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The Coming of CAD and the Changing Culture of the Architect's Practice

Catherine O'Connell and Christopher Spencer
Department of Psychology
University of Sheffield
GB - Sheffield S10 2TN
Great Britain

Summary

Computer aided design has affected the architect's practice in a range of ways. Some practices have seen it as just a sophisticated draughting tool, enabling them to achieve greater efficiency; others have stressed its role in facilitating communication with the client (or, more cynically, in impressing him). Finally, a proportion of practices have seen the flexibility and accessibility of CAD as affording them greater opportunities for actively involving the end-users in the design of their building. Three sample practices were studied to illustrate this range of emphases: all three had been using the same CAD system, GABLE, for similar periods. The primary perceived role of CAD in the practice - whether draughting tool, communication aid, or facilitator of user participation - would seem to reflect the prevailing ethic of the particular architects' practice. A comparison group of architectural students, undergoing training with GABLE, far from being idealistic about CAD's possibilities were concerned about the impact of the new technology on their self concept and role as architects.

Résumé

La CAO (Conception assistée par ordinateur) a un impact variable sur les bureaux d'architecture. Certains la perçoivent comme un moyen plus sophistiqué de dessin qui en augmente l'efficacité; d'autres soulignent le rôle de la CAO pour faciliter le dialogue avec le client (ou, plus cyniquement, pour impressionner ce dernier). Enfin d'autres encore voient la flexibilité et l'accessibilité de la CAO comme offrant de meilleures opportunités pour impliquer l'usager final dans le projet. Trois bureaux d'architecture ont été étudiés pour illustrer ces différents usages de la CAO. Les trois avaient l'expérience du même système CAO, du nom de GABLE, pour des durées semblables. Le rôle attribué principalement à la CAO dans ces bureaux - que ce soit comme outil de dessin, comme instrument de communication ou encore comme aide à la participation des usagers - semble être fonction de l'éthique qui prédomine dans le bureau d'architecture. Un groupe de comparaison, formé d'étudiants en architecture qui apprenaient l'utilisation du GABLE, loin d'être idéaliste sur les possibilités offertes par la CAO, était concerné par l'impact de la nouvelle technologie sur l'image de soi et le rôle de l'architecte.

1. Introduction

Computer Aided Design has had many claims made for it: but, as the present set of case studies will attempt to show, what CAD is actually allowed to do within an architectural practice varies considerably. Indeed, we would claim that the uses made of, and the claims made for, CAD could almost be used as a projective test for the styles and belief system of an architectural practice.

While Computer Aided Drafting tools have been on the market since the 1960's, relatively sophisticated CAD, with 3-D colour graphics packages, have become commonplace only in the past five years. Their coming has afforded the architect a radically different way of handling information: essentially, (s)he inputs the information on the building before deciding how the information is to be represented - its scale, perspectives etc. The architect can build up a drawing file which can be recalled at any time, the implication being that the plan need only be constructed once, for it then to be available time and again at different scales and angles.

The implications for the design process become apparent when one realizes that, far from CAD being a mere graphics aid, it can transform the series of stages the architect goes through in working from initial concept to finished design. Claims have been made for CAD's ability to free up the architect to experiment with a much wider range of implementations of an initial concept than would otherwise have been practicable; equally, CAD has been seen as a threat to the creative process, because, for it to operate, the architect has to input values and measurements at an earlier stage than would usually occur in the first concept sketches.

Another two changes in architectural practice which may result from the use of CAD are to do with the architect/client interactions. First, the very vividness of images produced by the best CAD programs, and the facility to tour the unbuilt building has been hailed as a breakthrough in improving communications with the client (architect-client communication failures having long been recognised as an area in need of attention - see Akin, 1986; Lawson, 1990).

Secondly, the increasing accessibility and user-friendliness of the CAD packages has been seen as a way of incorporating the client into the design process. Consultation and participation have been important objectives for some styles of architectural practice. In reality they have often amounted to not much more than round table discussions with architect-drawn sketch plans and elevations as their focus; or a set of planning-games, where the clients (or, more adventurously, the users) are made to realize the real-world trade-offs that can be made within a fixed budget between various design desiderata.

Previous research has shown a range of effects may follow the introduction of CAD into the architectural practice. Changes may be at the broad organizational level: Cooley, in 1977, had forecast that it might lead to job fragmentation. By 1985, Schaffitzel and Kersten offered evidence to indicate that firms were being replanned to reflect changes in the flow of design information; and in the amount of draughting needed.

The present study, while noting changes at this level, is more particularly concerned with the design process itself, and the changes CAD may bring. For, as Warren and Whitefield argued, in 1987:

> "For a CAD system to be an effective aid, the organization of the system should be compatible with the way the designer performs the design

> task. If this match between system and user is poor, then many of the potential advantages will not be realized" (Warren and Whitefield, 1987).

But what exactly is design? Is it useful to compare the architect's production of a design to problem solving in another domain? Archer, for example, had described the design process as a "goal directed problem solving activity" (1984); but Lawson (1990) has shown that its complexity cannot be represented as a linear sequence; and that the architect's problem is ill defined. He has to work through the problem space, via a series of stages represented both by internal/personal symbols and by external ones - his notes, sketches, diagrams and plans. As Akin (1986) has suggested, there must be some metaprocess in the form of a control structure, in order to prevent a 'combinational explosion' of solutions, and to recognize when an acceptable solution has been reached. Indeed, Lawson goes so far as to say:

> "Design is the task of producing a solution rather than solving a problem. The solution is something that has been formed by the design process and has not existed in advance of it" (Lawson, 1990).

Several writers have characterised the earliest stages of the design process as a kind of brainstorming, producing as wide a range of proto-solutions as possible (e.g. Powrie, 1987). Introducing CAD at this stage may require the architect to specify things too closely to allow this fertility of ideas.

In a study which compared design with and without CAD, Whitefield (1986) concluded that despite the fact that CAD is able to relieve the designer from the mundane aspects of the process (especially drafting and redrafting), the newly 'unburdened' designer is then constrained by the CAD system's own demands.

Yet consider the findings of Waern (1986), who has also looked at the differences in approaches to design problems between those using CAD and those using the drawing board. She found that CAD users felt less need for accuracy at the initial stage since it was easier to correct at a later stage than one was inclined to do on a drawing board. Those architects working on a drawing board, she found, spent more time planning before putting pen to paper.

Hence, one major aim of the present study was to look again at the impact architects believe CAD has had on their design process, for we hypothesized that the answer might not be the same for all styles of architectural practice.

2. CAD as a Communication Tool

Similarly, we hypothesized that the potential of CAD to aid communications with clients and users might be very differently realized across these styles of practice. Some practices are, one might say, more ideologically committed to a participative or consultative style, others see the architect as an expert, apart from the clients and users.

Some writers lay much stress on this role for CAD. Thus, for example, Aish in an early research/implementation project from the ABACUS Unit at Strathclyde University positively glows with enthusiasm. In one of the experiments, he invited nursery school headteachers to use his PARTIAL program to design their ideal nursery school:

> "When we came to compare a participant's design with one designed by a professional both represented in the same computer graphic conventions, it is extremely difficult to identify a design which is not the product of seven years of professional training" (Aish, 1979).

Designer and client sitting together at the keyboard, rather than - at best - consultation by questionnaire: CAD can certainly be represented as facilitating true participation in the design process. We hypothesize that this aspect will be emphasized by those architects most committed to Community Architecture. Other architects, if stressing CAD's potential for enhancing communication, may be more likely to emphasize this facilitating role within the design team. Evans (1987) for example, has suggested this may be achieved by the sharing of a Common Project Database between the different professions: the architects, engineers and quantity surveyors. This, he argues, will help integrate the team, as well as improving efficiency, by ensuring that design updates will be made to a common data base.

3. Design of our study

We wished to study the impact of a sophisticated CAD system on the design practices of three contrasted groups of architects, chosen to represent the diversity of styles found in contemporary British architectural firms. Some CAD systems have been adapted from engineering applications: we wished to work with one specifically designed for architecture, and chose one of the most widely used British systems, GABLE.

3.1. The system

GABLE consists of a suite of programs, comprising systems for ground modelling, integrated drafting, object modelling, building modelling and data management. Its promotional literature claims an overall productivity increase of 3:1, with certain areas, for example the production of perspectives, axonometrics etc., improving by as much as 30:1.

Of particular relevance to this study, we noted that GABLE lays stress on the reduction of errors and omissions through the co-ordination of data from a 3-D model; and also upon improvements to communication, easy evaluation of building design, and the immediate access to the project data base.

3.2. The three practices

We chose three practices whose use of the GABLE was sufficiently long that we were not picking up issues associated with novelty, nor yet so long that those we interviewed could not recall earlier procedures for purposes of comparison. We wished to contrast the impact of CAD on a large group of architects, embedded within a national organisation, an independent commercial firm, and, thirdly, an architectural team working within the public sector - in this case local authority housing.

3.2.1. The bank: In-house practice in a leading national clearing bank.

GABLE was in its second year at the Bank, where the headquarters team was a multidisciplinary practice, comprising engineers, quantity surveyors and architects. Its

architectural work, in the main, consists of the redesign, extension and refurbishment of existing properties owned by the bank throughout the country: very few new buildings are being designed. This type of work involves continual redrawing and updating of plans. The bank is currently embarking on a longterm program, feeding plans and details of every property they own onto GABLE. In carrying out refurbishment work, the bank needs to recall standard items like counters, desks and chairs frequently. The architects had received thorough training in GABLE: a two week residential course, followed up by a fairly intensive in-house training period.

3.2.2. The commercial practice: an independent commercial practice in a provincial city

GABLE had been used by some of the architects within this practice for 5 years; more recently, there had been both residential and in-house training for staff provided by GABLE. The practice's workload is varied, consisting mainly of one-off jobs. Much work is speculative, and involves entering competitions to gain further commissions. The practice employs a total of 62 people, and comprises architects, interior designers and engineers.

3.2.3. City council: the local authority housing department

GABLE had been used for the four years prior to the study, with increasing emphasis in the immediately preceding year. The practice is part of a multidisciplinary team of architects, quantity surveyors, land surveyors and engineers all of whom currently use separate systems, and who are backed up by a computer support group. Given recent Government cutbacks in funding, there is little new building coming from the practice; and most of the work is to do with the refurbishment of local authority owned housing. At the time of the study, a major 1960's housing project was being refurbished. GABLE had been used extensively on this project, with the tenants on the refurbishment committee being encouraged to come into the architects and have hands-on experience of GABLE to experiment with, for example, different colour schemes.

3.3. Interview Procedures

Participant observation, questionnaires and other forms of data gathering were considered as means of comparing the three practices; and, after piloting, we decided that interviewing of key and representative personnel in each organisation would provide the most natural method for eliciting the perceived impact of CAD on their working practices. We found the architects, interviewed in their home territory, were keen to talk about the experience, and they adopted an open and reflective tone.

The interview was structured as follows. Section One dealt with general issues: familiarity with computers, thoughts on the training process, and the initial stereotypes within the organisation about the potential role of CAD.

Section Two recalled the impact CAD had on the design process. Had there been a need to change procedures? In this section, architects were free to indicate how they perceived CAD - whether as a high level or low level design tool; and to what extent they saw CAD as a tool for enhancing communication.

Section Three concluded the interview, inviting more general reflections on the likely impact of CAD on the architectural profession as a whole. Interviews (N = 3x9 = 27) ranged in duration between 30 and 90 minutes.

3.4. Results of the three case studies compared

3.4.1. Preconceptions about CAD: the three organizations found to be similar

Across the three organizations, there had been, interviewees recalled, a range of expectations of CAD - from eager anticipation, through a calculation that this new skill would advance ones career to concern about ones likely learning speed. The age of the architect was - perhaps surprisingly - not associated with the type of preconception: in this, our study confirmed the findings of Majchrzak and Collins (1986).

3.4.2. CAD: a high level design aid or a low level tool?

The three practices were much more clearly differentiated in their aims and ambitions for CAD than they had been in their anticipations: the bank architects stressed its role as a useful but low level tool; the commercial practice architects stressed its tool properties, especially with relation to financial gain; and the City Council architects were the most enthusiastic about CAD's role as a design aid which could lead to a new approach (e.g. "There is more flexibility: the whole process is not dominated by producing a set of drawings ... but frees the imagination").

But, we pressed them, what role did CAD actually play in the design process? Here, we found that, whatever people's ideals had been, in practice few felt that they were yet designing with CAD. (Note that these were not novices: some had as much as five year's experience). These quotes sum this feeling up:

> "I tend to work a design all the way through almost to completion before getting it into a physical form on CAD". (Bank architect).

> "I still find I would need to sketch something before I put it onto the computer because you can get all sorts of impressions if you sketch, which you just don't on the computer". (City Council).

> "I think we start to use CAD at the time when you put down the 6B pencil and pick up the 2H - when you've virtually worked out the design solution in broad terms". (Commercial practice).

3.4.3. CAD: what changes in design practice?

Architects in all three practices, when asked to describe in detail how their design practice might have changed, indicated that CAD required:

- more planning,
- more detailed specifications at an early stage, and
- a different way of handling information.

Schaffitzel and Kersten (1985) had predicted that CAD would lead to a changeover from 'planning during' to 'planning before'. One of the Bank architects captured this change thus:

> "I spend a longer time at the beginning to get some clear understanding of what goes where in relation to what. Previously, I'd jump in with both feet, and start drawing, trying to understand as I went along. Now, however, I need to have a much better understanding of the building at the beginning of the exercise."

As a development of this point, many architects (20/27) emphasized the need to make specifications at an earlier stage than at the drawing board, thereby exerting a tighter control:

> "Something you'd not been used to doing at the initial stage: drawing to scale" (Commercial practice architect).

The conceptual approach, as a consequence, changes:

> "When an architect is planning a drawing, he thinks in 2-d, you defer thoughts in 3-d until later on. CAD will not let you do it that way" (Bank architect).

In other words, we are not just witnessing a procedural shift, but something potentially more profound and demanding. Most of the architects agreed that one had to think differently in order to use CAD: in other words, we are not just dealing with a changed drafting tool.

A minority (6/27) of architects, in recognising this new way of thinking, reported it as if it strained the natural order, e.g.:

> "CAD doesn't think the way an architect does".

> "I don't think that CAD works the way my mind works".

3.4.4.The impact of CAD on creativity

Some writers have suggested that CAD in the office facilitates creativity, by allowing the designer to try out more design solutions (eg Schaffitzel and Kersten, 1985). In contrast, Cooley (1977) had predicted that CAD would lead to the deskilling of the design function, and encourage a greater formalisation of behaviour.

Creativity or formalisation? The answer, from our study, would seem to relate to the ethics and aims of ones organisation: where, as in the Commercial Practice, there were ever-present financial pressures, architects tended to report:

> "The main impact has been quicker turnround: the faster you can draw, the better and faster you can get on to the next job.... We can do more work with fewer people."

In contrast, the City Council's architects, charged with providing alternative design solutions for housing, seemed more aware of the possibilities for creativity:

> "I think it makes people more prepared to try different options.... I feel I can experiment more ...."

Some architects in our sample mused on the ending of the individual draughting style, and on the impression that "the computer tends to iron out personal differences" - but, in both bank and commercial practice then countered this thought with "... but we're not here to produce pretty pictures". Very few, this point aside, saw the coming of CAD as deskilling the design process: instead, "it frees you from the ball and chain of the drawing board".

3.4.5. CAD as an enhancer of communication

While many of the architects acknowledged that having CAD in the office could aid communication, the 'house style' of the three practices emerged most clearly at this point in the interviews.

In the Bank, the comments reflected the architects' role within the larger organisation, as people having to serve their employers, yet still maintaining professional standing, e.g:

> "They've (the clients) given us the brief and we want to convince them we've come up with the best possible answer: if we can come up with pretty drawings, we can use whatever view we think".

> "To a certain extent it will be used to impress clients: a selling tool ... with CAD, you can work in front of their eyes - its much more impressive".

The Commercial Practice again stressed keeping control, for example:

> "I use it as a tool to try and convince them what we're doing is right; not to give them the opportunity to change things".

> "CAD helped us to give clients information at an earlier date than before".

> "It can cut out a lot of wasted time in backwards and forwards communication"

Contrast this ethos with the approach of the City Council, where collaboration with the clients (who significantly were often also the end users) was stressed:

> "Easier to involve the tenants by using 3-d information"

> "They were really taken by it. They went away feeling they'd had a good chance to explore aspects of the design".

> "We've brought the tenants in to look at colour combinations: I feel that's fantastically useful".

The projects in progress at the City Council involved a great deal of client participation: tenants would comment on plans at weekly meetings. Some features could be modified then and there, and others changed for the next week's meeting.

Greater client participation, as we have implied, was not the benefit of CAD which was perceived by the other two practices: all talk here was of greater communi-

cation efficiency, and of meeting important deadlines. (When asked about participation, these architects thought that giving the client more say in the design would add greatly to the length of the projects).

Similarly, efficiency and cost savings were stressed by these teams when asked about the effects of CAD on liaison with the other disciplines, e.g.:

> "Closer teamwork rather than segregated disciplines: we get results quicker for the client because we have the facilities to hand for common use. That's the way forwards." (Bank).

> "You used to do a drawing, and the engineer his drawing; and hopefully they tied up - but it was so easy to miss something that's been changed. With the systems integrated, it's there, it's in the model: you should be able to see it striking through the wall if it's not right". (Commercial Practice).

Consistency of information between the disciplines was seen as a major benefit of an integrated CAD system: it would reduce the possibility of mistakes, and bring the disciplines together.

4. Follow-up Study: the student view of CAD

Our main study has looked at the experiences and attitudes of those who have, at some point during their career, introduced CAD into their existing design practice.

We were interested to compare these views, of practising architects, with those of a student population. We therefore conducted a follow-up study, with second year architecture students being trained in the use of the same CAD system, to examine impressions of CAD among those who were, as yet, uninfluenced by the realities of working within any particular architectural practice, and who would therefore not have absorbed any specific practice's ethos.

The second year architectural students at Sheffield University (N=27) attend a lecture course on the general principles of CAD, with specific concentration on the GABLE system. This is supported by a ten-week training course, consisting of a 3 hour practical session each week. This course is nested within the students' intensive training in general design methodology: hence, surveying such student's impressions of the potential role of CAD in practice seemed a useful comparison with those of architects already experienced in its use. Would they be more idealistic? (They were, after all, being taught by the team who developed the GABLE system). Would they stress elements which the practising architects had down played?

We constructed a questionnaire, derived from the study instruments used with the architect sample, changed in aspects of its wording to make it appropriate to the students' situation: in effect, changing the perspective from 'in your experience' to 'would you anticipate?' This questionnaire was completed by the students whilst they were finishing the CAD course.

The results broadly matched the communalities reported above for the practising architects; but with more striking individual differences between the student architects. Some were extremely, idealistically, in favour of CAD; while many others (17/27) expressed concerns about the loss of individuality in the design process. Representative of this latter point of view was the student who suggested that the increasing use of CAD in architecture might attract a different type of person to enter the profession:

"I think a lot of people enter architecture because they think it involves a lot of drawing, and that you can put your own personal touch in. In future, I think it will get a lot of people who are just interested in computer graphics, and not really in the design point of view."

5. Conclusion

Our impression of the profession, following the interviews with practising architects, is perhaps more encouraging than this student's view. CAD, all the architects agreed, reduced the need for the repetitive elements of drafting; and might well offer the chance of coming closer to the needs of the client through greater mutual understanding. These must surely be two considerable benefits to the nature and practice of architecture, if certain conditions are met.

Reducing repetitive work has been proferred, by the advocates of CAD, as allowing more time for the truly creative and innovative work that is central to architecture. If, as seems from many of the interviews, its main effect is simply to increase the throughput of jobs through the office, then, although 'efficiency' may increase, many may feel that creativity has not benefitted.

Secondly, although CAD was spoken of as a facilitator of communications with the client, our survey shows that this potential benefit is mediated by the custom and practice of the particular firm. The three architectural firms were chosen to demonstrate the range of ethos, with respect to client and user involvement in the design process.

We conclude that, for some firms, the coming of CAD has simply been used to impress the client with the office's"new technology", but has not led to any greater involvement. At the opposite end of the continum, there are firms where ethos is so much in favour of client and, often user-participation in the design process that the coming of CAD has been used as a major step forward in sharing of the decision making.

(It is perhaps salutary to realize that, among our supposedly idealistic student sample, few of them (3/27) stressed participative design work among the advantages of CAD: their major concern was for the impact of the technology on their own self concepts as architects).

As this case study has attempted to illustrate, there is a wide variety of consequences that the use of CAD entails. Only some of these were the ones that the initial proponents of CAD envisaged. And, indeed, if one studies the publicity brochures for the various systems on the market, and the published evaluations of these systems, the situation remains the same: the emphasis remains on the technical production side, with as a second major theme, the within-team communications that CAD offers as a data base common to all. And often when assessing the impact on a company, such evaluations stress the financial payoffs of the initial heavy investment in hardware, software and training: eg "the benefits brought to the practice are numerous but the most important, in very simple terms, is that they have been able to handle much more work with fewer staff" (Design, March 1991, pp 52-53). Only as an afterthought does this recent review mention relations with the clients!

But, as we have seen in our case studies, CAD can be much more than an economical drafting system: CAD has come to have a life of its own.

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