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Teaching Computer Aided Design to Engineering Students

The organisation and control of the engineering product cycle is currently undergoing a drastic change and it seems probable that some of the skills being taught on our engineering courses will become obsolete. I shall briefly discuss some of the developments that we should consider in the evolution of strategies for teaching design in a way that will respond to the needs of industry.

The engineer up to the 1930s was a good all-rounder who could design a product for both function and production. This was because components were comparatively simple, quantities produced were relatively small and a limited range of materials and processes were available. Gradually, materials profilerated, the manufacturing processes to work them became more complex and components became more complicated. Consequently, no one person could be a total expert and effective design for production could only be brought about by employing specialists such as materials scientists and stress men.

Our engineering courses were designed to provide first-level expertise so that engineers could ask specialists the right questions and so that they could produce a coarse design which coud be refined by more detailed specialisation. One effect of the specialisation process was the conventional organisation of the product cycle with departmentalised skills. Each box of Fig. 19 (which shows a considerably simplified organisation) represents a distinct function which may be performed by a separate flow of information. The information media may be bits of paper, telephone messages, progress chasers and so on. The whole sequence is driven by the management control mechanism.

From the 60s, many firms have been using computers to assist this process; from the mid-70s many have provided interactive interfaces. By 1980 about 1000 of the 10000 or so industrial concerns in the UK had invested to some extent in these computer-aided systems. The procedure generally adopted was to provide a discrete computer-aided system mapping to each of the boxes in Fig. 19; this process is shown in Fig. 20.

Notice that organisation and control are exactly the same and information flow is identical, except that the information medium in some parts is computer files. Firms have normally been very tentative about providing computer aid; the usual points of entry being computer-aided draughting and numerical control tape preparation since these functions are easy to understand and present an obvious prospect of increasing productivity. Also no organisational restructuring is required.

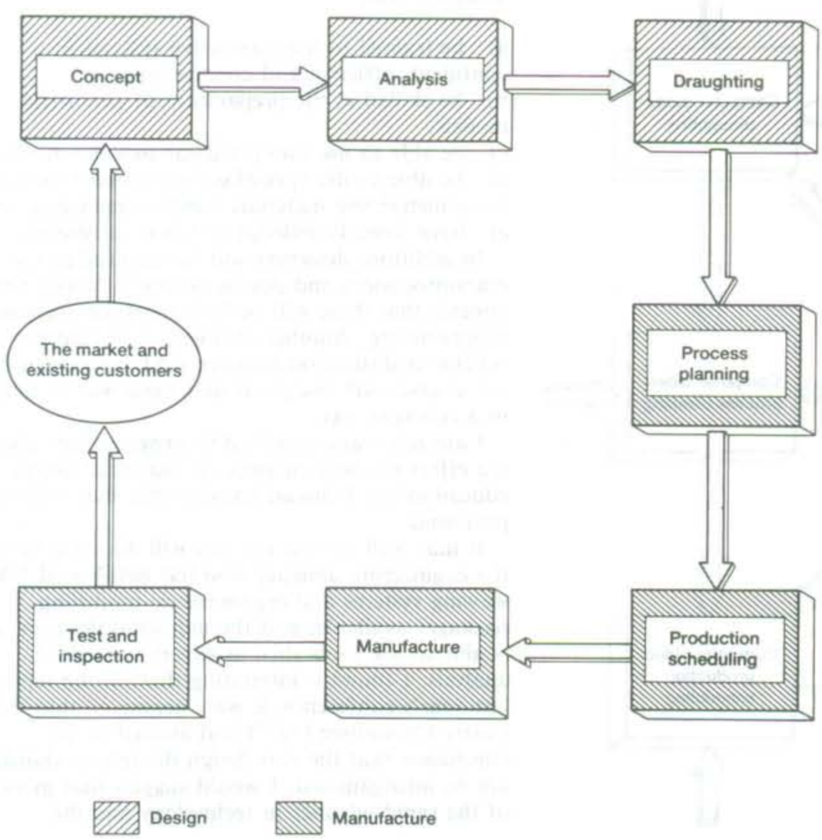
Fig. 20 is in no way an integrated system; the information flow and control are identical to those in Fig. 19. Note also that the prime source of information about the product is the conventional engineering drawing which contains information about its geometric form, material and method of production. This is fairly inconvenient since it is difficult to calculate even the volume of a part directly from the 2D orthogonally-projected drawing.

At the moment, many firms are attempting to evolve a truly integrated system using a centralised database as shown in Fig. 21. Some are well on the way to producing such a system. This produces several fundamental changes in the product cycle; for instance, it is generally considered that the conventional 2D representations is inadequate as the core of the database and that for many reasons a 3D geometric model is superior. From a 3D model, the user can directly obtain mass properties, finite element meshes, NC machine tapes, information to aid group technology, images as realistic as is considered desirable or economic and also conventional 2D drawings if needed. Many authorities consider that the engineering drawing will be unnecessary by the early 90s and judging from the present real decrease in the number of draughtsmen employed, this seems feasible.

Some problems have not yet been adequately solved in the complete 3D representations of components — tolerancing is one example. There is also some controversy about the type of 3D model used. However, in view of the time and money being spent in this field, it seems probable that

Fig. 19

The conventional product cycle.



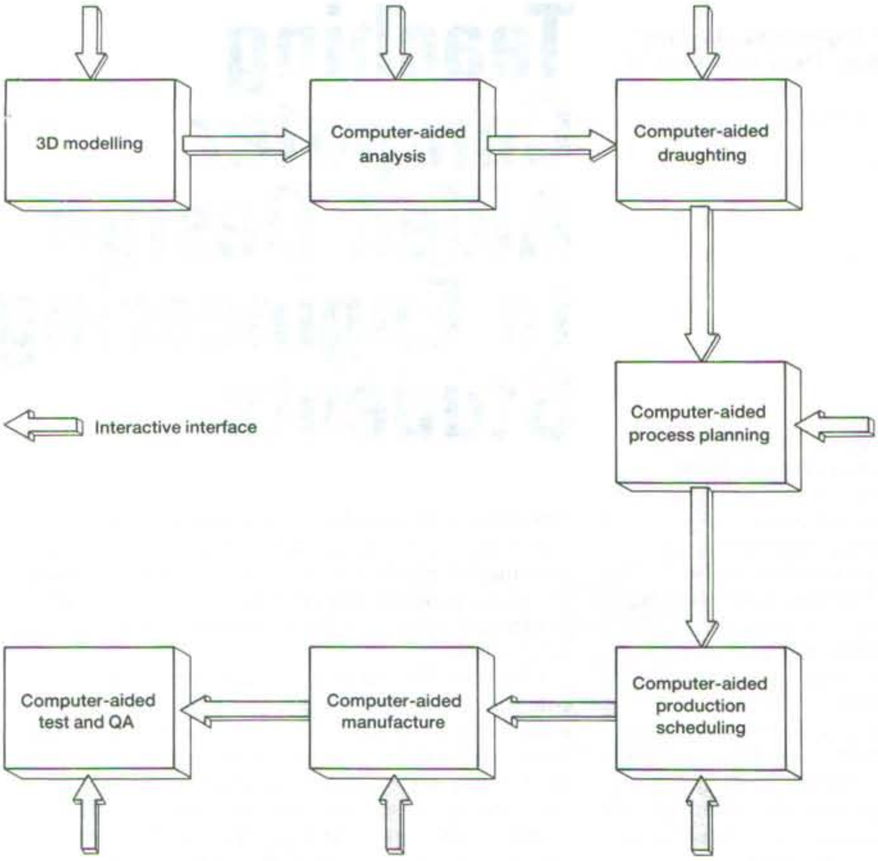
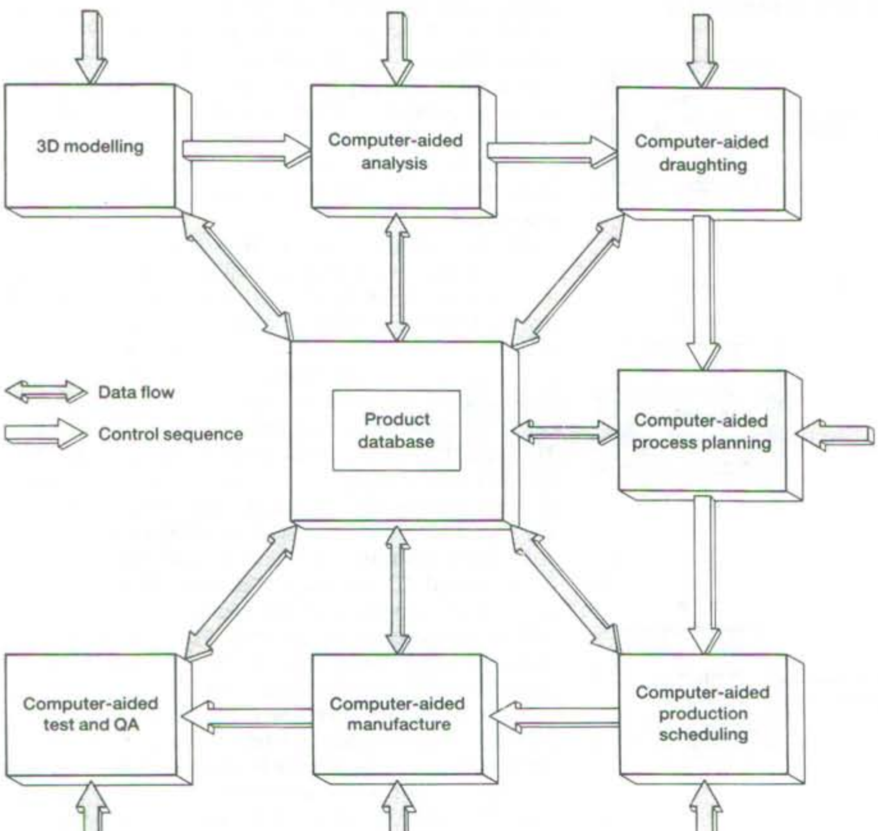


Fig. 20

The computer-aided product cycle.

Fig. 21

The computer-integrated engineering system.



efficient and easily used 3D modelling systems will soon be widely employed. With the adoption of specialised graphic chips and the current emphasis which is being placed on human/machine interaction, it is also highly probable that the 3D systems of the late 80s will be considerably more sophisticated and easier to use than those available now.

A further advance intimately affecting the training of the design engineer is the inclusion of artificial intelligence in the subsystem under interfaces. It seems probable that much of the first-level expertise mentioned previously will be delegated to expert systems. Fig. 22 shows the result.

The aim of most of these advances is to link the engineering function to the financial and policy-making functions of a firm to produce an integrated business system. It is wrong to believe that this applies only to the larger firms.

Our courses must supply engineers who can use these CAE systems effectively and intelligently and it is possible that we shall partially revert to the 'good all-rounder'. In particular, design engineers should have a fair knowledge of the traditional fields which we currently teach but with a critical rather than an analytical emphasis. It is possible that the rather blurred distinction between design and production might disappear. In addition to traditional topics, it seems clear that engineering designers will:

a) be trained to use interactive systems in a confident, efficient and creative way,
b) be skilled in the preparation of geometric models,
c) be able to use product databases effectively,
d) be able to use specialised subsystems such as econometric and materials selection packages, and
e) have some knowledge of CAM subsystems.

In addition, designers will be required to use microprocessors and design elements. Notice that it appears that there will be little need for computer programming. Another change will be that the ridiculous distinction between CAD and dsign in our courses will disappear and these will be taught in a coherent way.

I am not really qualified to prognosticate about the effect of these changes on industrial design education but I should imagine that they will be profound.

It may well be that the gap will diminish between the engineering designer who has easily-used 3D viewing systems and ergonometric modelling packages available, and the industrial designer who is able to use tools such as expert systems of analysis. I found it interesting that, in the report of last year's conference, it was mentioned that the Carter Committee (1977) had arrived at the conclusion that the two design disciplines should not be amalgamated. I would suggest that in view of the rapid advance in technology and the

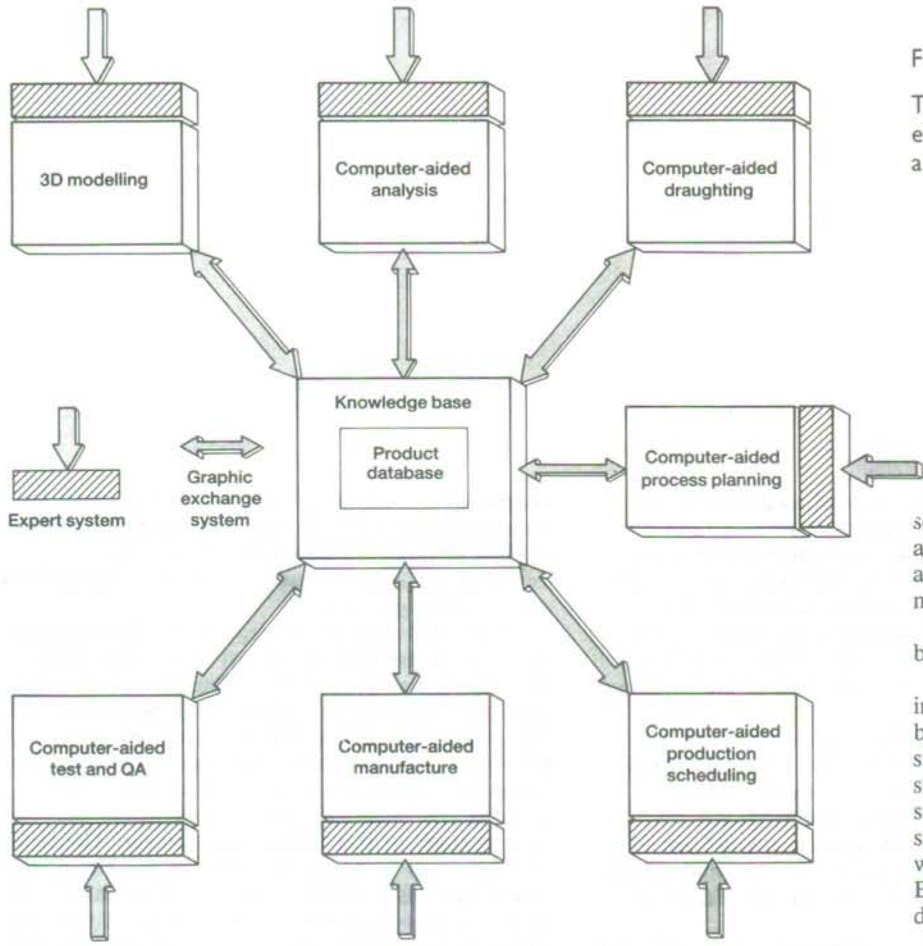


Fig. 22

The computer-integrated engineering system with artificial intelligence.

exponential rise in the number of CAD systems, it is time for a committee to be set up to re-examine the needs of design education in the 90s,

I have examined the responses to the Design Council's survey of computer software and hardware, which made interesting reading. However, it is often difficult to see from the list of equipment what activity is being performed. It does not, in most cases, seem to be much to do with CAD and I imagine that many industrial design departments are observing Alfred Hitchcock's maxim that 'It's the action that counts, not the plot'. In my opinion, it is pointless to introduce computers in a haphazard way, especially in degree courses, since syllabuses are often overcrowded already. No meaningful CAD can be done on an Apple, even with the aid of a Robo Bitstik.

Of course, we cannot all be in the fortunate position of Huddersfield Polytechnic who have spent £750,000 on a full blown Computervision system, but it is important that systems used should bear some resemblance to those in industrial practice. At my polytechnic in the department of mechanical and production engineering we have a modest CAD/CAM facility — we have spent over £100,000 (from several sources) and have seven workstations, which are minimally compatible with those used in industry, and a fair range of realistic software covering computer-aided draughting (DOGS), surface asnd solid modelling (DUCT and BOXER), finite element analysis (PAFEC 75 and PIGS) and computer-aided manufacture (GNC). There is also a central graphics facility which is used on a casual basis for CAD/CAM and some of the other departments, including art and design, have CAD equipment. We started about four years ago with a £2,500 graphics terminal connected through a £120 acoustic coupler to a commerical bureau-Deltacam. At no time have we ever used other than realistic software and at the moment all our design students use the CAD/CAM facility. In particular, we use the systems with BA industrial design students who seem to have no problems with them.

If you want impartial advice about hardware or software matters the FEU have funded a CAE advisory centre for FE sited in my department. We also market small scale software on a non-profit-making basis.

Some other points should be considered when buying equipment.

Most departments have followed the led of industry and chosen to enter CAD/CAM tentatively by buying a draughting system and machining simulation system. If you decide to do this, make sure that the overhead of time required to teach students to use the system is not excessive, that the system should be capable of being used in a natural way and that drawings produced should be to BS308. Here are some approximate costs for draughting systems:

Rock bottom
CAD/CAM system marketed by CAE Advisory Centre.
Cost £100. Runs on BBC machine.

Low cost
COMPAS 2D marketed by British Thornton.
Cost: £3,184 for first seat, £400 for subsequent.
Runs on BBC machine; plotter and digitiser included.

Medium cost
AUTOCAD. Runs on IBM PC.
Cost of software £1,000/seat.

Medium high
DOGS. Runs on Prime. Marketed by Deltacam.
Cost £9,000 for software.

Although 3D modelling is immediately attractive to industrial designers, it is used for purposes other than viewing in practice. Other packages are also of equal utility, e. g. econometric modelling, materials selection and database management systems. I would repeat that there is currently little useful in the field of 3D modelling which can be done on micros. On the other hand, if you are financially restricted, for for 'bottoms on seats' rather than quality terminals. The cheapest graphics terminal costs about £1,000 and is adequate for most purposes.

There are extra costs to be considered when buying equipment. Hardware maintenance is usually of the order of 10-12%. Software maintenance is also important because of the rapid developments which normally take place in even well established packages. This normally costs much more than hardware maintenance.

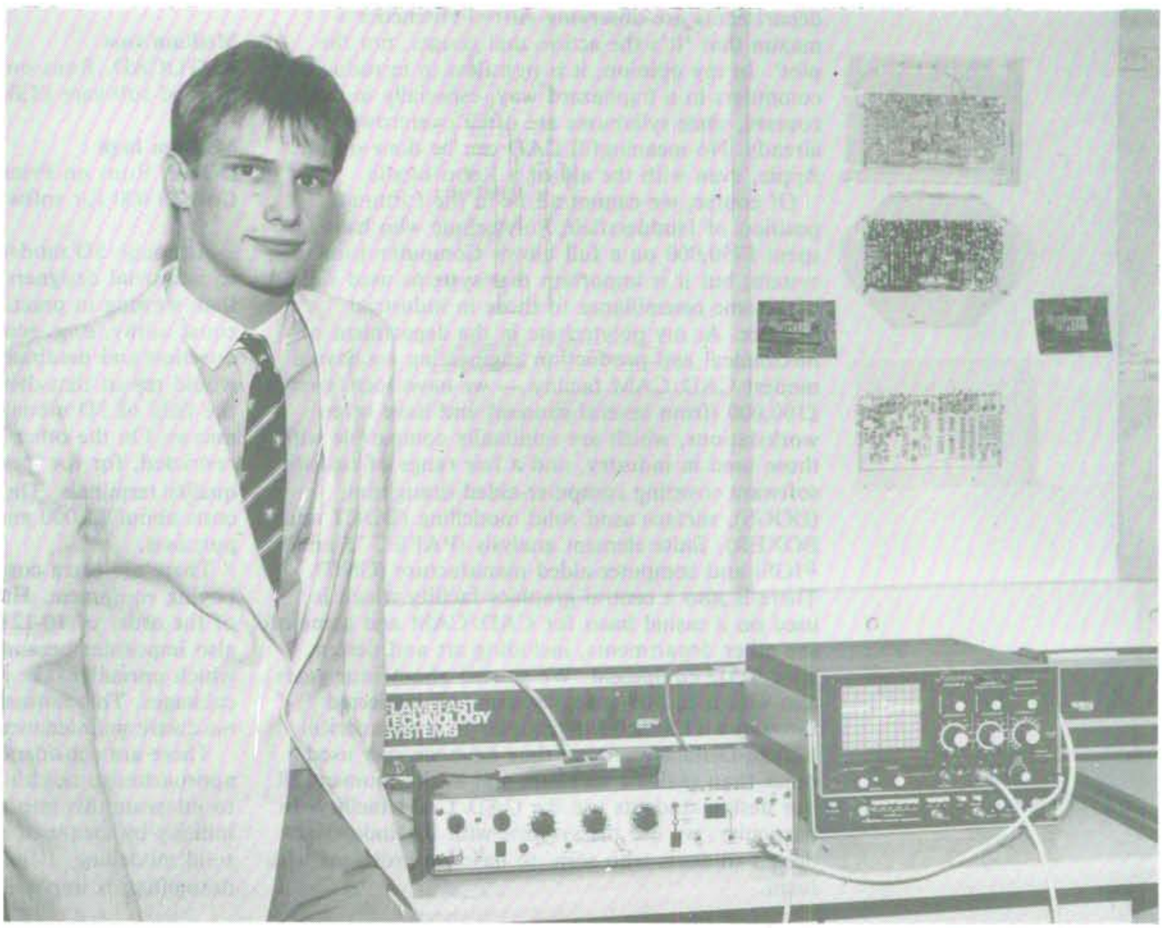
There are considerable differences between approaches to teaching CAD material. I find it best to integrate this into the normal design syllabus initially by means of the draughting package, then solid modelling. I find that computer-aided draughting is impossible to teach but fortunately it is a fairly low level activity and students get on very well without my ministrations if access to the system is freely available. The solid modeller that we use is ideal for teaching purposes; students can produce quite complex geometric models after an hour's instruction. Incidentally, the Business and Technician Education Council (BTEC)* CAD V course is an excellent starting point in the design of any CAD course.

If I did not have access to good software, I should introduce CAD by means of small didactic teaching packages linked to particular design projects. Manchester Polytechnic is taking this approach and seems to be making a good job of it. The advisory centre has a few of these, and we are looking for more so that they may be offered to colleges.

Ideally, some form of regionalisation would have many advantages for both industrial and engineering design. I would suggest that this should be considered nationally as a matter of urgency. Colleges unable to buy their own software would then be able to access a full range of up-to-date systems over a telephone line. Of course, there are some problems involved, not least being the macho attitude towards equipment which is widely prevalent, but the clear advantages of a regionalised system outweigh these.

Finally, I should like to regsiter my disagreement with one of the speakers at last year's conference who stated that the use of computers in design is a transient phenomenon. All the large (and some of the small) firms that I deal with have invested heavily in terms of manpower, money and mental energy in CAD systems. We shall be doing our students and industry a disservice if we do not include study of this field in our courses. The field of CAD is an exciting and vital one and I hope this conference has helped to fire your enthusiasm in it. However, to teach CAD properly needs money and I hope that the heads of industrial design here will address themselves vigorously to the problem of obtaining it.

* BTEC, Central House, Upper Worburn Place, London WC1 OHH.



One of the 110 winners of the Young Electronic Designer Competition. Robert Rowe of Wymondham College with one of his projects, a digital storage module to convert standard oscilloscope into a 20 KHz bandwave digital oscilloscope for schools.