Introduction

From 1968 until 1982, advocates of Computer Aided Building Design were consistently and vigorously challenged by architectural teachers and practitioners to justify their claims of the benefits to be derived from the application of the (then crude and simplistic) technology to architecture teaching and practice.

From 1982 until the present, advocates of Computer Aided Architecture Design have taken for granted these benefits and have enjoyed a privileged, if provocative, position in architectural practice and pedagogy.

In Paris in 1998 it is timely to re-introduce the challenge, pose some pertinent questions and, hopefully, provide some cogent answers.

Q1: How Did We Get Here From There?

It might be said that in the latter half of the extraordinary “sixties,” computer-aided architecture design (caad, soon to become CAAD) was born from the adolescent parents of Operational Research and Design Methodology. In the UK Whitehead and El'Dars were pioneering generative layout algorithms [1] while Sounder and Sounder, in the USA, were pioneering interactive methods for design appraisal [2].

In the late 60's and the early 70's, effort was focused on the development of computational methods for generating or appraising design layouts in relation to the measurable parameters of design performance (e.g. heat loss/gain, lighting, movement efficiency) and costs (construction cost, recurring cost and life-cycle cost).

A breakthrough was achieved in the latter part of the 70's with the advent of Direct View Storage Tube Technology which allowed the graphical representation of plans and elevations and, subsequently, algorithms to allow the representation of wire-line perspective geometry. For the first time it was possible to model, crudely perhaps, both the functional and formal attributes and characteristics of building designs [3].
Architectural practice seized upon the drafting potential of computer graphics as a means of making the production drawing phase of office practice more efficient; this offered a "safer" use of the technology than did the use of appraisal models which, of course, had the potential to expose poor performances in building design.

In the last decade, with the advent of increasingly advanced hardware and software, 3-D colour modelling packages (3-D Studio, Form Z, etc.) have assumed importance in practice and in student project work. Regrettably, however, the integrated modelling of form and function is not yet established as a design aid in practice or education.

Q2: Where Are We Now?

Q2.1 Computer Aided Drafting?

Highly sophisticated and ubiquitously used in most practices. The increasing sophistication presents problems for its use in student projects but students demand training in the most widely used software systems to enhance their acceptability in practice. Whereas some systems support added functionality, (e.g. AutoCAD), there is little evidence of its use as an integrated modelling facility.

Q2.2 Visualization?

Practitioners and students now have at their disposal software tools to represent, in a reasonably realistic way, how design proposals will look when built [4].

There is, however, little or no commitment to the use of advanced lighting and visualisation software which reproduces, with a high degree of verisimilitude, the actuality of building interiors and exteriors under differing lighting conditions [5].

Q2.3 Integrated Appraisal?

The recent interest within other engineering disciplines in the issues of design, coupled with the outcomes of research and development in applications of artificial intelligence has stimulated considerable development in design decision-making support systems, a number of which have focused on architectural design [6]. Whereas there is some cause for optimism that these will yield positive outcomes in the longer terms, little or no practical implementation seems likely in the near future.

Q2.4 Emerging Technologies?

The emergence of new software developments - from sources within the discipline such as the Media Lab rather than from outwith it - coupled with serious desktop computing power and advances in telecommunication networking, is offering new and thrilling opportunities for architects, urban designers and planners. Recent conferences (ACADIA 97 [7], ECAADE 97 [8] and CAADRIA 98 [9] include papers which report positive outcomes, primarily in the area of communication, co-operation and collaboration amongst all those involved in the design decision-making process.

Q2.5 So What?

After 25 years of CAAD, with all that has gone before and all the current promise, there is next to no evidence that the way we design or the way we teach has improved; indeed we do not yet know how we would measure improvement, let alone evaluate it.

This fact raises some very important questions, not least: where do we want to be?

Q3: Where Do We Want To Be?
First, the hard questions then the easy question:

**Q3.1 What Do We Not Know?**

Despite the fact that design has been a human activity since pre-historic times and an explicit, conscious activity for at least 3,000 years, there is more we don't know about design than we know.

**Q3.1.1 Facts and Figures?**

- we know little, and understand less, about the weather through which our buildings travel in time
- we know little, and understand less, about the properties of the materials which embody the buildings we construct
- we know little, and understand less, about the needs of those who will use our buildings
- we know little, and understand less, about the cost and energy resources embodied within the materiality of our buildings
- We know little, and understand less, about what motivated and inspired all the architects from Vitruvius to Ando who have produced buildings which we admire; we know even less about how they took design decisions
- we know little, and understand less, about ........................................

**Q3.1.2 Cause and Effect?**

- we know little and understand less, about how the orientation of a building impacts on its potential for solar exposure/shading
- we know little and understand less, about how the geometry of a building impacts on heat loss/gain
- we know little and understand less, about how the fenestration of a building impacts on the quality of natural lighting within the building and on its energy balance.
- we know little and understand less, about how the geometry of the building and the choice of materials impacts on the cost of construction, the recurrent costs over the building life cycle, the use of irreplaceable resources.
- we know little, and understand less, about why the computer design decisions taken by architects like and Tombazis [10], yield buildings which work well for people and for the environment.
- We know little, and understand less, about ........................................

Now the easy questions:

**Q3.2 What Do We Need to Know?**

**Q3.2.1 Everything!**

**Q4: How Do We Get There From Here?**

There remains the view, nurtured by at least a few within the CAAD community, that computers are indeed amplifiers of the intellect, not just faster slide-rules or more accurate drawing-boards, and have, therefore, the potential at least to help us address the central questions in architecture design education and practice.
Picasso is quoted as saying "computers are useless: they can only give you answers"; he is wrong, perhaps, on two counts:

i) they cannot even give you answers to anything other than an over-specified questions (of which few exist in the realm of design decision-making) and,

ii) they do, however, help you formulate questions.

An example is, perhaps, useful.

One of the earliest applications of computer modelling to building design (circa 1969) was focused on the energy behaviour of buildings. The earliest models were extremely simplistic, assuming steady state conditions and taking no account of short or long wave radiation. Little innovation existed to make the models more sophisticated: architectural practitioners at that time considered these matters to be wholly in the province of the engineering consultant who, in turn, was content simply to size the pipes and ducts for whatever form and construction specified by the architect.

Fortunately:

i) A few academics retained sufficient intellectual curiosity to continue experimentally to develop computer-based models which, progressively, incorporated the many energy exchange phenomena which take place through and within the building envelope [11]

ii) the political crisis in the Middle East, with the resulting increase in fossil fuel costs, raised the importance of energy efficiency on the design agenda.

Unfortunately, a gap had opened up between:

i) the growing aspirations of architects and engineers to engage in design decision-making which takes proper account of energy behaviour, and

ii) their ability (or willingness) to climb the steep learning curve necessary to use the increasingly complex models of energy behaviour.

Two complementary initiatives have been taken to bridge the gap:

i) innovative use of emerging information technologies intended to "hide" computational complexity by providing intelligent data defaults and multi-media interface to advanced simulation software; so-called "intelligent" CAD (12), and

ii) establishment of intelligent human interfaces between the designer and the software, such as the UK Energy Design Advice Scheme (EDAS [13].

Observation of the operation of EDAS over the ten years of its existence begins to address the question "How Do We Get There From Here." EDAS, subsidised by the UK Department of the Environment, offers an initial half-day free consultation to architects, engineers and their clients and a further full design analysis, if desired, at 50% of the real cost. To date, the four Regional centres of EDAS have conducted around 1,500 initial consultations and 500 full analyses; independent auditing of the scheme has evidenced savings of:

i) 240 MGJ savings in energy consumption

ii) 21k tonnes reduction CO₂ emissions

iii) 28 MECU savings in costs

What is more important, however, in the context of this paper, is the modus operandi of the scheme. Architects and engineers (and occasionally clients) are encouraged to sit at the computer screen with the EDAS consultants, to explore an evolving set of "what-if" questions:

• what if we change the orientation of the building?

• what if glazing on the north facade is decreased by 10%?

• what if a south-facing Trombe wall is introduced?

• what if the set-back temperature is reduced x₀ in winter?
There is clear evidence that during these sessions surreptitious teaching and learning is taking place in such a way that designers are developing wholly new insights into the "cause-and-effect" of energy efficient design decision-making, an insight which can be carried forward to subsequent design commissions.

Currently, EDAS in Scotland is capturing all the case material from its ten year operation within an interactive multimedia resource which is intended to make the lessons from over 100 case-studies accessible to all architects and engineers practising within the relevant climatic zone.

There is no doubt that access to computer based models of the energy behaviour of buildings has, in the UK, saved money, reduced pollution, improved comfort within buildings, conserved irreplaceable resources, enhanced the professional reputation of the architectural profession and restored, to some degree at least, client confidence.

The remaining 64,000 ECU question is: HAS THE CAAD COMMUNITY THE WILL TO WIN SUCCESS IN ALL THE OTHER ASPECTS OF GOOD DESIGN.

References
10. Alexandros N. Tombazis and Associates, Athens, Greece.