipitate the conflation of telecommunication and interactive
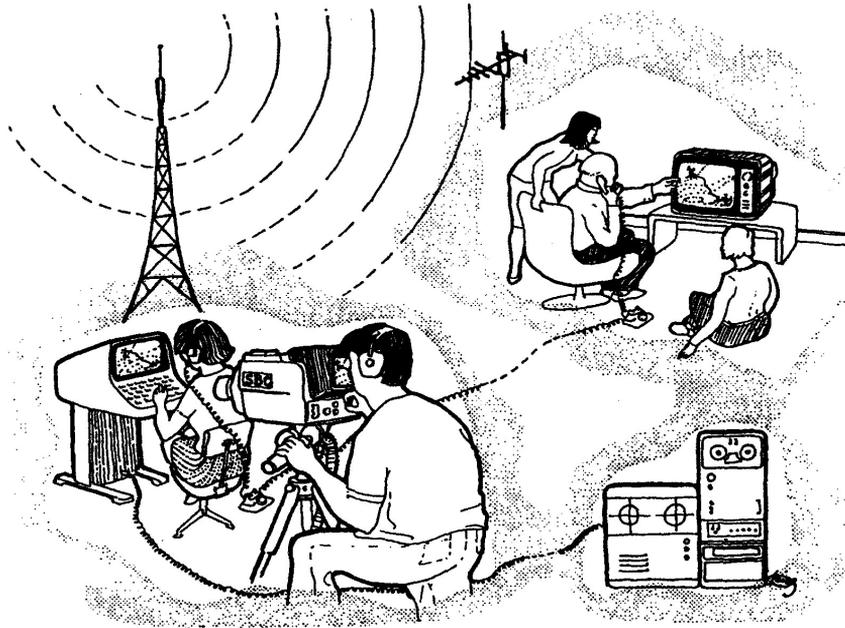computing. The scenario could soon become commonplace (Figure 5).

Figure 5

5.3 Multimedia in Support of Participation

The survey of the users of multimedia presented to ECAADE [9] in 1995 exemplified eight categories of use, including:

i)   explanation of architectural cases
ii) explanation of urban environments
iii) explanation of technical issues

In all of these respects, the potential of multimedia to assist in facilitating the effective participation of users in design decision-making, clearly evident.

6. FINALLY

The history of computer applications in architectural teaching and practice is short, sweet and significant. The contribution to innovative uses of the technology by those in architectural education will be embedded in the heroic history of the subject. There is, of course, a bigger prize: environments designed and built by professionals and people, in participatory partnership. Central to this will be **mediation** through **media.**

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