26. The Impact of Computer Use on Design Practice

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This paper presents a critical review of the impact of computing on design practice. It presents an overview of the impact as it relates to the intrusion of a highly technical resources into organizations. This involves a discussion of the changing nature of computing, the implications of training, management, and perceptions about the compatibility of computers and design. This leads to a consideration of less direct implications in terms of power structures, how computers influence the way we carry out intellectual tasks, the emphasis instilled by computers on form in design, and the influence of computers on attitudes of self worth.

Introduction

The influence of computers on design practice would appear to exceed that of other technologies. Computers become pervasive. They touch on almost every aspect of an organization: management, public relations, clerical tasks, and in the case of design practice, documentation and design. Some of the influences of computers arise out of the implications of managing a highly technical resource. But computers also change work practices. They affect the way people work together, they affect attitudes, and they impinge on power structures within organizations. There is nothing impartial about computers. By design or otherwise, they can serve as a mechanism for propagating certain value systems.

It can be argued that computing has only a relatively minor impact on the activity of design itself (or design decision making), other than in areas with a substantial engineering orientation. However, computers exhibit many indirect impacts on designers by changing the dynamics or organizations. Computers are commonly used in drawing documentation. Inevitably this brings with it the imposition of a new culture. Furthermore, it can be argued that the promises or threats of the possibilities represented by computers unsettles attitudes to design.

Although considerable attention has been given to the impact of computer use on clerical workers (Otway and Peltu 1983; Turkle 1984; Wainwright and Francis 1984; Long 1987) there has been little in the way of formal studies of the impact of computers on the attitudes and work practices of designers. Some of the factors motivating computer use in architectural practice are discussed by Radford (1988), Radford and Stevens (1987), Stevens (1989) and Radford and Coyne (1989). Helpful summaries of the implications of computing in general form a social science perspective are provided by Kling and Iacono (1988), Danziger (1985) and a compilation of papers by Forester (1989). The discussion in this paper relates specifically to the impact of computing on the interests of designers. The views are derived from the author's own observations and interpretations of computer use in relation to

academic institutions (Coyne 1989), corroborated by experiences in consulting and in discussions with other design practitioners.

The paper focuses primarily on computers as multipurpose devices and CAD workstations. A case could be presented that related communications technologies such as video, facsimile machines and electronic mail are exerting significant impacts on design practice, as they are on office practice in general (Marien 1989).

The argument presented in this paper is that certain implications of computing for design practice have gone largely unacknowledged. Computing has the potential as a focus for acrimony, and it can serve as a banner from behind which ideologies are espoused. Some of these issues will be confronted head on in this paper. The paper may assist in accounting for the difficulty organizations experience in making decisions about personnel, capital and training relating to computing. It also suggests some appropriate responses to these issues.

The Computer as a Technical Resource

The introductions of any new technology has ramifications. The nature of computing technology can be considered within four areas: making decisions about computers within a climate of change, changes to work practice the fact that computing requires intensive management, and the observation that work spaces occupied by computers appear to assume a certain ambience that influences the way people respond to them and work within them.

Making Decisions About Computers

The first concern relates to the rate at which computer technology is changing. In making decisions about computer resources it is helpful to be able to appeal to accepted practice. The difficulty here is that, whereas computer-aided drafting is obviously a current priority, there would appear to be no accepted norm of computer use in design practice. The scope of computer use is currently very wide, ranging across accounting, desktop publishing, drafting, three dimensional modelling, simulation, animation and image processing (photomontage).

The cost of commitment to any or all of these endeavours varies. Due to an increasing degree of standardisation and the falling cost of equipment a commitment to some of these technologies can be tentative and incremental. Experimentation is affordable. This is less the case with elaborate CAD modelling and documentation tools. Apart from the relatively high cost of the facility the major burdens are the training overhead and the increasing value of the investment in computer drawings and models that accrues as the system is put into use. Once a commitment to a particular system has been made it becomes more difficult with time to shift allegiance from one CAD system to another. Of course, there are concerted efforts to standardise the way drawings are stored in CAD systems. The Initial Graphics Exchange Standard (IGES) format is an example.

Computer use has increased enormously over the past few years. Even during this short history there have been significant changes in the underlying technology. Coupled with this is a highly active market place where new products appear and disappear each week. There is every reason to expect that change will continue to be an influential feature of computing. The question arises as to what extent organizations should commit resources to an unsettled technology. Insufficient time has elapsed to monitor, evaluate and influence the course of

events. So, added to the cost burden is the fact that patterns of computer use in practice are unstable.

As a consequence of the pattern of change, expertise in the area of system selection and management is in scarce supply. As the advice givers generally include vendors, junior staff members, experienced CAD operators and competitors anxious to justify their own decision making prowess, decision making in relation to computers can be expected to impose considerable stress on an organization. The lack of a clear source of advice sets up interesting dynamics within patterns of decision making in organizations, providing opportunities for enthusiasts at different levels and of different persuasions to exert influence. Computing is one area in which many less experienced workers can legitimately claim superior knowledge. Design schools are increasingly integrating computer use into the curriculum and the job of CAD operator would appear to be increasingly important as the first point of entry to the design professions for new graduates. Of course, these enthusiasts generally have less stake in the outcome of their advice.

Changing Work Practices and Attitudes

There is little doubt that the introduction of computers increases the repertoire of skills to be found within an organization. The need to acquire 'conventional' skills that a new employee is likely to encounter, such as understanding the nuances of office practice, can be met by training carried out on the job. However, the acquisition of computer skills generally requires considerable training. (Some CAD systems involve six weeks of full-time training.) There are several problems in relation to training. One is the cost of terms of fees (if the courses are external to the organization) and productivity losses. If the training is in-house then this means a commitment to an activity that is far removed from the normal concerns of practice. Another commonly reported problem with training is that the firm is effectively enhancing the prospects of its employees to bargain for more lucrative employment elsewhere. Some of the positive side effects that accompany the acquisition of new skills are the extra dimension of interest added to the work task, and the enhanced sense of self worth engendered by the opportunity for advancement.

Computing can also change the distribution of traditional work skills. For example, computers as word processors tend to change patterns of clerical support. It is the experience within many organizations, such as academic institutions, that some non-clerical or managerial staff are happy to take a greater role in the production of text documents. The development of the content of reports and other documents becomes more closely integrated with their production. This has implications in terms of autonomy, control and patterns of dependence. A redistribution of tasks that is more problematic can occur as skill as an operator becomes the major criterion by which workers are selected for particular projects. In the case of CAD systems this may mean those with the least design ability but the greatest enthusiasm and technical skill are carrying out the important design tasks.

A further negative effect of computers on work practice is that they can tend to over-formalise work tasks (Cozier 1983). This is manifested in the organization of drawings relating to a design project. The apparently disordered arrangement of material on and around a drawing board can be seen as a highly complex access system. Information is sorted and categorised according to some dynamic logic and changing system of priority. In spite of all

the appeals to desktop analogues, the ordering of computer files is essentially two dimensional and tree-like. We can extrapolate this example to other aspect of office automation. Computers impose static ordering systems. Customising computer systems to particular needs can induce workers to externalise their work practices, but in doing so ignore the subtle ad hoc operations that actually facilitate the task.

These are changes that computerisation can make to work practices that are more difficult to pin down. There are ways in which the technology can take over as the central interest of the worker. These effects are less likely to be observed in the case of clerical tasks. Partly because of their design and their novelty computers tend to be used very consciously and deliberately in design and drawing. By contrast, conventional tools such as the T-square, set square and drawing board go largely unnoticed by their users. According to Winograd and Flores (1986) one of the goals of computer systems design is to instil the computer with a similar immediacy that a hammer has when wielded by a competent carpenter. Until this goal is achieved the design and documentation process often takes on the form of a challenge: how to do the task well with a computer. A special culture has arisen as support for the particular nature of working with computers. This culture provides special terminology, user groups, journals and societies. For many the hobby-like nature of the enterprise can provide the impetus for the development and promotion of expertise. The negative side is a distraction from the primary concerns of the design enterprise. Of course, some individuals and design organizations become specialists in CAD. CAD specialisation also provides an opportunity for diversification during periods of economic stringency.

Of even greater significance on work practices are the likely long term effects of information technology. Computerisation, tied in with telecommunications, may have the effect of breaking up locational dependence on the work place, though it is thought that the popularity of working at home will be suppressed by certain social needs (Forester 1989). Perhaps more likely is a general trend towards the decentralisation of organizations away from the areas determined by clientele and support services to locations that are more convenient to employees.

Many of the changes that have occurred in the last number of years were unpredictable. The lesson is that there must be a preparedness to expect and challenge change within organizations. The distribution of work tasks and systems of reward and advancement should reflect the new distribution of expertise rather than reflect assumed but often outdated work practices.

The Critical Relationship Between Computers and Management

There are management implications in using computers, both personal and corporate. Computing tends to heighten the need for personal organization. The exercise of poor skills in managing files, disks and backups can be catastrophic. Time management is also critical. Whereas a last minute effort before a client meeting (involving manual drawing) produces a partial result at lease, a last minute effort in front of a computer can produce nothing. It is difficult to allow for contingencies in the event of file loss and system crashes.

As computers are a limited resource there is also the burden on the organization of managing the access of people to computers, and organising schedules to optimise use. Other management issues involve the purchase and staging of acquisitions (both equipment and

software); training; and maintaining databases, software and manuals. Many of these activities are essentially foreign to the traditional concerns of design practices. As computers become more pervasive the effective management of computer resources will become critical to the entire organization.

As computers are a failure prone and highly technical resource they also need managing. The technology currently seems to require individuals who are specialists or systems managers. Modern computer installations are generally networked to facilitate the sharing of disk space, plotters, printers and digitisers, and to facilitate communications. Computing can be a distributed resource. This means that computers can be positioned around an entire building. The flexibility and power that accompanies this distribution also brings with it a certain dependence on centralised expertise. Due to the pervasive nature of computing, the role of the systems manager or specialist becomes far more critical than that of other technical and support staff within an organization.

Centralisation and the intensity of management issues may render the workings of the entire organization prone to 'bottleneck effects'. The breakdown of the plotter means that there are no drawings; a break in the network disables half of the workstations; uncooperative technical support can bring a project to a halt. This becomes an even greater problem due to the inaccessibility of drawings and other documents to untrained project managers and supervisors—the bewildered project supervisor standing in a room full of blank computer screens.

An appropriate response to these issues is firstly to acknowledge the management implications of computerisation in making resource decisions and selecting staff. A further response is to promote systems of management that reduce the bottleneck effect. This may mean: having backup personnel; ensuring that the technical skills are distributed wider than a single expert; partitioning networks and clusters of equipment so that failure in part of the system does not mean failure in the entire system; establishing fast maintenance and repair procedures; and establishing cooperation with other organizations for equipment exchange during a crisis.

There is an increasing need for design practitioners who are also systems manager. This suggests the need for specialist courses in computing and management within design schools that go beyond the general design curriculum. It also points to the need for continuing education of designers and managers.

Computer-Based Design Environments

Most computer use by designers is generally in the areas of documentation and 3D visualisation. Due to advances in systems design and improved computer graphics the computer is proving more attractive as a medium for design expression generally (Radford and Coyne 1989). However, the idea of the computer as a tool for decision support or an 'intelligent assistant' is currently very limited, and advances in this area are the subject of considerable research effort both within and outside practice. These researches are generally accompanied by considerable questioning of the overall role of computers in the design process (Bijl 1989).

Apart from issues of software design, one of the major barriers to the use of computers in the design process lies in the nature of the spaces they occupy. Spaces occupied by computers

have their own distinctive character. Computers are still expensive. For various reasons it makes sense to link computers together into networks. This sometimes means keeping them close together. So the first characteristic of spaces occupied by computers is that they tend to be gathered in coteries.

The second characteristic of these spaces is that they resist attempts at being personalised. Computers often have to be shared. A third characteristic of computer spaces is that they support a much narrower range of activities than many other spaces. There are restrictions to muscular activity imposed by the immediate task environment of keyboard, mouse and screen. Apart from the occupational health implications the restrictions create an environment in which people appear passive, and possibly introspective and uncommunicative (Bjørn-Andersen 1983). A fourth characteristic of computer spaces is that they hum, rattle and beep when in use. They also glow. Of course, when the computers are turned off they assume a different character again: cold and silent. The upshot of this is that to enter the presence of computers is to enter a special place.

Conventional drawing offices and design studios are also special places, although with a more sociable aspect. There may be a general ambience of disorder. Designers generally surround themselves with drawings, material from which inspiration may be drawn. Designer's workstations are very readily and rapidly personalised. There is generally a range of activities taking place: talking in groups, moving around the room, sharpening pencils, and drawing. To the extent that design is able to flourish in such an environment we may question the suitability of computer spaces as effective environments for design.

We can make further observations about computer spaces and the people in them. To work in front of a computer is to focus attention on a very small area (part of a computer screen). The nature of the task, which in its detailed execution often takes on the characteristic of an intense kind of game (matching wits with the computer by persuading it to scale a rectangle by one more pixel), seems to combine with the intense spatial focus to produce a mesmerizing effect. One's own experience is corroborated in observations of novices unused to working with computers. They are frequently surprised at the way their perception of time changes in front of a computer. They are surprised at the extent to which their obsession with detail is heightened.

The case against computer workstations as design environments can be supported further. Several people can gather around a drawing board. Drawing boards are large. They invite participations. Computer monitors are very much the domain of the user. Watching a computer operator at work is akin to reading a book over someone's shoulder. Participation in the task is about as welcome. The distorted and shadowy world reflected in a computer screen engenders a peculiar awareness of people and spaces. It is difficult to look over somebody's shoulder without arousing suspicion. Computer operators work as if they have eyes in the back of their heads.

None of this need matter. If design can flourish in a railway carriage, in the bath and while perched on a wooden stool then it can happen in front of a computer. The main lesson is that we need to be aware of the characteristics of the physical and social environment that generally attends computers. This may be a first step in overcoming the distaste of some designers towards 'computer culture'. We should not be averse to challenging the norms set by the designers and manufacturers of computers, computer networking systems, computer furniture and security systems. There is enormous scope for experimentation.

There are several approaches to handling computers in the workplace — from relegating computers to a back room to distributing and integrating the computer resource throughout the organization. The latter approach may serve not only to facilitate effective movement patterns, but also to offset any tendency to see the technology as precious and possibly menacing. The computer facility is sometimes employed as a selling point to promote a certain high tech ambience within the organization. The objective might be to enhance the sense of excitement, the sense that technology is at hand to solve our problems. As with a great deal of design there is scope for an appeal to myth and theatre as much as ergonomics, efficient circulation and effective environmental control. Experiments in the design of architectural offices attest to this.

Computers and Ideology

Apart from the technological impacts of computing there are less direct sources of impact. There is something about certain technologies (such as television) that have far reaching effects. computers and the attendant culture are incredibly influential. Computers change the way we think about ourselves. The issues in the following summary are not necessarily inherent in computing. They relate to the marketing and promotion of computers, our perceptions of ourselves and how we view machines. For good or ill people are not the same after working with computers.

Computing and Power

Mastery of any skills instils a sense of power and control. This applies to learning a musical instrument, throwing clay and operating or programming a computer. This manifestation of power serves an enabling. There is also a sense of power that comes from belonging to a group — a trade, a profession, the cognoscenti — that has its own language and its own boasts. This phenomenon is certainly evident in the acquisition of computing skills (particularly programming), where entry is perceived to be difficult.

Some tasks assume connotations of power by virtue of their influence over a large number of people. so there is a sense of power in the practice of architecture or writing or the design of artefacts for mass production. Computing is the archetypal cottage industry. In computing, a finite amount of effort with modest resources can produce an infinity of outcomes. Even if the potential for mass production is not fully realised, the trappings are there: files can be copies and disseminated, building models can be viewed from an infinite number of angles, and generative algorithms can produce an infinity of patterns.

A further dimension to the power of computing is that it is possible to create something that resembles a world and then exercise mastery over it. This world may be some esoteric mathematical world, or the representation of a building or a city. You can fly over buildings, walk through walls and commit heinous acts of desecration in computer worlds, without reprisals. Computing to some becomes as engrossing as a game of chess or Dungeons and Dragons.

To what extent do these connotations of power make any impact on the actual relationships between individuals? The power would appear to be largely illusory. This illusion itself

may also serve as a means of manipulation. Computer operators are content to dominate their own small worlds while others dominate them.

The distribution of real power, in a democratising and egalitarian sense, would be expected to lie in the potential of computers as a medium of the dissemination of information and knowledge (for example, through the electronic mail system, databases and expert systems). There is evidence to suggest that there are subtle shifts of power to those with technical expertise, but some commentators, such as Gotlieb and Borodin (1973) and Danziger (1985), suggest that computing tends to reinforce existing power structures.

Subtle power plays are evident in organizations that use computing. The ability to orchestrate expensive capital acquisitions can serve as spectacular demonstrations of power by individuals and groups, especially where this is seen as a competitive enterprise. Within the organization, if the resources and expertise are centralised there is the necessity to grant permissions, and offer instructions and assistance when things go wrong. Again, this relates to the 'all or nothing' nature of the computing enterprise. A partially working computer is one that is not working at all, and partial knowledge is ignorance. So the co-operation of experts has to be thorough. There is enormous scope for condescension and the subtle misuse of power by the experts, where patterns of accountability are unclear. This problem is not new, but because of the pervasive nature of computing the effect of these power games can be all the more debilitating.

A further power dimension is the common perception that computing is on the ascendancy. It is a growing field. Practitioners with a foothold in the technology are in demand. A strong case could be presented that the aspirations of young designers or students relating to computing are closely linked to perceptions of power in the employment market and in the world place. In academic institutions computer-related research finds favour with funding bodies. Computing has a high profile and impresses certain client groups. Even modest initiatives with computer are sometimes seen as innovative and advanced. Tied to this are Utopian expectations of computing ushering in a better world, better pedagogy, perhaps even better design. Some of the mythologies and ideologies behind computer advocacy are addressed in detail by Kling and Iacono (1988). Of course, the advocates and perpetrators of computing have a vested interest in its ascendancy.

There is no simple response to the power issue as it is an integral part of any enterprise involving people. The exercise of power in the market place that enhances the competitive enterprise can be debilitating when manifested within the organization itself. What would help the most is a general recognition of the potential of computing to amplify power problems, and a preparedness to set up mechanisms for accountability.

Computers and the Exercise of the Intellect

A further impact arises from am emphasis on method, order and organization instilled in computer users, and that pervades the way they tend to approach problem solving, even when computers are not being used. This is attested to by Kling and Iacono (1988) and Danziger (1985). We may suppose that there are two ways in which this influence is perpetrated. First, you have to be well organised to get what you want from computers. So computing instils good organizational habits. The second source is the views embodied within the culture that

attends computers—the ideological trappings of the general discourse relating to computing. The discourse of the design theory and methods movement is one such source.

The advocacy of method is something of a tight rope act. There are aspects of the emphasis on method that are undesirable. These are summarised by Danziger (1985). First, there appears to be a tendency to undervalue, or fail to recognise knowledge that cannot be made explicit, and thereby potentially represented and manipulated in a computer. If it can't be put on a computer and made to work then it isn't worth knowing: "real life is life on line" (Kling and Iacono 1988). Second, there is a tendency to increase the importance of quantitative and technical criteria in making decisions. Third, there are tendencies to overestimate the reliability and significance of quantifiable information. This summary is supported by Weizenbaum's (1976) pejorative characterisation of "instrumental reason".

The most extreme manifestation of these excesses in organizations is demonstrated by the 'scientific management' of Frederick Taylor at the end of the last century (Mumford 1983). According to this view individuals in an organization need a relatively narrow range of skills and the worker has little if any discretion. A corollary to this is that the worker only needs to be presented with information that is relevant to the task at hand. Computers tend to raise the spectre of a resurgence of technical rationalism if not by the actual work practice changes imposed by computers then by the philosophical baggage that often accompanies the enterprise.

Although most computer advocates would decry any links with Taylorism, computing has developed and been promoted within theoretical frameworks that carry with them a strong bias towards 'rationalism'. This carries with it notions of objectivity gleaned from particular views of science and extended to other areas of human endeavour. This kind of thinking is under constant challenge (Coyne, 1991a). An interesting illustration of the diversity of thinking in this area is the recent work of Winograd and Flores (1986) who present a critique of computing and artificial intelligence in the light of the 'post rationalism' of Husserl and Heidegger (Heidegger 1962). This theme is taken up in relation to design generally in Snodgrass and Coyne (1990, 1991) and Coyne and Snodgrass (1991a, 1991b).

Computers and the Emphasis on Form

The influence of computers in promoting the idea of 'design methods' is well known. There is also a readily observable phenomenon engendered by computer use that is less subtle and impinges heavily on the issue of design. This is a tendency of computing to focus on form—the shape of things and their configuration. There is no question that computing provides enormous scope for the exploration of matters relating to form in design. An interesting and recent example is provided by Oxman, Radford and Oxman (1988). This kind of activity is supported by the underlying capabilities of computing to configure symbols and the irresistible lure of computer graphics. The emphasis on form also spills over into theories of design as exemplified by Stiny's shape grammars (1980).

Of course, this tendency also reflects preoccupations within the architecture community generally. Leaving aside arguments about the importance of formal considerations in design, computing can tend to amplify and distort this preoccupation. Computers are generally employed for three dimensional modelling and visualising. The time required for this activity alone has a distorting effect on the designer's perception of what is important. Furthermore,

computing does not appear to support other considerations with the same opportunity for panache.

Of course computers can support other activities and there is enormous scope for experimentation. Computers have a role to play in participatory design. The computer can serve as a medium for bringing people together and facilitating the sharing of information. A simple example is the use of a wordprocessor or database file as a medium for storing, collating and analysing information. This becomes particularly powerful when combined with networking that allows 'distributed input'. One interesting development is that simple tools are becoming available for tailor-making applications. So practices can embark on their own relatively inexpensive research and development. Media such a s Hypercard open up possibilities by providing simple yet novel ways of storing, manipulating and displaying design oriented information.

Computers and Models of the Mind

The final issue to be raised here is that computers influence the way we think about ourselves. The impact of computers on the attitudes of individuals to their self worth has been raised by Weizenbaum (1976) and Turkle (1984). The impact of computing on work has been one of the major causes of discontent with computing (Cooley 1980; Jones 1980). One of the manifestations of this influence also comes through contemporary models of human cognition.

Computing has been a major influence in contemporary models of cognition. Most notable has been the 'information theoretic' view of cognition presented by Newell and Simon (1972). At the very earliest stages in their development computers were seen as potential thinking machines. The corollary is that the brain is a machine with the mind as its program (Hofstadter and Dennett 1981). Critics of this approach include Searle (1987) and Dreyfus (1987). Rival positions within cognitive science gather around those who emphasise symbolic processing as a basis of cognition and those who support models based on low level 'connectionism' (Coyne, 1991b). An appeal to computing features prominently in various dialogues within cognitive science and psychology.

At the lowest level, computing serves as a useful source of analogies. The most positive aspect of computing in this context is that computers have served to sharpen debate and stimulate the generation of important cognitive models. Similar claims could be made for the role of computing in helping to understand design and designers. Some recent accounts include those by Coyne (1988), Mitchell (1989), and an account with a different emphasis by Winograd and Flores (1986).

A negative effect is that computing can engender simplistic interpretations of human behaviour, and thus design. The general mood of enthusiasm, the 'bandwagon effect', the lack of intellectual consolidation and the disproportionate recognition of modest achievements that often attends computer-based research can instil a sense of false security.

Conclusion

There is a certain inevitability about computing. There is also considerable resistance. Resistance from practitioners is based as much on the time and competence problems raised earlier in this paper as it is on ideology. Whatever the source, both of these factors (inevitability and resistance), lead to extremes of enthusiasm on the part of individuals. The supporters of computers tend to be enthusiastic. They are caught up with Utopian myths about computers, and they marshal their enthusiasm to overcome resistance amongst colleagues. There is an extent to which computing is oversold. However, the sober reflections of this paper should be modified by an appreciation of the motivating power of myths.

In the face of the daunting prospects and awesome responsibilities presented in this paper, what are the options? The precise response will depend on the management structure and the mechanisms for decision making in the organization. In loosely structured organizations, such as many architectural offices, the fall back position is to leave it to the enthusiasts to present their case for decisions in relation to computing.

In the short term, where there is a commitment to computerisation, practices require competence in the management of technical resources, enthusiasm for the idea of computing, effective computer systems and able technical knowledge. The long term view should be to decentralise expertise within the organization. The computer enthusiasts should also be facilitators. As long as the concern of computers in design resides with the few there is the potential for some of the excesses described in this paper.

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