The history of CAAD is just 25 years. In that short span of time the subject has advanced from the minority time hobby of a very few academics to a multi-billion ECU industry. This presentation highlights four areas of application of Information Technology to the education of architects and anticipates how these applications will impact on practice.
ADDED VALUE FOR CAAD IN EDUCATION
Highlights of an Exciting 25 Years

History

Three of the origins of CAAD can be found in the work of Souder and Souder, Whitehead and El'dars and ABACUS.

Souder et al made clever use of the first graphics technology. They were able to construct, using a light pen and a circular CRT Screen, flickering images of floor plans of proposed hospital designs. Accessing a database of the typical journeys made by medical and nursing staff on a typical day, the programme evaluated each layout proposed, in terms of total travel time. This pioneering work is an outstanding example of users (i.e. designers) determined to try to use the best possible tools (i.e. CAAD) to improve the quality of design.

Whitehead and El'dars attempted to take the application of the technology a step further; they developed an algorithm to generate floor plans which sought to minimise travel distance. This was the forerunner of many algorithmic methods/programs which paradoxically discredited design methodology and CAAD technology, in the early 1970's.

The Architecture and Building Aids Computer Unit, Strathclyde (ABACUS) came into existence in 1968 and drew inspiration from both Souder and Souder and Whitehead and El'dars. Despite their initial implementation in a primitive hardware/software environment (Tectronix Direct View Storage Tubes/Fortran) the only programs developed by ABACUS still represent the primary poles of CAAD: to generate or to evaluate.

Of course, there are many other aspects of design to which the information technologies can contribute; one of these - computer aided drafting - blossomed in the 1980s and wholly overshadowed computer aided design. The importance of computer aided drafting, to the
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fig 1 - 2
efficiency of architectural practices is well established; we can look forward, hopefully now, to the application of computer aided design to a built environment which is fit for purpose, cost-effective, environmentally friendly and formally pleasing.

The following sections of this paper describe current developments of significance in CAAD.

They are:

i) developments in computer aided appraisal of design
ii) developments in CAL and CBT.
iii) the use of high-bandwidth communication networks.
iv) the concept of virtual heritage.

**Computer Aided Appraisal**

This section gives a detailed account of a 12 week student project to design a Primary School relying very heavily on computer aided design support. It was a requirement of the brief that the design produced by the student should come within the (severe) cost, area and energy consumption constraints set out in the brief. The process of design search was so complex and so closely related to the computer output that it was difficult to convey the process and product of the design activity using conventional drawings in a conventional crit. For this reason, students were encouraged to make their presentation in a multi-media environment.

The multi-media presentation of one of the students, Lindsay Johnston, is in six sections. The **Introduction** explains the intentions and requirements of the project; the section on **GOAL Analysis** explains how she used the CAD software to investigate issues of geometry, construction and orientation; the section on School Analysis is concerned with modelling an existing school; **Conceptual Design** explains how she generated the original idea; **Design Process** explains how the CAD software guided her search for a good solution; and the last section presents her **Final Design**. Initially, Lindsay used the CAD software known as GOAL (which was first devised in 1972 and is constantly being updated and improved) to investigate, in abstract, the impact of **Geometry**, **Materials** and **Orientation** on building cost and performance.
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Fig 3 - 4
The 'benchmark' against which students were required to test their design ideas was Eastfield, an existing Primary School designed to exactly the same brief. Lindsay and the 15 other students in the CAD Design Units input the geometry and construction of Eastfield into GOAL to assess its cost and performance. This level of cost and performance then became the "target" or "benchmark" which the students were encouraged to match or to beat. The students visited Eastfield School in order to assess, by observation and interview with teachers, the qualitative aspects of the design which were not predictable using GOAL. An architect and an administrator from the client organisation - Strathclyde Regional Council - contributed to the briefing process and took part in all subsequent crits.

The concept was developed and a single storey plan form, Design A, produced (Figure 1). She also generated Design B and Design C which are on two storeys. Figure 2 shows the cost-performance profile generated by GOAL of Eastfield against Designs A, B and C.

Although Design A is the most economical, Lindsay develops two further variants of Design C which she identifies as C1 and C2.

She also develops a family of designs identified as Designs D and D1 which again she compares, using GOAL, with Eastfield and with Design A. The detailed cost output from GOAL suggests that the more economical schemes are those with a lower volume. Lindsay then compares the sections of D and D-1 and goes on to develop Design D-1.

Design D-2 compares very favourably with Eastfield (£60,000 lower in capital cost) so she then explores alternative constructions for D-2, arriving finally at a complete specification, in terms of geometry and materials for her final design D-3 (which is £91,000 lower in capital cost).

Figure 3 compares all designs. The buttons on the left side of the Frame allow the user to access plans and elevations of any scheme.

Figures 4 and 5 are part of an animated sequence in which Lindsay shows the detail of her final design for the Primary School - a design judged by her tutors to be superior in form, function and cost-effectiveness that the existing school, Eastfield, which formed the benchmark.

It is clear from her presentation that her search for a good design was informed and guided by the cost-performance predictions of the program GOAL; without the CAD support it would not have been possible to find, and evidence the quality of, such a good design.

Fig 5 - 6
**Computer Aided Learning**

The concept of environmentally friendly buildings is encapsulated in a multi-media document commissioned by GA Design and Build.

GA Construction had a declared commitment to 'quality' in design and build, with a particular concern for energy conscious design. The TCS presented the opportunity to work with ABACUS over a two year period in an effort to establish "what are the life-cycle costs/benefit from energy conscious design and construction and how can improved quality be marketed".

The project was carried out in five overlapping phases:

i) establishment of the basic physical principles which determine the energy behaviour of buildings.

ii) analyses of case material drawn from EDAS.

iii) establishment from the case material of the main design parameters of form and fabric which are likely to impact on energy consumption.

iv) simulation, using the ESP computer model, of the predicted impact of these design parameters in two main building types.

v) evaluation of the life-cycle costs, energy consumption and production of pollutants relating to each design variant.

The core activity of the project was the application of the ESP programme to a wide range of parametric variations on two main building types and the subsequent costs-in-use analyses of each case. The incontrovertible conclusion - which matched perfectly with the prime concerns of responsible building client organisations - was the paradigm that:

"good (computer-aided) design, without costing any more over the life-cycle of the building, can reduce energy consumption and, therefore, the associated harmful levels of atmospheric and stratospheric pollution, by a full 50%".

This whole research project was reported in a specially commissioned multi-media document which includes 6 main sections (Figure 6) and over 100 case studies. It also includes CAL modules which explain the principles of energy efficient buildings (Figure 7).
Fig 7 - 8
This application demonstrates the power of multi-media to communicate, to students, to practising architects and to their clients the complexity, importance and attainability of energy conscious, environmentally friendly building design.

**High Bandwidth Communication**

The University of Strathclyde and Glasgow School of Art are currently involved in a collaborative project which is primarily aimed at exploring the potential of video conferencing over broad bandwidth communications networks using Glasgow's Metropolitan Area Network, commonly known as the MAN. CREDIT (Collaborative Research in Education for Designers using IT), funded by SHEFC, has been initiated by the Schools of Architecture in both institutes, under the premise that resources may be shared by broadcasting lectures, hosting joint design reviews, seminars, and expert tutorials.

To date video conferencing has yet to prove its potential in this field of application. This is mainly due to the constraints of current network technology. Even *Narrowband ISDN Communication* which represents the highest quality of video conferencing technology in general use today is fraught with difficulties caused by lack of network bandwidth, resulting in degradation of image and audio quality to the extent that communication is often disrupted.

The Glasgow Schools of Architecture were hopeful that by using the MAN and ATM (Asynchronous Transfer Mode) communications, most of the reported problems connected with video conferencing could be solved, and at the same time guidelines established for future users.

In application five types of session were run, in order to explore various forms of communication relating to the teaching of architecture. These were:

- Lecture - traditional presentation format using traditional media with a participating audience at both sites.
- Lecture - computer oriented presentation format using video media, where the audience were at the remote site.
- Design review - traditional presentation using traditional media, with jurors and participating audience at both sites.
- Design review - computer oriented presentation using interactive, multimedia presentation tools, with jurors at both sites.
- Exhibition tour - where the participating audience was remote.
At the design stage it was envisaged that the most problematic experiment would be the design review. Traditionally, this comprises a student presenting a design hypothesis using a number of different physical media. It was expected that the introduction of an additional remote jury/audience into this situation which was rich in information types and communication paradigms would push both the technology and the managerial aspects of conferencing to its limits. In practice it emerged to be perhaps the most successful of the sessions, with the biggest surprise being the ease at which drawings and models could be read with clarity from the remote site.

To date the quality of the pictures and sound achieved over the MAN has been exceptional, with full screen, full resolution, s-vhs quality visuals and CD quality sound experienced (Figure 8). The system even supported the use of projected 35mm slides used during the traditional lecture. Feedback from these sessions, has been in general very favourable. The quality of communication having attracted much interest and also the participants' experience of feeling 'involved' with events at the remote site.

The quality of this communications infrastructure undoubtedly liberates the users from the problems incumbent in previous video conferencing hardware. In the past it has been suggested that the negative aspects of struggling with a limited technology base may outweigh the cognitive benefits of having visual communication. The experience of this project would suggest that the technology now exists to support high quality communication.

Virtual Heritage

The emerging technologies of QTVR and VRM offer an unparalleled opportunity to explore and to communicate our historical and contemporary architectural heritage. An important example of this is the current collaboration between ABACUS and Historic Scotland - custodians of around 2000 magnificent examples of Scotland's architectural heritage - and a virtual reality experience of Skara Brae, Northern Europe's most complete Neolithic settlement.

• The objective of the project is the development and preparation of computer based presentational material which can be used to enhance the users understanding of the Skara Brae settlement. Due to a growing concern about the conservation of our heritage and an increasing focus on the need to manage the physical impact of tourism on heritage sites it is not possible to allow public access to all areas of the settlement. The presentation is designed to take full advantage of the introduction of Interactive Media and especially the role of Virtual Reality in mitigating these constraints.
• The presentation sought to place Skara Brae in the context of Orkney's pre-history as well as dealing with the site's more recent history in terms of its discovery and subsequent excavation. Users will be able to explore the village in the company of an expert "interpreter" as well as in an interactive mode. A choice of "interpreter" will allow users to gain an overview of the site from different perspectives such as that of an archaeologist, historian or perhaps an original villager.

• Features of special interest are highlighted and explained. These features can be approached on two levels, differentiating between what experts think is unquestionably true of the village and the life of its people and secondly offering a best guess as to what was thought most probable. The interactive nature of the presentation should seek to encourage the users curiosity and help answer the questions that this remarkable village may have provoked.

• Parts of the village that have succumbed to the ravages of time will be reconstructed. This aspect will explore the methods of construction and materials used. It should be possible to experience a recreation of a part of the village as it would have looked 5000 years ago. A rich collection of objects have been recovered from the site, these will be reintroduced to their original locations and a mechanism should be provided to encourage users to "virtually" touch and handle artefacts.

Because of the perceived need for an experiential approach to interpreting the site it was decided to investigate the potential of QuickTime Virtual Reality, a recent addition to the multimedia developers tool kit from Apple. QTVR is a means of creating virtual environments from photographic source. A typical virtual reality environment is comprised of three elements:

• An object is an interactive item that the user can pick up, turn and view from all angles. Objects can be embedded in panoramas.

• A panorama is a 360 degree image that allows the user to pan and zoom within the confines of the space. A single panoramic scene is termed a node. Hot spots can be defined within each node to provide hypertext links that index associated information or provide access to other nodes within a scene

• A scene is a collection of panoramas linked together by hypertext hot spots. In a multi node scene a user can navigate between nodes to move throughout the scene (Figure 9).
Added Value for CAAD in Education

This technology was well suited to the project for a number of reasons.

- The high level of interactivity that is expected by today's more technologically literate audience (the SEGA generation) is well catered for as is the requirement for an experiential virtual reality interface.

- The quasi organic nature of ruined structures is not conducive to traditional 3-D modelling CAD tools, which function best in a more rectilinear environment, so the photographic approach combines a high level of realism with a relatively quick and easy mode of construction.

- The hardware requirements are at the low end of the technological scale, far bellow those required by VR in it's conventional guise.

- The use of a VR interface simplifies many of the navigational problems encountered in mainstream interactive media. In the traditional format interactive media is structured as a series of hyperlinked pages each containing interactive elements. With a VR interface the context is always apparent, thus reducing the structural depth of the media while interpretative media area always presented at the top level.

- As with many sites, recovered artefacts tend to have redistributed to national museums, virtual media enables the reinstatement of items into their original context.

Conclusion

This paper has summarised four different but effective approaches to the use of information technology - notably computer aided design and multi-media - in architectural education. It is clear that as our young graduates enter the profession we can anticipate a massive increase in the use of the technologies in architectural practice.