SOME SUCCESSES IN THE ENVIRONMENTAL TRAINING OF ARCHITECTURAL STUDENTS.

INTRODUCTION

Thomas W Maver, holds the Chair of Computer Aided Design in the Department of Architecture and Building Science at the University of Strathclyde in Glasgow. His research group ABACUS has been engaged in the application of Information Technology to architectural teaching and practice for some 25 years and he was instrumental in setting up the Energy Design Advice Scheme which now operates in four regions in the UK. Currently he is Vice-Dean in the Faculty of Engineering.

SCALE OF THE PROBLEM

In the majority of developed or developing countries throughout the world, building is one of the largest single industrial sectors, accounting for up to 8% of the Gross Domestic Product and employing, directly or indirectly, 8% of the working population.

Yet despite its scale and importance in the national and regional economy, the building industry is under-developed and dis-aggregated. In the UK for instance, only 6% of contracting firms employ 7 or more people; 50% of architectural practices employ 2 or fewer professionals. The research and development budget of the industry is a meagre 1/2% of turnover. The professional education provision is highly fragmented and Continuing Profession Development opportunities are very limited. Overall the labour force is poorly qualified.

This has a serious consequence for the quality of the built environment. Conservative estimates suggest that remedial treatment of building defects costs the UK upwards of £1,000 million per annum (excluding normal maintenance): some 50% of these defects, it is judged, could have been obviated by better design. In a high proportion of post-war buildings, energy consumption is profligate: UK Department of Energy figures suggest a potential saving of up to 50% through better design of new buildings and 25% through appropriate design intervention in the existing stock.

In response to these challenges, research and development has taken place over the last two decades in the Faculty of Engineering at the University of Strathclyde which has resulted in a number of computer-based models of the energy behaviour of buildings, suitable both for practising architects and architectural students.

MODEL VALIDITY vs ACCESSIBILITY

The simulation of the energy behaviour of buildings throws up the issue which lies at the heart of all modelling activities: what is the appropriate trade-off between the accuracy of the model and the ease of access to it.

As part of its long term commitment to the development and validation of energy models, ABACUS, at the University of Strathclyde, compared the performance of its own advanced model, ESP [1], with a simple model being promoted at that time by the RIBA. The RIBA model generated results diametrically opposite to those generated by ESP (Figure 1)! The dilemma is that:

i) reasonably accurate models are too inaccessible to students,
and

ii) reasonably accessible models are too inaccurate to be useful to practitioners.

The strategy adopted by ABACUS was two-fold:

a) to make the most sophisticated (and validated) first principles computer-based model (ESP) available to architects and engineers through a government subsidised Energy Design Advice Scheme,

and

b) to build a relatively simple computer based model (which exhibited relative rather than absolute accuracy) into a multi-variate design support system (GOAL), for students of architecture.

ENERGY DESIGN ADVICE SCHEME (EDAS)

The UK Energy Design Advice Scheme (EDAS) is a regionally based independent design advice scheme which is sponsored by the UK Department of Trade and Industry (DTI) through the Building Research Establishment (BRE) to improve communication between design teams and experts in low energy technologies applied to buildings. It delivers advice on all aspects of energy effective building design and refurbishment to architects, engineers, designers and building users.

Through EDAS, designers can gain access to simulation modelling at a reduced cost, similarly simulation modellers are linked with designers with real design problems, during the exercise, EDAS provides ongoing technical support. By opening up this channel of communication EDAS creates a two-way information flow between these complementary aspects of building design while underwriting the risks perceived by design teams not familiar with the technology. The creation of these links is seen to have a positive influence on the development of the design process and of simulation models as applied to building design.

To date EDAS has:

• impacted upon over 10,000 new building design schemes in the public and private sector,

• yielded savings of:
  - £14 million
  - 100,000 tonnes of CO2 pollution
  - 1,000 million Giga Joules of energy

Equally importantly, it has made a major contribution to:

• the Continuing Professional Development of practising Architects and Engineers

• the education and training of undergraduate and postgraduate architects and engineers

A major multimedia archive of some 300 Case Studies generated by EDAS is under construction and will contribute to an understanding of the complex paradigms which contribute to an energy-efficient, environmentally-friendly, cost-effective built environment.
THE EDAS MULTI-MEDIA CASE-STUDY DATABASE

Since 1993, EDAS has been compiling a series of paper-based case studies, outlining the advice provided and benefits accrued on a number of projects. These illustrate the process undergone in involving EDAS on the projects, what tools were employed, how they were used and why. The aim is to highlight the benefits of the service, and to encourage designers to make use of the service available.

In order to expand the dissemination routes, and to reach a wider audience, a current initiative is transforming the design advice and performance information generated by EDAS into a hypertext based repository of case studies to conflate the achievements from applying good practice principles and state-of-the-art computer simulation at critical stages in the design process. So far, each case study includes specific design questions; information on the nature of assessments undertaken; the resulting performance predictions and the design advice given (Figure 2). The ultimate aim is to produce a fully interrogatable, interactive database, built-up in layers of complexity and varying interests, to inform designers and clients about key design issues, features and decisions which affect the energy and environmental performance of buildings. The work includes a review of relevant case study exemplars and information sources.

In order to be of real benefit to designers and students, the database must be coherent, integrated, and informative. It is therefore considered critical that a common thread exists. For each project the following are identified:

1. Factors considered to be key design issues.
2. Key features - architectural and energy related.
3. Initial analysis indications.
4. Impact of further analysis.
5. Final Decisions.

At the 'top' level, information held within the database is project specific, it contains project summaries and reports set out in such a way that users can browse similar building types; design issues, climatic information, and so on, in order to identify issues relevant to their own projects. Low energy design principles which were employed are built into each case study as 'hyper_links' which, if selected will lead the enquirer to a different 'layer' of the database. The information contained within this second layer will not be project specific, rather it will provide design information for application on a more general level. At a third level, it is the intention that the database will reveal, for each project, the methodology by which advice was provided, including details of simulations conducted and how this was integrated into the process. For each case study, up to four initial and four detailed level design issues are identified, explained in general terms and analysed in the context of the specific project. Comparisons with exemplars are also made as a reference point. The potential to build-in links to other methods such as simplified design tools or spreadsheets is being explored, as is access to project specific simulation / dynamic analysis 'snap-shots'.

The chosen format for the encapsulation of the data offers the opportunity to add and remove case studies as required. In addition, scope exists to expand the information included for a particular project - by post construction or occupancy re-evaluation for example.

To date, the multi-media database contains around 70 projects, most of which are entered as outline case studies with links to a layer outlining how and why a detailed analysis was conducted, and the aforementioned 'hot words' linking the case studies to more general advice.

GOAL - A DESIGN SUPPORT SYSTEM FOR STUDENTS

The EDAS multi-media case-study database is, of course, a major teaching resource. It is supplemented, in the Department of Architecture and Building Science at the University of
Strathclyde, by a computer-based design support system which attempts to embody all the formal and functional attributes which contribute to a building design which is fit-for-purpose, cost-effective, energy efficient, environmentally friendly and enhancing to the visual environment.

The initial prototype (PACE) [2] evolved into the software known as GOAL, the use of which in teaching was reported at the 1993 ECAADE conference [3]. The (student) designer proposes a geometry and a choice of construction materials, GOAL accesses a number of databases which hold information on climate, unit costs of materials, user requirements, building regulations etc and numerically appraises each proposed design in terms of construction cost, annual energy costs, combined costs-in-use, thermal energy consumption, lighting energy consumption and planning efficiency; additionally the software generates any number of perspective views of the geometry. Related software (GLOSS), allows the "fingerprint" - i.e. the main design and performance characteristics - of every design hypothesis to be recorded and compared. These fingerprint archives provide the benchmark against which each new design can be compared; the more designs which are appraised, the more knowledgeable and useful the database becomes (Figures 3 and 4).

Although developed and extensively used before the terms were invented, GOAL embodies all the characteristics of a "knowledge-based, integrated, case-based design decision support system".

NEW DEVELOPMENTS

Two developments outside the field of architecture have been significant in their impact upon CAAD research and development and, therefore, an energy conscious building design:

i) the emergence from the computer science community of advance hardware and software technologies in the field of artificial intelligence and telecommunications.

ii) a significant increase in design-related research and development across the range of engineering disciplines.

This sub-section of the paper identifies a number of CAAD projects which draw from these other fields.

At Carnegie Mellon University, Mahdavi [4] has developed in SEMPER, the notion of an "open" simulation environment in what he calls a "multidirectional" approach to simulation-based performance evaluation (Figure 5). A preference-based formalisation of design intentions/criteria is used to cope with ambiguities through dynamic control of the degrees of freedom of design-related parameters during the interactive design process. The system, then, has some degree of generative capability.

Mahdavi's work is contemporary with two other developments in the USA. Pohl [5] at California Polytechnic State University has been developing the ICADS system in which it is intended that multiple domain agents interact with each other and with (student) designers to cooperatively solve design problems. Researchers at the Lawrence Berkely Laboratory have been developing the Building Design Advisor [6], a software environment that seeks to support the integrated use of multiple analysis and visualisation tools; currently the system supports a daylight analysis tool, an energy analysis tool and a multimedia case-studies database (Figure 6).

The European Community gave recognition to this area of research and development by funding, over the last five years, the pan-European COMBINE project [7] which has concentrated on the development of an integrated data model which facilitates data exchange between tools and offers tool-tool interaction supervision via a blackboard mechanism.

Current research and development by Chen and Maver [8] at the University of Strathclyde and Georgia Institute of Technology has yielded a prototype implementation of what they call a
Virtual Studio Environment (VSE). The uniqueness of this work lies in its attempt to combine the strengths of several other related approaches, namely the product modelling from traditional integrated design systems, the distributed architecture based on message-passing communications from cooperative design systems and the explicit support for human-human interaction from computer-supported co-operative work (CSCW).

The VSE recognises the importance of maintaining a collaborative context as the basis for design tool integration; this context consists of information not only on the design data and design tools but also on the human designers. The VSE framework links the technical resources with the human resources. Collaboration-aware properties have been added into design data and tool models. The current implementation supports three levels of integration; tool-tool interoperability, automated coordination of tool interoperation and dedicated human-human interaction facilities for semi-automated and informal coordination of the design project. The VSE is currently populated with tools for energy analysis, lighting analysis and cost analysis (Figure 7).

The intention is to re-implement the VSE on the WWW to facilitate its evaluation by interested parties.

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