- Much experience has been built up in the "teaching of teachers".

- there is now a growing movement for the joint development of software.

Professor Maver ended his speech hoping that "over the next two and a half days this conference should turn its attention to at least three issues:

- to advance teaching and education
- to advance research
- to relate the first two to practice

We now have an opportunity to use CAD as an "integrating theme" for our cooperation. It is a perfect subject for collaboration not just across international but also professional boundaries".

DISCUSSION FOLLOWING TOM MAVER'S TALK

Q: Could you give us a set of priorities among the issues? For instance it seems that "teaching teachers" is a very important area where much effort could be concentrated. Will it be possible for us to hear more about the Eindhoven exercise?

A: The Eindhoven workshop is a very exiting and appropriate first step in teaching teachers about CAD. It has been run twice. The first time for 20 people and the second for 12. I hope that we will hear more about it during the next few days.

CAD TECHNOLOGY, ITS EFFECTS ON PRACTICE AND THE RESPONSE OF EDUCATION, AN OVERVIEW.

William Mitchell
Professor
University of California
Los Angeles

As a context the history of the CAD field in the USA may be sketched in terms of the four generations of hardware.

1ST GENERATION (60's)

Serious work in CAD begun in the 60's. Ivan Sutherland of MIT developed Sketchpad in 63-64. It was an interactive graphics system. It caught peoples' imagination and soon afterwards CAD in architecture begun.

This work was all based on mainframe computers and refresh vector displays. They were demonstration systems and did not address any & the real database problems.

This generation had no impact on everyday practice, there were good ideas but they were not yet cost effective.

2ND GENERATION (70'sto 80)

The second generation hardware was based on 16 bit minicomputers (typically the PDP-11 series). For the first time computers became relatively cheap, still giving a relatively high performance. The displays were storage tubes which gave a good resolution but they were, however, rather slow in operation.

The new minicomputers marked the beginning of practical applications of CAD/CAM technology. Soon there were some 100 vendors and CAD started to penetrate into day to day practice.

Most of the applications were oriented to drafting. In other wards computers were used to produce similar drawings as drafted manually before, the only difference being that the computer system was much +aster.

So the computer systems of 2nd generation had only little real impact on the design process.

3RD GENERATION

The third generation was born with the new 32-bit superminis, particularly the VAX-11 series. The display technology changed to raster graphics, which started to have good enough resolution. The raster graphics first time enabled real interactive use of CAD systems.

There were also a number changes in software development. A set of new multi-user operating systems appeared. More attention begun to be given to database management. Databases in CAD are large and complex and a good management of them is essential! to effective use of CAD systems.

Software engineering was gaining importance. The continuously increasing complexity required sophisticated software engineering techniques to improve the reliability of programs and to reduce development costs of them.

A great majority of all the present CAD systems belong to the 3rd generation.

4TH GENERATION

This started in the early 80's and was driven by the rapid development of very large scale integration (VLSI) in the microprocessor production. The cost of processors dropped spectacularly as well as the cost of memory.

This has changed the way we view the computers. Now we have the concept of distributed intelligence. it is now cost effective to put as much intelligence as is possible in the workstation itself.

We are starting to see CAD systems not as stand-alone devices but rather as a part of large, complex data processing environments operating in networks.

There is also an increasing use of colors and specialised processors for color graphics and efficient database management. Most vendors are now putting out systems of this nature.

SOFTWARE ISSUES

The provision of generalised applications such as modelling and drafting are not enough. There is now an increased demand for special applications.

There is also an increase in very low cost CAD systems (PC-class). These are, however, often not cost effective, but they provide an opportunity of giving architects the hands-on experience they need, they also help in education.

This may be regarded as a transitional technology. In four years or so 32-bit PCs with good graphics will be available- at similar costs to today's personal computers.

The real issue today is the availability of software. It is needed to take up the advantages offered by the new hardware. This is sometimes referred to as "the software gap". Software and databases are dominating costs at the moment.

RELEVANCE TO PRACTICE

In architectural practice the past three years have seen a spectacular increase in enthusiasm and awareness. The large firms have moved into production drafting on turnkey systems.

This is mainly because much research and development is needed to produce a system and most architects cannot afford to do this. In the USA there are a few dozen very large firms which do most of the work.

Among other things CAD is changing the financial structure of architectural practices. Architecture is and always has been labour intensive and now it is becoming capital intensive. Therefore there is a need for a new management style with knowledge of investment strategy.

Also there is a need to calculate new fee scales, merely charging for the architects time in now less appropriate.
Practice is well on the way to accepting CAD as normal. "Computer aided" will be dropped and it will just be called "design" again.

EDUCATION

The growth of CAD has presented new problems for the education of architects.

There is a shortage of skilled people to teach CAD. Not enough good designers are familiar enough with CAD to teach in studios in architectural schools.

There are many equipment problems. Carnegie-Mellon university and UCLA are rapidly approaching the situation, where each student will have a personal computer on the campus, but this does not solve the problem for architects.

There are different needs for research and for teaching. The nature of computing in research is that it is experimental and sometime unreliable. Teaching in turn requires stable and fast equipment. Also student demand for education in CAD is growing rapidly.

The problem of an intellectual direction for studies in design and CAD is a fundamental one. What exactly do we want architectural graduates to know?

CONCLUSION

UCLA has been involved in CAD for 15 years and has developed an approach to addressing these problems based on the following guidelines:

Computer support: For a university computer is as essential as the library. It must be available on an open access base. If CAD is to be the standard working method this must be achieved although it involves much work.

Computer literacy: Architectural students must not be passive consumers. They must have a rigorous knowledge of algorithms and data structures, not just the ability to write some trivial programs on a personal computer. They should have the computational abilities to produce non-trivial designs.

Professional practice implications: Students need to know the difference between a capital intensive and a labour intensive architectural practice. They also need to have the basic knowledge necessary to do a feasibility study for the acquisition of CAD systems.

Explore CAD as a design medium: If one can assume, that students "know" CAD at a technical level the next stage is that they must reach the point where they forget about the process and think about the problem.

There is a need to confront aestethic issue here to see where they take our designs.

Theoretical foundations of CAD: So far development of CAD has been on an ad-hoc basis just taking up interesting opportunities as they appear etc.

There is a need to begin to formalise the foundations in a rigorous way. This is not an issue of technology, it is one of architecture.

This has recently been recognised by the national science foundation which has funded a research project to be carried out at UCLA next winter entitled "The computational foundations of architecture".

In conclusion there are some parallel developments in the USA where the ACADIA group is the American equivalent of ECAADE. it is a group of teachers with some members from industry. Contacts between ECAADE and ACADIA should be encouraged with good reason.

Finally a word of warning. Tom Maver referred earlier to rivalry between schools and that is indeed sad. However, we should be aware of accepting premature standards and of imposing too much uniformity. We need to take a multiplicity of approaches but Also to meat and discuss the successes and the failures. We should resume a direction of "creative anarchy" for a little longer.

DISCUSSION FOLLOWING WILLIAM MITCHELL'S FIRST TALK

Q: A propos the hardware, how effective are people from architecture in researching the hardware and workstation design?

A: Three of the more important issues from the paint of view of architects are:

- firstly a consideration of the object being modelled

- secondly, turning to the operators, we need to assess the impact of the medium an the form. This could be compared to working with clay as opposed to cardboard etc. In CAD, in solids modelling the objects are polyhedra, the operators are geometric transformations. CAD therefore gives us genuinely new media, this has exciting new possibilities.

- thirdly we need to consider the kind of evaluations we want.

These issues can best be approached by thinking about how we do design, not about technology.

Q: What did you do in the workshop with Charles Moore?

A: We decided to explore some of the formal issues affecting what we could do with the given media. A simple project was set up and then we made studies of elements, mouldings, columns, steps etc. We turned then to address formal questions such as, what is. the universe of objects which we wish to represent?

We then explored light and shade, colour, and proportion using a very good colour raster graphic screen. Charles Moore, like many a creative architect, was "greedy" for the new media to do things that could not be done before.

Q: When you listed things, were they in order of priority? I felt that for each list I would reverse the order. You mentioned looking at architecture in computational terms among other things, either you in the USA are starting at the wrong end or we are (in Europe)!,

A: The order of things was not necessarily in terms of their relative importance but rather in the precedence which you have to tackle them. For example you can't really get students to use CAD until they first have a well founded knowledge of computers, and so forth.

Q: Are there any schools (of architecture) in the USA not using computers?

A: Most schools want to and are trying hard to get people and equipment. Out of 100 schools about 12 have made a "significant impact".

Q: Out of the dozen or so big architectural practices, has the use of computers reinforced "house styles" or led to diversification?

A: Unfortunately it has not led to an increase of diversity. They have tended to use CAD for "production". Expensive equipment needs to be used intensively because of its costs. One can't afford to use it casually. When CAD becomes cheap enough and ubiquitous enough to be used casually then it will become more creative. This will not happen in the third generation financial environment.