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FOREWORD

The Ove Arup Foundation was established in March 1989 in memory of Sir Ove Arup, the Founder of The Ove Arup Partnership, who died early in 1988.

The objectives of the Foundation, which is a Charitable Trust, are “for the advancement of education directed towards the promotion, furtherance and dissemination of knowledge of matters associated with the built environment”, and, acknowledging the contribution of Sir Ove, “with some emphasis of the multi-disciplinary nature of design in engineering and architecture”.

In seeking how best to apply its funds, it became clear to the Trustees that it would be desirable to mount a seminar to debate the present and future of education for the built environment. Firstly, it would enable both those involved in education and those at the receiving end of the educated graduate professionals, to exchange views, thereby perhaps influencing teaching and, secondly, it might provide pointers for the ways in which the Foundation could fulfill its objectives.

During late 1990 we commissioned the Cambridge Programme for Industry to set up the Seminar and we invited about thirty or so distinguished academics and practitioners to participate. We were very pleased that so many of those who were invited were able to come to Madingley Hall outside Cambridge, which provided an excellent venue for the event.

We were particularly fortunate to be able to persuade Sir Eric Ash, Rector of Imperial College, to be the Chairman and we are most grateful to him for contributing immensely to the success of the Seminar.

We would also like to acknowledge the parts played by all those who attended the Seminar and gave freely of their time and ideas. We do not under-estimate the disruption which two days away from one’s faculty or office causes and it says something about the serious subject matter of the debate that so many came and stayed the course.

Lastly, we extend our thanks to the Cambridge Programme, and in particular to Christopher Paxfield, who were in no small measure responsible for the smooth running of the event.

Keith Dawson

December 1991
# Education for the Built Environment

Madingley Hall Seminar Cambridge  
11-13 September 1991

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SUMMARY OF CONCLUSIONS

From Christopher Padfield’s summary of the discussions which took place at Madingley, one can draw out a number of threads which the industry would do well to follow up. Many of the difficulties of the industry were exposed. Among them were:

1. The conflicts imposed by the different time constraints in the long term by the impact of construction on the environment, and in the short term by political and financial considerations.

2. The fragmentation of the professions in the industry and the demarcation between them.

3. The lack of understanding of construction among designers.

4. Our isolationist, or as Corelli Barnett put it, “Britannocentric” aspect. These issues, among others, are real and conspire to make us less successful than we might otherwise be.

Insofar as those who attended, as leaders of our industry, were influenced by others, or confirmed in their views, we hope that they will be motivated to play their part in resolving them. However, the areas where the Foundation can or should play a constructive role are more limited.
There are a number of educational issues which should be addressed. They include the need to adjust the output from courses to give the right balance in industry of technicians and fully qualified professionals - engineers and architects. The lack of research funding and the difficulty of obtaining resources for multi-disciplinary research, again because of fragmentation, is a pervading concern.

Specifically it was suggested that the Foundation could play some part in a number of initiatives.

1. Funding of an analysis of the sociology and practice of the construction industry.

2. The encouragement of multi-disciplinary awareness among professionals by:
   
   (a) persuading schools of architecture to import some visiting engineering teaching, persuading schools of engineering to bring in visiting architects, and getting both to include lecturers versed in modern construction.

   (b) funding a multi-disciplinary modular post-graduate course for architects and engineers.

A detailed analysis of the papers and summary of discussions will reveal other suggestions. Over the next few months the Trustees will consider all these to see where they can usefully play a part.

Keith Dawson
Education for the Built Environment
Madingley Hall Seminar Cambridge
11-13 September 1991

SOCIETY'S NEEDS

Alan Muir Wood and Francis Duffy

ARUP

Sponsored by The Ove Arup Foundation
Organised by The Cambridge Programme for Industry
SOCIETY'S NEEDS
Sir Alan Muir Wood and Dr Francis Duffy

1. Thesis

Acceptance of the second rate in Britain has been a dominant factor in poor economic performance, in inefficiency, which has resulted in all manner of waste, and above all in widespread failure to create tolerable urban standards, leading to all manner of consequential social problems and divisiveness. In commerce and manufacture, failure to build upon the early successes of the industrial revolution has been much remarked (since the mid C19, e.g. Sir Lyon Playfair 18511). Apart from products of war, advanced science, artistic and intellectual pursuits, the absence of concern for quality has been a common factor in British society. It is significant that these three exceptions are in all areas where the free market mechanism, dominated by minimum cost without regard to other attributes, does not operate. Elsewhere, however, British consumers have tended to accept what was offered. It is true that for the individual, consumer-interest interest bodies have made considerable contribution to enhancing expectations for fitness-for-purpose. In some areas

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1 Introductory lecture to the Government School of Mines: England is the only European state not yet thoroughly awakened to the importance of giving an intellectual training to those entrusted with its manufactures.
standards have improved in relation to demand, resulting in a reasonable UK market share in supply, eg. in food, domestic furniture, clothes. But even in these areas continuing British success is by no means guaranteed.

Industry, typically, has reacted too late by which time Japanese and German quality products have already captured the markets. This is the main reason for our manufacturing trade deficit which should otherwise have been helping to finance the improvement of our built environment. The free market mechanism of take-overs or buy-outs of manufacturers, large as well as small, often fails to address the specific factors for success. The consequence is the smothering of enterprise.

In the collective or social sphere, preferences are even more difficult to express in terms of investment and objectives. Our national expectations - and largely achievement - have been second-rate. Examples are public transport, educational buildings, much city development. Are we destined to continue to muddle through? Why are isolated, individual contributions frustrated by collective self inflicted injury?

There is a difference between the judgement of quality by individuals and by society? For personal transactions comparative experience is helped by exchange of views, aided by 'Which' type advertising based on quality. Once higher quality is recognised and appreciated, the consumer expects it as a matter of course. For social transactions, however, it has proved far more difficult in Britain for Government and Corporate consumers to develop the appropriate level of sophisticated judgement. Transactions are large, complex, and relatively rare for each purchasing body. Hence there is little direct comparative experience. Projects are interdependent, with complex and often multiple customer-contractor relationships. Benefits are long-term and, to be appreciated, require predictive capability. The tangible element of cost is unrelated to the more important, but more complex, calculations of value-for-money to that continuity is lost in great projects and aims are readily diverted by political expediency. Social objectives, which are essentially inter-related, are too frequently fragmented, sub optimised, and inadequately coordinated. Expertise, foresight, analysis, synthesis are undervalued. In fact the media
encourage widespread suspicion of such skills to conceal their own ignorance; 'the simple man knows best' approach.  

To reverse these trends and to renew in the built environment a reaffirmation of the role of the Professional (PBE), Architect, Planner, Engineer, is essential. The PBEs ought to be:

- interpreters of requirements;
- guides towards means;
- seers for future change, and coordinator of other elements for success;
- organisers of consequential projects;

but it can hardly be claimed that they are currently fulfilling these roles successfully.

Why is this? What is to be done? Who is to do it? To answer these questions PBE's need first to identify the elements of their own inadequacy.

2. The Fragmentation of PBEs

In private practice, each species of PBE has traditionally retreated behind an actual or metaphorical brass plate, emerging only in response to specific demands. Such responses are often confined to a specialist function or are over-extended to shallow generalisations. No responsibility (other than directly physical) is assumed for consequential effects. PBEs use yesterday's technology and yesterday's products, responding slowly to change rather than stimulating it.

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2 Sir Lyon Playfair (1851). At present England's reliance in the 'practical' or 'common sense' of her population is the sunken rock directly in the course of her agriculture and manufactures.
In the public sector, the responsibility of PBEs has been split between departments, with little coordination and no synthesis of individual and often contradictory objectives. An important issue, overlooked for example by the Fulton Report, is that each climate of work tends to embrace those attracted by that climate. Changing the climate depends on the inherent adaptability of each working population until that population can be superseded. To make things worse the notion of public/private cooperation has been anathema. The sum of optimisation of individual objectives does not equate to the overall optimisation of the sum of all of the objectives.

In the private sector PBEs working for private developers in general have been insufficiently engaged in issues of policy. They have worked as single-project designers and detailers, obeying narrowly conceived commercial criteria.

Fragmentation of functions and of relations between professions has been assisted by separate education and training (from the age of 15!). Each profession has failed to recognise complementary competences. Divisions and the false notions of incompatibility (eg artistry versus numeracy) breed mutual contempt, a subset of the so called polarity between science and the humanities. Research and development have been largely looked upon as the responsibility of government, until almost too late. Unfamiliarity with new materials and processes has at last been perceived as a handicap affecting the Professional’s ability to deliver an optimal product.

3. Reasons for this Failure

What explanation can be given for the educational and professional fragmentation of PBEs, their tendency to react rather than to lead, and their frequent inability to come to terms with Society’s needs?

Part of the explanation is the vastness and complexity of the built environment, the scope of which is measured at one end of the scale by cities — the largest and most enduring of human artefacts — and at the other by such tiny and transient components of design as paints, ceiling tiles and fabrics. The construction industry, of which PBEs are part, seems even more complex and less comprehensible than the object of its intentions - perhaps not surprisingly.
given the huge diversity of sites, technologies, budgets and clients. For project based (and project remunerated) PBEs it has always been difficult to comprehend the importance of time, not just as a dimension of the construction process, but as an inherent feature of the life of all buildings - which are so transient in some respects and yet in others capable of enduring for centuries.

Perhaps simply in order to cope, PBEs are constantly tempted to retreat into what they imagine, within each separate profession, they are able to handle. To each his own. It is significant that architects left to themselves will focus on drawings, planners on proceduralism, engineers on calculation, norms and safety factors. They all expect to tussle with the management of the constructional process but with diminishing expectations of achieving success, related no doubt to the increasingly tense and adversarial nature of the interface with various kinds of contractor and sub contractor. Nowhere in the world have contractual procedures been so elaborated as they are in Britain - and we do not believe this to be evidence of great success in our construction industry. The principal defect is that success is justified by cost and not by volume.

Meanwhile, where are the clients? PBEs, absorbed by their own professional concerns or by the excitement of confrontations with colleagues in the construction industry, have taken clients for granted. Muzzled clients are by no means rare — it is, for example, still considered good practice to freeze changes in client requirements for the convenience of the construction process without need for broader assessment.

It is arguable that even more significant than the PBEs' inability to avoid fragmentation, and their related failure to resist being mastered by stronger forces within the construction industry, is their neglect of Society's needs - whether expressed in meeting popular demands, responding adequately to specific client requests, or anticipating the great societal changes which are shaping our future.

Not unnaturally some clients have reacted by developing their own skills in the procurement of the built environment, sometimes (eg through design/construct) by side-stepping the traditional services of PBEs. Most significant has been the rise of a new profession, the so called Facilities Managers, whose special claim to competence — of enormous strategic importance to PBEs — is the ongoing
management for organisational ends of the vast stock of existing commercial buildings.

It is within this changing and, on the whole threatening, context - with growing evidence of loss of power and status by PBEs - that we address the issue of professionalism within the market economy.

4. The Case for an Intelligent Market

Political extremes lead to the Manichean view that society's needs have to be met either wholly by free market mechanisms or by central planning (eg. Roger Scruton [The Times, 31.12.85]) 'a country where property, profit and advertising dominate the collective consciousness, where law is fiercely adversarial and unscrupulous' is seen as the only alternative to 'the centralised planning of the socialist state'. Such attitudes are wholly destructive to the built environment where planning at all scales and for varying time horizons represents an absolutely essential element, ultimately to be afforded by the surplus value of marketable products. Recent concentration on marketing, accountancy, management — divorced from the particular functions to be managed — has not been matched by qualities of judgment, by synthesis which lead to optimisation, nor by the recognition multiple objectives. For far too many clients, decisions are made on the basis of the cheapest option, in fear of the critical accountant or auditor.

The PBE should have a vital place in the market economy, with the ability to help to transform market aspirations towards the notion of an intelligent market. How to achieve this objective is the main concern of this contribution. Essentially, the intelligent market concentrates on the overall set of transactions that contributes to achieving value-for-money in an integrated manner. The intelligent market recognises that this objective is defeated by applying over-simple market evaluations to individual transactions that should themselves be coordinated towards the main objective. So far as the services expected from the PBE are concerned, two simple truths should prevail:

- The quality of professional service defies contractual frameworks. Time is simply wasted by attempting to do so. While major incompetence may
occasionally become apparent there is vast scope — and in practice
great differences in result — between marginal competence and true
enlightenment.

- The drafting of terms of reference for the work of PBEs involves
  considerable skill based on understanding of the requisite activities and
  phases of work. It is a wise client who evolves terms of reference in
  cooperation with the PBE.

A most remarkable recent trend has been the irrational adoption, by
accountant-dominated project promoters, in both public and private sectors, of
increasing fragmentation of the project and the appointment of different PBEs
for different phases, each at least cost. These arbitrary divisions disregard not
only the essential iteration and continuity between phases but also ignore the
need for the overall operation to be directed with enlightenment, a quality
blighted by the least cost criterion. North American precedents (where the
most obvious defects of such practices are already having to be modified) are
sufficient to make unnecessary the bitter experience of another generation of
decaying domestic achievement before the trend is reversed in Britain.

If PBEs are appointed on price competition, there is an immediate dilemma for
the most talented and proficient. They will be competing against those whose
commercial attitudes will incline them to undertaking the minimum (disengaged
from any wider concerns with consequences) while still showing a profit. Yet
this is the fundamental relationship between the parties in any development
from which the success of all else should flow. The PBE should advise on the
appointment of all other parties, to ensure overall achievement of objectives, as
the agent for continuity and synthesis. In particular, the PBE should be the
source of foresight concerning effects on infrastructure (eg. transport,
education) and relationships with other developments. The over-simple
fragmented market has no place for the professional. In the intelligent
market, the professional represents a key element to success.
5. The Built Environment and the Market

If the Market is to be the arbiter for success, it must be an intelligent market. What are the criteria for applying market mechanisms to the work of PBEs. What are the limitations?

The economic horizon of a market is inversely proportional to the expected rate of commercial return. In consequence, the period against which good city planning needs to be judged is well in excess of the ten or so years which would justify a commercial development. The time-span for such developments may be even shorter when justified by speculative capital appreciation (which if excessive – i.e. ahead of increase of GDP – must in due course be compensated by falling values until the bubble bursts). Adam Smith foresaw market mechanisms being, over time, self-correcting as a result of such effects as ‘civic esteem or stigma’. Development was a slower process at that time. Increasingly today there is a realisation that a holistic approach must be taken to the built environment whereby successful cities or regions compete for commerce, industry, services against appraisals, by present and future potential occupants of the area, of standards of building, resources, amenity, transport, security, environment. It is the achievement and synthesis of these objectives that will define the success of cities in the market economy of the future, on a European (if not world) wide scale of comparative values. While many are now speaking in such terms, recognising the recent exacerbation of urban problems as the direct result of applying over-simple market economics, fewer are prepared to discuss the mechanics for its achievement. But this is the dominant issue for PBEs and Society. Everything hinges on their relationship and on the functions of each PBE within this relationship.

To answer the two questions at the head of this paragraph:

- Market mechanisms must be expected to justify private commercial investment in any aspect of the built environment. Apart from aesthetic/environmental criteria of acceptability, each project must fit within acceptable schemes for future development and conservation, and make an appropriate contribution to the infrastructure. Infrastructure is to be understood as all the ‘service’ needs of the community, including transport, utilities, education, culture, amenity. In this sense a city is greater than the sum of its individual elements. A university contributes
more to a city than the nett value of its buildings and its spending power. Elements complement each other. A community depends on houses, shops, schools, libraries, public transport and many other services and amenities, all in conjunction.

- Many civic developments must be viewed as enabling investments without which further desirable and commercially profitable development will not happen but which, considered individually, would not show a viable economic return. Public transport may be viewed in such a light, with the added benefit of reducing the costs of providing for cars. Attempting to set monetary values on many aspects of environment and amenity is pointless: the methodologies for so doing are contrived and spurious. The likelihood of values, in whatever terms, increasing with time as the successful city becomes more and more attractive, implies that values used in cost/benefit analysis are set too low.

Thus the PBE must be familiar with methods of economic assessment but at the same time be ready to reject them, and to recognise their limitations, according to each context. The faculties of judgment must prevail, with the responsibility of helping those, who in their turn are responsible for the locality, to appreciate latent and potential values.

6. Society and the PBE

The PBE has a responsibility as a professional to give best advice in achieving a client's objectives, by pointing out expected consequences, desirable and undesirable. PBEs should recognise that such consequences may not be apparent to those without the background and training of a PBE. R H Tawney (The Acquisitive Society) describes a profession as being 'subordinated to the community in such a way as to render the best service technically possible ... excluding the element of speculative profit'.

In exercising such functions, PBEs need to assemble teams of diverse talents, with the capacity for:

- creative thinking, a distinctive feature of a professional;
the application of judgement, particularly in reconciling conflicting views between experts. This entails a sufficient overlap in understanding between the PBE and the expert. A gap in understanding is fatal;

- the exercise of a holistic approach, in conjunction with others, recognising that features of a single project need to be compatible with the achievement of wider overall objectives.

Underlying all PBEs' work must be an understanding the needs of Society. To achieve this entails much discussion, the definition of long-term objectives and the development of the ability to listen. There are occasions when PBEs may need to be articulate persuades but only after acquiring confidence in the ability to speak for their local community's perceptions of its interests.

Planning objectives should be energetically displayed, explained and discussed with the general public. Local television, display centres, exercises in public participation all contribute to an interested community - which will also take a greater pride in preserving the good - which is the counterpart of the PBE responsibility to society. Such a concern will lead to good local government justified against the criteria of worthy and imaginative objectives.

7. **Redefining Professionalism**

The functions for the PBE set out above imply large claims which certainly involve PBEs in the politics of change not only in local communities but at a national level, and increasingly within the European Community.

There are two parallel dangers in the opening up of the design process to the consumer: the first is to delude oneself that the veracities of outmoded professionalism will be enough to carry one through constantly renegotiating needs within a changing Society. The second is to succumb to overgeneralised and simplistic pressures of the market place represented by dependence upon the primitive level of 'consumer' information in retailing which has found its expression in The Sun, The Mirror, and the TV Ratings.
Professionalism for PBEs has to be based on something much more substantial than the choice between believing that either we or the public must by definition be right.

The answer must be to build up rapidly the intellectual basis on which professional judgement relies. PBEs are Society's gateway to the construction industry. In order to act effectively in channeling the huge resources of constructional technology to meet the requirements of society, it is essential to build up a much more systematic body of knowledge than is currently available on:

- user needs at every level - and particularly the underlying forces - which are likely to change peoples' expectations, forms of social organisation, ways of working, living, and leisure - all of which are directly related to the substantial use of environmental resources;

- ways of measuring the capacity of the built environment to meet these needs;

- the performance of buildings (and cities) in use to allow feedback not only to improve the design of buildings and building components at every scale from the door knob to the city (the hardware of building design) but also to create more effective facilities management (software) to make possible better use of the built environment for individuals as well as for every scale of social organisation.

Wherever there is a design decision, there is the need to link physical resources to human needs. PBEs will only achieve respect and eventually the power to achieve change if they can demonstrate that they know more about managing this interface than the users of buildings themselves and certainly more than the vendors of real estate or buildings and building components. Only through maintaining an autonomous, constantly renewed, continually validated body of knowledge about buildings, building users, and buildings in use will PBEs be able to justify the free exercise of their professional judgement.
8. Education of the Parties

Given such a starting point there is every opportunity to educate individual as well as Corporate Clients. There will be just as much need to educate the Public Client in the best use of the Built Environment. Clients should be helped to acquire the distinguishing features of HM Treasury's definition of the 'Enlightened Purchaser', a role complementary to that of PBEs acting in the knowledge-based professional capacity, described above.

A particular defect of central and local Government is that issues are discussed and decisions made predominantly at departmental level. Extremist views in politics have promoted a polarisation in attitudes but even in the most unpromising environments, experience demonstrates that, once superficial cynicism is overcome, local issues presented in a sufficiently coordinated and holistic framework can help to develop a much more widely shared set of attitudes towards the community interest. The essential issue remains that of identification of the intelligent market against which changes to the built environment need to be tested, and an understanding of the essential symbiosis between commercial property and quality of life which the built environment can promote or obstruct.

PBEs need to acquire a wider appreciation of the factors that lie outside their particular disciplines, be able to synthesise knowledge across disciplines and be prepared to apply techniques of appraisal of alternative solutions to problems. PBEs also need to understand the nature of innovation, the contribution to be expected from R and D and how to contribute to such work. Demands on the contributions expected from PBEs by the enlightened purchaser should be such as to provide the stimulus for the sponsorship of R and D by PBEs in order to retain the ability to innovate and to be in touch with the innovations of others. Reduced government support of R&D could indeed be justified if government conformed to its own definition of the enlightened purchaser and rewarded PBEs for their own efforts towards innovation and reliability.

The role of PBEs should be transparent for both the public and private client, subordinating personal interests to maintain an objective view of the interests of other parties. Above all, PBEs must communicate clearly, using language appropriate to their audience. Professional predilections should not be cloaked in mystery to enhance respect.
If PBEs are fully and successfully to satisfy Society’s needs, the systems in which they need to operate must be understood, and each element fitted to its particular task. The potential competence exists. However the successful mobilisation of all the intellectual and physical resources of professionals within the building industry requires radical changes, in the directions outlined in this brief paper.

9. Practical Next Steps

Given such a reorganisation, such a knowledge base, and such a commitment to both the short and the long term interests of the user, PBEs could be in a position to:

- educate the client;
- initiate new ways of working which are less supply-side dominated and far more consumerist;
- adopt research-based, and thus testable, positions on matters of local regional and national policy;
- resist market-driven pressures towards short-term solutions;
- integrate the several disciplines and resources concerned with the future of the built environment;
- lead the planning process at every level.

Too often, when reforms are advocated, the complexities of relationships to be affected by the reforms are overlooked. Fruitless attempts are made to change isolated factors, instead of addressing the system as a whole. In the present context, we have identified several systems as well as the interlocking reforms which must be coordinated if the desired benefits are to be achieved.

For example: PBEs need to give greater emphasis to innovation resulting from R and D; for benefits to be perceived in making such investments:

- Those who commission services from PBEs must measure the benefits on capability rather than a price;
- There must be improved linkages between those want the research and those who shape the research programmes.
As another example:
Development of the intelligent market for a locality requires an integration of economic, environmental, ecological, and amenity factors so that appropriate infrastructures may be planned in the wider competitive model. To achieve this:

• these must simultaneous changes in local government politics and administration. Equally important is the education of the local community and far more effective communication between the public and politicians.

• PBEs must play an essential role in defining ‘the art of the possible’, in helping to shape ideas for the future and in ensuring their practical achievement.

In summary, if PBEs are to achieve their full potential, the relationship between them and Society must be intimate, complementary, and complete.
Education for the Built Environment
Madingley Hall Seminar Cambridge
11-13 September 1991

ARCHITECT AND ENGINEER
M J Long

ARUP
Sponsored by The Ove Arup Foundation
Organised by The Cambridge Programme for Industry
ARCHITECT AND ENGINEER

M J Long

1. Introduction

I shall declare my hand at the outset:

In my own experience, sooner or later on every job, there has been some measure of misunderstanding between the architect and the services engineer which has led to frustration on both sides and often to compromises which have had a direct effect on the quality of the built building. From conversations with other architects and engineers, I do not believe that my experience is in any way unique.

Architects, as coordinators of the design team must address this problem, and I have lately become increasingly interested in looking at it.

Clearly in the last couple of generations, the scope and specialization of the mechanical and electrical ingredients in buildings have grown enormously, and this has led to a shifting set of relationships within the design team that may not have been sufficiently recognized.
I would like to address two aspects of the relationship between architects and services engineers:

- The need for them to be explicit about the strategic aims of their combined efforts

and

- The need to find ways of structuring their design tasks to achieve those ends.

2. Strategic Aims

It is of course difficult for a team to make coordinated design decisions if the strategic aims of the design task are not explicitly clear to everyone working on it. Architects may be guilty of taking for granted general intentions for the building that have not been adequately discussed with the other consultants. It is important to find some space for such general design discussions at the outset. And then there must be some structure (perhaps a question and answer format) through which the strategy becomes clear. Without being too proscriptive, it would be worth looking at some of the questions that might be asked. They could take the form "Is the building a this or a that? Because through juxtaposition of opposing pairs of ideas, the strategy and its implications are clarified. The following list of pairs is illustrative rather than exhaustive.

3. The Duck v the Decorated Shed.

Robert Venturi’s terms have been taken by a couple of generations of architects to represent approaches to buildings demanding a very different collaboration between members of the design team. The duck - a one-off building shaped for a particular use and expressing its volume and its function on the outside, demands an integration of structure, services and cladding. In the decorated shed, the structure, services and cladding each occupies its own territory and can be seen as more independent from the others. If the architect is designing a duck and the services engineer is working on a shed, they will both be profoundly frustrated.
It is a situation that frequently results from the natural inclinations and background of architect and engineer - the former often interested in unique sculptural form (which can mean re-inventing the wheel) the latter in assembling standard components.

4. Assembled v Subdivided

The designer can imagine that the building is assembled from a series of parts each of which has anatomical integrity, or is created as a large unit and then subdivided. A number of architects (most poetically represented by Louis Kahn) have insisted on the identification of the unit of space with the unit of structure. In this architecture, each space should be defined by its own four columns or four structural walls. The role of the distributary systems for air, electricity and water in such a cellular model of architectural space has to be very carefully thought out, and it was over these systems that Kahn himself had most difficulty in his buildings.

5. Specificity v Flexibility

No word in modern architecture has been more misused than flexibility - it has too often been believed in a hazy way that to provide 'it' makes anything possible. In fact those of us who have struggled with the notion of flexibility know that there is nothing general about it at all - if it has any meaning in architecture it must be carefully contrived to provide variability within a limited and highly specific range (and budget) - otherwise what is achieved is a building in which nothing works well. A detailed and explicit strategy must be worked out between the architect and the engineer.
6. Mass v Weightlessness

The relationship between modern architecture and modern manufacturing processes has never been very clear, but the tendency of machines to get smaller and lighter as they advance in efficiency has suggested a similar test of efficiency in architecture. Buckminster Fuller even demanded to know the weight of a building for this reason. As buildings became slimmer and lighter, new 'systems' had to be invented to replace the capacity of mass walls to deal with excess heat and light. As Rayner Banham pointed out, steel and glass buildings required the development of brise-soleils and air conditioning.

7. Generalisation v Specialisation

The replacement of the old systems of environmental control (in simply serviced massive buildings) with sophisticated systems of control in carefully tuned lightweight buildings produced a new breed of specialists. It became virtually impossible for a single designer to produce a workable environment, and difficult even for a single individual to coordinate the efforts of a team. Without knowledge in a variety of specialist fields, lateral thinking and real architectural invention became difficult on large buildings. Conscious effort is needed to make constructive use of all the 'experts' towards a real design solution. Experts can also quite naturally tend to protect their special field of expertise and its importance; and as a result, our buildings are often over serviced, over lit. This tendency became clear to us as a result of energy crises, and the services engineer took on a new specialist role as energy adviser.

8. Interlinked v Separate Responsibility (Liability)

Court cases dealing with liability in the construction industry have increased in number, and we have learned to be careful about the interfaces between realms of responsibility. We must be clear about the extent to which we let this influence the design strategy for a building. It could be contributing to the tendency to separate structural, architectural and services design responsibilities which may in turn lead to a kind of architecture answering to legal expediency.
9. **Cheap v Expensive**

The implications of budget on the building should be felt in an equivalent and integrated way by all disciplines. This requires an explicit agreement between architect and engineer about where the money can most tellingly be spent.

10. **Long Life v Short Life**

The intended life of a building profoundly affects the relationship between construction and services because the life of constructional elements is potentially so much longer than that of the services components. The longer the building is intended to last therefore, the greater its obligations to deal with changes and ultimately complete replacement of its plant.

11. **One Style v Another**

The 'English Free School' - Norman Shaw, Lethaby, Voysey are thought by many to have been England's special contribution to international architectural thought. They were interested in developing an asymmetrical and irregular order of building anatomy based upon an examination and dramatization of the pattern of use of a building. In the '20's Lethaby bemoaned the return to Beaux Arts design with its symmetrical wrapper and inarticulate massing - bearing no relationship to its anatomy of use. It is an argument which is again familiar.

12. **Technical Pragmatism v Technical Style (America v Europe)**

When I first came to England from America in 1964, I was puzzled by the Archigram publications then making the rounds. As one who grew up with disposable 'Dixie' cups littering the landscape, I could not understand the romance of calculated obsolescence. Americans grow up with a pragmatic and make-do attitude to their physical surroundings. Technology is a familiar servant. In England (and Europe) technology seems to have a mystery and romance about it. Archigram could never have happened in America.
There were no megastructures in America except for one or two very late European recolonisations. And Norman Foster and Richard Rogers could not have happened there. Technology as the basis for architectural style, rather than as the servant of construction, is a European idea.

Dichotomies. Choices. Each of them has a direct bearing on the relationship between construction and services, and the philosophical basis for that relationship must be understood by all the contributors to the design - at least as far as it affects their own work.

13. The Design Process

It would be easy to believe that designing involves making a sketch and then making the sketch work (justifying and confirming it). Students spend a good deal of time designing in this way. I believe that a much more constructive model for the design process is Karl Popper’s description of scientific method; you make a hypothesis, and then you test it. You test it (if necessary) to destruction. And if it survives that process of critical judgement (refined - transformed perhaps in the process) it has value as an architectural idea and becomes the touchstone against which detailed development continues through further testing.

Attempts were made in the ’60s to subject the design process to rigorous analytic techniques but these never proved useful in the synthetic operation of design. The judgements involved in the design process are not about linear logic, but about value, and the system of values against which these judgements are made is related to the kinds of issues raised in the previous section of this paper.

This brings us back to the design team. An architect working on a small job on his own is well able to manage the complexity of this operation, because he has all the variables in his head. But a larger building requires a larger team, and the process becomes cumbersome. The ‘first idea’ in the design process can come from a variety of sources. It can be an idea about environmental control; it can be a diagram of functional relationships, or constructional logic or civic symbolism.
The final design must deal with all those issues and more but there is no single ‘correct’ order in which they should be considered. The system of logic that links these variables is not a linear one, although each in itself may be susceptible to linear reasoning.

It is usually the architect who makes the first move. He is usually also the one who coordinates the ‘testing’ process. In order to do this effectively on a technically complicated building, he must develop a good understanding with the engineers on the team. Otherwise the redundancy of effort (which is to some extent inevitable in design) will begin to take up too high a proportion of design time to the frustration of the whole team. Good knowledge of each discipline involved is important, but there are bound to be limitations of knowledge in others’ disciplines. The hypothesis and its underlying principles must be clear to the members of the team and must be used as their criteria for testing it (developing the scheme). It is no good testing an architectural proposition with single line mechanical diagrams if the proposal stands or fails on the detailed three dimensional knitting of services. On the other hand it is not wise to expect three dimensional services coordination drawings if the terms of engagement do not allow time for such an exercise.

The members of the team must be clear about the timing of decisions in each discipline. Services issues cannot be left so late that the spatial character of the building is changed by late dimensional changes in services, but equally the architect must not, through nervousness, ask too much detail of the engineers while changes in design continue to make that work abortive. Some information will not be available until shop drawings appear, and the program for design decisions must therefore extend into construction.

The distinction between Architect and Engineer is actually not very useful here. The real distinction is between the development of the hypothesis and its testing, between strategy and tactics. Both Architect and Engineer can do both - it is a question of agreeing roles and the structure and programme of decision-making at the start, and being alert to the need for change along the way.
I believe that there are three specific and inter-related issues that have to be addressed in scheduling and defining the scope of work for the architect and services engineer.

- Having established the general design strategies (as described in the previous section), a program for specific decisions will have to be worked out. In some kinds of building, detailed three dimensional coordination can wait much longer than in others. The more 'integrated' the construction and services, the earlier the information is required.

- Responsibility has to be assigned for each task. In some cases it may be sensible to assign detailed three dimensional coordination to the architect, in others to the engineer. This may depend both on the type of building (how dependent it is on the specific appearance of services elements) and on the relative expertise of the individuals. Detailed drawings can be produced by the architect, the engineer, or the contractor or by a combination of all three. The way in which drawings are produced in each office must be taken into account in making a decision.

- The allocation of fee must reflect the agreed disposition of tasks. What is required is a coordinated attitude to fee by the entire design team. At the moment this is not easy because the architects and engineers are usually appointed separately and negotiate separate fees based upon the recommendations of their professional bodies. In offices that combine all disciplines, an overall fee can be negotiated, and then the amount of time spent by each discipline can be appropriate to the individual building. Something like this would be a constructive move generally - an overall fee should be agreed for a specific list of services by the design team. It could then be allocated to individual contributors to the design effort in relation to their agreed tasks (which will vary from building to building).
It is important to both consultants and clients that the relationship of fee to their tasks and the overall cost of the building be clear. It is important, for instance, that where the design team sees the need for detailed services coordination drawings during the pre tender period, the fee should be available for this to be done and the extra money at that stage should be understood as an investment to be repaid in reduced contractor costs (due to reduced drawing office commitment for the contractor).

CONCLUSION

I have concentrated specifically on the professional relationship between architects and services engineers and on the need for a more explicit structuring of the framework within which they make design decisions.

I have not drawn any conclusions about the implications for the education of architects and engineers, but scrutiny of their professional relationship leads me to support two points made in the papers on education; first that education need not try to homogenize the backgrounds architects and engineers but should build on their different talents; and second that education could usefully elucidate the difference between strategic and tactical decision making.

The Arup Foundation could be very useful in cutting across the barriers between different disciplines, and I would hope that over the next few years it might invest in a detailed follow-up on some of the issues raised in this paper.
Education for the Built Environment
Madingley Hall Seminar Cambridge
11-13 September 1991

ENGINEERS AND ARCHITECTS

Tony Marriott

ARUP

Sponsored by The Ove Arup Foundation
Organised by The Cambridge Programme for Industry
ENGINEERS AND ARCHITECTS
Mr Tony Marriott

1. Introduction

In attempting to write about this subject I find it rather like trying to map the world. Maps of the world tend to be centred on the location of the map maker, and mine does as well. I have tried to put it into some sort of context and then considered the people and how they function. I have tried to open up a few issues and make some suggestions, but I hope that this will be seen as a background and as the starting point for discussion. I am well aware that there is much of the world not visible from where I stand and also that some territory which is familiar and obvious to me may not be obvious to everyone.

2. Some Context

In most fields of activity where designers are found, they produce something which is made completely before a client (customer) appears on the scene. The customer, therefore, has the opportunity of seeing, feeling and if he chooses, testing a number of competing products before committing himself to any of them. This is not the case with buildings. Commissioning buildings is much more akin to commissioning creative works -- music, painting, sculpture or even papers for a seminar, and the client is more a patron than a customer.

There is a great deal of trust involved on both sides of this sort of relationship. The outcome of commissioning any work is by no means certain, and the outcome of commissioning a building has additional degrees of uncertainty. It is a prototype, as is a concerto or picture, but it is conceived by a team (at best) and
realised by a plethora of organisations deploying a small multitude of people most of whom do not need to have each other's best interests at heart.

In recent years there have been strenuous efforts in some parts of our industry to reduce the uncertainty, some based almost on the premise of failure and concentrating on an easy method of allocating blame and punishment. They may, in desperation, be thought necessary, but will always be a negative influence. They should be made unnecessary. Our challenge, surely, is to be able to deliver to our patron the work he has commissioned with the reliability of the technical outcome axiomatic and with the artistry and craftsmanship of the engineering and architecture better than he could have hoped.

The people who will bring this about, now and in the future, are engineers, architects and quantity surveyors, educated, trained, inspired and guided by people very similar to those attending this Seminar -- us.

3. Our people and how they work

They will be working in a matrix of teams; one axis being their discipline base, the other the project team, often put together on an ad hoc basis, containing many disciplines. Indeed the project team will, for much of its life, consist not just of "designers" but of "contractors" as well. It may well be that there is less of a shared culture between architectural and engineering designers than between designers and contractors in a similar discipline. It is, of course, naïve to think of architects as arty and engineers as scientific, or architects as explorers and engineers as problem solvers or as opposites in any other way. Naturally there will be some innate differences in their preferences and priorities which lead them to choose their career in the first place, and their education at secondary and tertiary level does tend to direct them into different patterns of thinking.

When differences lead to a reduction in respect for, or a lack of trust in each other, the design suffers. When the alliances are stronger between designers and contractors in a discipline than between designers across the disciplines, the effects can be insidious and far reaching. At the same time, there must not be an adversarial attitude between designers and contractors if the best of everyone's ability and experience is to be applied to the project.
Almost certainly, some team members will not have been educated with this industry in mind, but will have made their choice later. They will therefore bring a different viewpoint which is a potentially enriching ingredient to the very complex mixture.

The ad hoc nature of the usual project teams makes is simultaneously very important and very difficult for the team members quickly to get to know each other’s way of thinking and working. It is, in chemistry terminology, likely to be a mixture rather than a compound. As chemists will tell us, the result is that the properties of the constituent elements remain unchanged. Even catalysts have no effect on mixtures.

The most crucial decisions -- those that set the strategy for the building -- are made in the early stage of a project and if they are to be integrated decisions they must be taken by people who are working in concert. It is important in an activity like this that everyone has a secure professional base and frame of reference. From such a base a young designer can confidently embark on excursions into the unknown with the knowledge that he will always receive help, reinforcement or redirection without loss of pace or face. It is also important that the young designers have some knowledge of settling into project teams with the social skills that make it a pleasant experience.

Of the people making up these teams, the architects, structural engineers and quantity surveyors will have been educated fairly specifically for this industry. The majority of graduates in those fields will be designers, which poses the first problem. Only a small proportion of them will be good designers. What should happen to those who are not very good at it? In normal times the supply and demand are reasonably well matched, so there is usually space for the mediocre or worse. There are many buildings which appear to be completely untouched by genius, and too many which appear even to have been avoided by the mediocre. It is not good enough to have pieces of our children’s heritage produced by duffers, even though it may make good business for demolition contractors.

There are not enough mechanical or electrical engineers educated in this country to satisfy the needs of the home market, let alone the steady export trade in them at which Britain is still productive. There are so many fields into which M and E engineers can go that very few of them think about this industry, though it
does seem to be sinking in gradually that this is the only part of the engineering industry where someone can develop his own concept, generally in the company of interesting people, right through to signing it off on behalf of a satisfied client. There will, of course, be a number of Building Services graduates who will have chosen the industry, but numbers on these courses are small compared with the need.

This, then, is the area where recruitment has traditionally been most difficult and consequently where it has been most difficult to raise standards. The professional Institutions have gone through enormous changes in the last twenty years, the entry standards are at last on a par with those of the other professions, but it will be a long time before the culture change works its way through the working age population. There is still time to avoid losing the best of the old while welcoming the best of the new.

It is very welcome that the educational standards of M and E engineers, their confidence and ability to advocate a cause on the basis of reasoned argument are now much closer to those of the other professions than they were. As the demand for climate control, energy efficiency, communication convenience, security and so on has grown, the work of the M and E engineers has become ever more crucial to the performance of the buildings. It has become a major consumer of the budget for the man-hours making up the designers’ costs and for construction and operation of the buildings. Services also consume a considerable amount of the volume of a building and are subject to the greatest adaption to suit changing uses or standards. As a consequence mainly of the explosion in electronics in the last fifteen years, the M and E engineers have had to absorb much new technology and be confident and competent to put it to good use. It is all very exciting.

The design dialogue is now much more between architect and services engineer than it used to be, and much less between architect and structural engineer. Sometimes, indeed, the spatial organisation within a building is developed by services and structural engineers, with comparatively little involvement of the architect. Good architects remain central to these and virtually all other design discussions, but the shift is significant and has wide ranging implications.

The situation, therefore, is that the most crucial discussions at the formative stage of the project take place between people who may have known each other for...
some weeks only and who have little or no shared experience. In those circumstances it is very easy and tempting to let discussions proceed along safe paths and for another standard solution to appear.

It may not be advisable for discussions to proceed along dangerous paths, but standard solutions bring no progress. Innovation always has the delicious scent of danger which, in the right company, can be very stimulating for everyone. Innovation usually results from the particular chemistry between client and designer and between designers. It is usually also at the edge of the innovator's field of confidence and well within his field of interest. What we need, therefore, are people with as wide a field of competence and interest as possible.

The trouble with University education is that it is so short. There is so much to learn and so little time that it must be selective. I believe that it is a waste to have time consuming exercises to try to rub students of engineering and architecture against each other on what must be a notional project. The time is much better used to give them a more fundamental understanding of their own technology. Engineers who can get on with people (an essential quality anyway) will get on with most architects, and vice versa. In any case, new graduates should never be sent off unminded to put a scheme together. Traditionally the apprentice was under the wing of the journeyman who introduced him to life as well as giving him the wrinkles of the trade. The same is true in our business. It is much more difficult in an office to teach a new recruit the technology which he has missed on his course and the chances are that he will never pick it up properly.

I therefore worry about courses that are too vocational. By concentration on what is immediately relevant, they teach yesterday's technology and are likely to miss out on the more peripheral concepts which are so often the key to innovation. They limit the individual's field of understanding and confidence. The continuing retreat of architects from technical matters (including detailed design, in many cases) and the increasing reliance which many engineers and architects place on "specialists" is damaging, deskillling and, in the end, unproductive.

4. How we should work

All creative activities are an intimate blend of art, craft and science. It is impossible to think of a conceptual composer, artist or author. They are
immersed in the whole process, from the first idea to the final realisation. Engineers and architects cannot properly operate differently. At least painters and authors are in control of the whole process, but composers suffer similar problems to building designers -- somebody else is going to interpret "the drawings" and a set of tradesmen who have probably never met the composer, and may have been hired for the performance, will realise the concept. It is essential that the system of passing instructions is unambiguous and that, if the composer is not to be disappointed, he knows what can be achieved by each instrument and conceives the work within those constraints and opportunities. Engineers and architects are in at least as complex a situation. They must be educated as far as possible to deal with it, and trained and guided to deal with the rest.

People are most likely to have the confidence to try to break new ground when they know that they are in good, stimulating and trustworthy company and if they know the explored territory thoroughly. Great music is made by the inspired breaking of the established rules, and so is great architecture and engineering. To be able to break the rules creatively and successfully, it is essential to have absorbed completely the concepts that lie behind them. It is just as essential to know how things work in practice and the tolerances that must be accommodated. Nothing in real life behaves as simply as questions in examination papers would lead one to believe. Buildings have to be made of real materials and components, put together by human beings, frequently in the wind, rain and mud. What other product is made under such conditions? Worried? Read on! Not understanding the real behaviour of materials will lead to unrealistic expectations. To take some trivial examples, concrete slabs are not level, plasterboard is not flat, light output from a lamp is not uniform or constant, the length of a heating pipe is not constant, ductwork is not airtight and nor is cladding.

If our designs require them to be so, we are doomed to disappointment, so is our client and so are the people who build the buildings. They also have feelings and pride. Individual manufacturers and contractors are good at some things and not at others. If we do not understand their strengths and weaknesses we may well ask them to do things they are not good at and the results will be predictable. The "light trolley suspended on a thin string on a smooth plane at a uniform angle" mentality in real life leads to tears before bedtime, and should be abandoned before the age when bedtime becomes self controlled. If the successful
technical outcome of our projects is to be axiomatic, we must know how things work, how big and heavy they are, just what they do, what they cost, how long it takes to make them, in what order they are to be erected and much more. Consider what has to be done in order to answer the simple question of whether co-generation is worth while, or the even simpler question of what the structure should be made of.

The worst worrying thing is that I believe that the question of what the facade or finishes should be made of is likely to be answered with little or no reference to the previous two questions or even to what the occupants will be doing in the building. The vastly increased range of options available from many parts of the supply industry poses serious problems to us. The greater the choice the greater the rigour required in the choosing and in understanding the options. The load that is placed on education and then on training and guidance once the individuals reach real projects is heavy and increasing. We must carry it with confidence and enthusiasm.

We must, in my view, be prepared (by which I mean both able and willing) to engage each other in establishing just what the buildings are about. We must also never forget that they are never our buildings, even though a piece of our lives is in every one of them. They are our clients' buildings and we must winkle out from them what they expect or hope. Many of our clients will never have commissioned a building before and we must be willing to help them through the process to get what is best for them -- after all, that is why they have chosen us.

Conclusion

It would be foolish to think that the discussion could be concluded. It will be heartening to feel that it is opened up without entrenched positions, so I shall declare the extent of my entrenchment as a prelude to the debate.

If I regard (as I am frequently exhorted to do) the world as being made up of providers and consumers (or users), then I am a consumer of graduates in engineering and architecture. I hope that I do not consume them, or even use them, but welcome them to an exciting world, full of risk and challenge and with many more triumphs than failures. However, I am on the receiving end of the education process. What do I wish to purchase?
I do realise that I shall receive a partly formed “product”, whom it is up to me to fashion into someone better than I am.

Don’t send me people who see engineering or architecture primarily as a route to management -- I can buy dozens of them already, and pretty dull they are too, by and large. The people I want will be interested in the success of their projects and will come to the essential management of them from the right direction.

I want new graduates to have an understanding of a wide range of concepts in their field and of some in the surrounding ones as well. I want them to have a good practical grasp of the effect of realising those concepts and enjoy the rigorous thinking and discussion and sheer hard graft which is needed to wring the utmost from every opportunity.

I want them to be proud of their profession and determined to excel in it and to contribute as widely as they can to whatever is going on around them. I want them to have been excited and inspired by their teachers and to want to do marvellous things and mix in with whatever is happening.

Above all, I want people with minds like blotting paper, who will have a theoretical framework better than I had (or have, if possible) who will stimulate and challenge me. I do not want them to make me feel comfortable, and I promise to do the same for them.

To the teachers reading this I would say that all you have to do is to provide them. Excite and inspire us as to how the Foundation can help.
Education for the Built Environment
Madingley Hall Seminar Cambridge
11-13 September 1991

EDUCATION, RESEARCH AND TRAINING

Philip Cooper and Roger Stonehouse

ARUP
Sponsored by The Ove Arup Foundation
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1. **Introduction**

As we contemplate the words which make up the title of this conference and of the paper we have been asked to prepare, the eternally repeated question of Professor Joad of the B.B.C.'s Brains Trust continues to rebound through the ether and is once again called to mind. The question that begins 'It all depends on what you mean by and here we may insert 'education, training, professional, research, or built environment, etc. etc.' though not perhaps the ultimate Joadian 'mean'.

How we suspect Joad would have enjoyed the latter part of this century when so many supposed verities and certainties of so many aspects of our culture and society, often with their roots in the nineteenth century, are increasingly called into question; not, of course, that this is a new game. Questions about the relationship between engineering and architecture; engineers and architects; education and training; professionals and the society they serve; the individual, society and the built environment; and the natural and the built environment all have long historical perspectives. Arguably such questions begin with so called primitive man for they betray deep concerns about the way we think and about the way we make the world both in the act of perception and the act of construction (both these acts being closely related as acts of ordering). As such these are questions about how we dwell in and with the world; not just the 'natural' world (in itself a relatively recent concept) but the built world, the social world and the world of ideas and beliefs. Each age reconstructs and redefines these questions in its own image both at a deep epistemological level as we learn for instance from the philosophy of the history of science and art and also at an everyday level as we may see in more prosaic but nonetheless informative histories of art, science and architecture.
We start our paper in this vein, not to lend some spurious gravitas but to indicate our belief that the question of 'Education for Professionals for the Built Environment' must be seen in the broadest sense of tackling and redefining questions of the relationship between man and society and man and nature. The current definitions of these relationships (and consequent social/cultural patterns) largely have their roots in the eighteenth century. However, the vast and accelerating technological advances with their consequences for good and bad in every aspect of our individual and communal lives have led to estrangements between the individual and society and between man and the built and natural environment, and essentially to the need to reconsider the ways man may dwell in and with the world and with each other. W.R. Lethaby defined the central problem clearly in 1911 when he wrote 'before one knows how to build one must know how to dwell' (ref.1).

The problems which this conference is addressing are symptoms of much deeper and more widespread problems of dwelling in all aspects of our society - in medicine, the law, agriculture, education, the arts, politics and economics, for instance.

There are no immediate answers to these problems, neither are permanent answers possible for any answers can only be culturally specific and therefore temporary. However, we cannot wait for the answers before suggesting ways forward because we, in this instance as building professionals, are inevitably part of both the problem and the answer. At the very least we must recognise that we are making proposals for education in an imperfect world in order to equip those whom we teach to question, to evaluate and respond, and to work for change. If we are to discover ways of living in harmony with ourselves, with each other and with the planet and not to prolong and propagate destructive ways, then this questioning must be at the deepest level. This is neither an argument against progress per se nor in terms of technology. It is an argument for having a clearer understanding of the world about us and our relationship to it. If we take just one example; energy conservation in the heating of buildings should be seen not just as a limitation of the use of fossil fuels and consequent pollution, but through passive energy control and solar heating as a stimulus to means of enriching relationships between the inside and outside of buildings and thereby of our 'dwelling' with the climate - the true antidote to sick-building syndrome!
2. **Scope**

Like all good designers we will oscillate in our paper between the profound and the prosaic so that each may test and inform the other.

The phrase "professionals for the built environment" covers the most formidable range of disciplines. The recent television programme on the new terminal building at Stansted Airport revealed some of the people who played a part in the creation of the terminal and its surroundings from the obvious architects and structural engineers through transportation engineers who planned roads and runways and regional, local and transport planners to civil engineers and railway engineers and landscape architects. Then there were services, lighting, acoustic, electrical and mechanical engineers, and specialists in component design and glazing and roof drainage systems and furniture manufacturers and carpet designers and graphic designers (no interior designers this time!). Then there were the quantity surveyors, contracts managers and project managers. Not forgetting the clients, of course, who had a big say in what was built and how it was furnished. The clients, of course, as so often in these days were multi-headed, and each head had its say and sang its song to a tune called by the financiers who determined how much might be invested in the built environment and where. And then there were the contractors and the subcontractors and all their teams, and what about all those people who actually built it? And what about the shuttles which are an integral part of the terminal complex, and all the people concerned in their design and construction? And then those other enormous buildings on wheels - amongst them Sir Norman Foster's favourite building as he described on another television programme, the Boeing 747 Jumbo Jet - which we suggest are every bit as much a part of the built environment as the fixed buildings?

The point is obvious, leaving aside the outmoded and possibly soon to be discarded question of who is a professional and who isn't, the range of people who influenced the final form and appearance of Stansted from the Secretary of State, who approved the location, to the person who laid a kerbstone in the carpark, is enormous (and not only enormous but international). You cannot talk about education for the built environment as some sort of finite programme. A different model is required.
In some sense everyone is concerned in the formation of the built environment. We nearly all 'Do-It-All' - mostly on a Sunday afternoon, if not in the house then almost certainly in the garden; and if not D.I.Y.-ing then perhaps 'Nimby-ing' at the local Planning Department. There is a seamless web in society of those with greater or lesser concerns, greater or lesser involvement with the built environment, involving perhaps everybody in one way or another. It is neither discipline specific nor a professional preserve.

It follows that there needs to be much greater emphasis on the built environment, visual matters and the interplay of art and science in design in our primary and secondary education. This is hardly a new proposal but we still spend much of our lives trying to put back together that which has been split or neglected in our initial education and that of our students. However, it is an increasingly urgent proposal with the increasing rate of change of our urban environment and the estrangements mentioned earlier.

Underlying this concern are the ways in which our secondary education still sets the arts against the sciences, esteems the literary and numerate above the visual and awards and prizes scholarship at the expense of creativity, instead of considering them to be complementary. Along with the majority of academics and following the rejection of the Higgenson Report, we fear that the schisms will widen rather than narrow under current Government proposals.

One of the purposes of this conference is to consider ways for improving the education of professionals for the building industry. It is quite clear that in order to do this we must improve the way in which the various disciplines work together and contribute to the production of the built environment. It is also quite clear to us that the enormous and growing (just consider I.T. for instance) range of disciplines, skills and trades involved in the production of the built environment militates against recent suggestions of the introduction of common foundation courses for all being educated for the building industry as proposed in the reports Investing in Building 2001 and Building Towards 2001 commissioned by the National Contractors' Group.

Such common foundation courses could never be wholly inclusive, as we have argued, thus undermining the very rock on which they are proposed. We are also concerned that the proposals are orientated around the concept of the Building
Industry. Whilst we are all obviously involved in an industrial activity and one in which the consulting professionals should be an integral part we would argue that it is a misconception which can be dangerously misleading to talk in terms of a single 'Building Industry' analogous to the car or chemical industry. We are concerned with a much more complex and varied activity covering a vastly wider range of scales of operation than these other industries. In addition in both the design and construction aspects there are large numbers of very small companies and practices, which are appropriate to the small scale of much of the work. It is also questionable to think of the product, i.e. the built environment, in the same terms as cars or chemicals. The creation and maintenance of the built environment is an activity of immense social, cultural and political as well as technical complexity. Whilst buildings and our other structures must be built to a price and on time they cannot in any general sense, except possibly the particular circumstances of speculative development, be considered in the same way as cars or other mass-produced market place products. A more efficient building industry would be more productive which would be good but it would not necessarily lead to a better built environment: to believe so would be to confuse means and ends.

In addition, there is evidence of problems arising when common foundation courses have been attempted in the past and also we believe there are intrinsic academic problems which must be an inevitable part of such courses which we will refer to under the section 'Wholes and Parts'.

An alternative model is required and this we will explore. It is a flexible model which can help the common understanding and promote the working together of those who contribute to the formation of the built environment. However, it is dependent upon certain fundamental changes of attitude within education and the professions which we would argue are essential in any event if society is to confront the problems which we referred to earlier.

We will explore this model through the education and training of architects and structural engineers but it will become clear how it extends to other engineering disciplines, the landscapers, surveyors, planners, interior designers, transport engineers etc. etc. That there is need for change is quite evident. We see this daily in our experience of the built environment and practice. We learn it from studies such as the analysis of the problems in the building industry carried out by the Centre for Construction Studies at Reading University for the National...
Contractors Group. That it is possible for common understanding and working to be attained is evidenced by the practices which Ove Arup founded and which have led to this conference. The question is, how can the aspirations and achievements of the particular, which in the case of the Ove Arup Partnership is by means of a closed society of largely like-minded self-selected and carefully initiated individuals be transposed to the general open-ended world of the "Building Industry"?

3. The Model: 'The Wood' not 'The Tree'

There seem to be two basic models for interdisciplinary education. They can be characterised as 'the tree' and 'the wood'. (See diagram). The first starts from a common core course and leads to increasing specialisation into separate disciplines with successive stages of the course. The second starts from the basis of the separate disciplines but promotes greater relationships between the disciplines as the education progresses allowing specialisations to be developed within and between disciplines to meet the broadening range of needs in practice, and the range of potential and interests of individuals. It leads to a breaking down of the narrow professional definitions of the disciplines and a growth in interdisciplinary knowledge and skills.

Both models recognise the existence of and need for the different disciplines and for inter-disciplinary education and working. The former model we have argued cannot accommodate all those who need to be involved; the latter model can but in a much looser and more flexible form. The former presupposes a commonality of view, purpose and intent ab initio, whilst the latter recognises the reality and strength of the diversity of personality and potential of those who enter education in the built environment as we shall explore later.

The model we propose has the following in common with the 'Arup' philosophy; it is discipline-based but promotes interdisciplinary practice; it promotes specialist skills within the disciplines but a broadening of attitude of the disciplines; and it is based on the fullest personal development of individuals each with their own strengths and interests through continuing education. (Ref.2)

We will now consider various educational consequences, characteristics and potentials of this model. As we said earlier, we shall concentrate on the needs of
architects and structural engineers, for the sake of brevity and clarity, but the general propositions can be extended to the other disciplines.
THE TREE

MULTIDISCIPLINARY SPECIALISMS IN CONTINUING EDUCATION
INTERDISCIPLINARY COLLABORATION IN EDUCATION INITIALLY

ROOTED IN EACH DISCIPLINE

THE WOOD

DIAGRAM 1
THE TREE AND THE WOOD
4. Education: Problems Based or Subject Based?

Karl Popper reminds us that we should be students of problems not subjects. Certainly many of the problems in the creation of our built environment have arisen because the students of the various subjects - or might we say the disciples of the various disciplines? or protagonists of the various professions? - have been so concerned to protect their position that they have failed to recognise the real problem, the raison d’etre, or through the narrow perspective of their profession and its training failed to see the full nature of the problem.

And what is the central problem of which we should be students? It is the production, transformation and maintenance of the built environment, which occurs at many different scales. However, it is not the scale which we believe to be significant but the need to consider the formation of the built environment in a fully rounded way seeing it as a cultural as well as a social, political, economic, ecological, technical and managerial act. Fundamental to this is the recognition that the creation and transformation of the built environment, irrespective of the scale, is concerned with a need for architecture (in its broadest sense); a need which transcends but does not subvert the need for shelter and utility. However, in order to formulate and tackle problems in this rounded way the insight, knowledge and skills of many disciplines are required. The various disciplines have evolved and acquired their value precisely because they have been able to develop ways of seeing and analysing the world and hence insight, on the basis of the discipline of thought, logic and knowledge which they have developed through the interplay of theory and practice, within the skills specific to the discipline. Each discipline has a ‘logic bubble’ of evolved values and use of language which enables it to develop new knowledge and hence new tools of understanding and technique to tackle problems. However, this process is self-defeating when pursuit of the discipline becomes an end in itself and/or it is perceived in isolation from other disciplines.

We would argue for discipline-based but problem-orientated education and research; the problems being inevitably multi-disciplinary and holistic problems concerned with the formation of the built environment. In other words the methods of teaching in the disciplines should be orientated to the ways in which the discipline can contribute to the understanding and formation of the built environment.
5. The Kinds of Knowledge and Abilities Required

What then are the kinds of knowledge and abilities required to tackle these problems? Clearly they will come from many disciplines and they will overlap in various ways and have varying degrees of prominence at different scales and in different types of problem.

As we stated earlier, we are concentrating on the education of architects and structural engineers and here in particular in the context of the scale of problem associated with the design of buildings, believing that the arguments and requirements are readily extendible across the scales and disciplines. We chose the exemplar of this scale both because it is so pervasive and because it embraces so many of the aspects encountered at other scales.

We are going to consider the 'design of buildings' and 'architecture' as synonymous. This may be considered contentious by some, notably Pevsner, but we believe that at the most this could be argued to be a difference in intention, but because design can never be wholly pragmatic, in practice the synonymity is inevitable.

The design of buildings requires:

- Cultural, social, aesthetic, technical and managerial knowledge, skills and judgments.

- Knowledge of architectural precedents so that the vocabulary of forms used in design may be understood.

- Skill in the manipulation and resolution of complex, three-dimensional organisation problems.

By its very nature the design of buildings requires an interplay of rational, ordered and tested thought and action with speculation, imagination and sensitivity about people, forms and places.
In this context three interrelated levels of educational objectives can be identified (Ref. 3):

A. The mature development of the personality and character of each student and the maximum development of his/her intellectual and creative potential through:

- encouraging open-minded, enquiring attitudes to the spectrum of arts and sciences, and to the interrelated activities of creativity and scholarship;

- opening the mind, the heart and the eye to a sensitivity to people, places and forms;

- training the mind in scholarship with an ordered and ordering ability to learn, to reason and to communicate;

- developing powers and skills of creativity, invention and design;

- developing inter-personal and managerial skills.

B. The development of an understanding of the principles of the discipline of architecture, and the ability to apply these sensitively and rationally in the design of buildings in response to known and unpredicted social, cultural, environmental and technical problems and possibilities.

These principles can be related to a series of frameworks of thought concerning

- how buildings are ordered by means of formal languages in response to needs (practical, social, cultural, emotional and economic), ideals, contexts and technologies;

- the reciprocal relationship between the form of a building and its use;

- how a building behaves structurally and environmentally and how it transfers load and energy and moves;
how a building fits together dimensionally and constructionally through the interrelationship of materials in response to a set of ideas and ideals;

- the process of building in the context of the building industry and economic constraints;

- the way people and societies generate and use buildings and interpret and invest with meaning their use and form.

A basis of knowledge and competence in the relevant skills needs to be established within each of these frameworks of thought, the extent or depth of which will vary with each discipline.

C. Instruction in the basic practices, skills and knowledge necessary for initial entry into professional life as a basis for subsequent development, experience and education in practice.

These objectives are broadly based because we believe that education must be problem-orientated; the different disciplines will give different emphases within the whole. The broadest educational objectives concerned with the development of the personality and character of an individual and the realisation of their potential are set firmly at the front, for it is only through this that the broad-minded and rounded approach which we believe is essential to tackle the problems set out at the beginning of this paper can be developed.

6. Wholes and Parts

The diversification of human endeavour and the growing complexity of society is conspicuously reflected in the built environment. For its citizens, the city is more than an arbitrary collection of buildings. There are systems for communication, travel, power and waste disposal. In addition, the physical, topographic, social, cultural and aesthetic dimensions all influence the life and soul of the people who live there. Likewise, for its inhabitants a building is more than a collection of rooms. The spatial subdivision provides a discipline for organisation, the structure
constraints loading and adaptability, environmental systems govern comfort
conditions, and appearance and finishes affect mood. In short, the whole is more
than the sum of its parts.

The example of the new Stansted Airport terminal building nicely demonstrates
that, like a well-oiled machine, the parts must all work together to create an
efficient whole. The orderly elegance of Stansted is deceptive. It has been hard
won. Only through the clarity of vision on the part of the architect, and extensive
cooperation between specialists, has such apparent simplicity been achieved.

A hallmark of good design is a conspicuous straightforwardness - (a place for
everything, and everything in its right place) - which quickly communicates itself to
the user. If the built environment, with its unavoidable complexity, is to have this
quality, then its creators must develop enough mutual understanding to allow each
individual discipline to function properly in the context of the whole. No single
profession can hope to own all of the knowledge needed to distil simplicity out of
complexity.

As knowledge and skills increase, so new specialisms evolve from their former
professional roots (Civil Engineers tend now to be classified as Structural, Bridge,
Geotechnic, Public Health or Transport engineers). Such growth in any subject
stimulates new interest, and eventually a new professional body emerges to foster,
moderate and protect the new knowledge-base. Ideally, the specialist needs to
retain an interest in the whole so that the value and contribution of specialist
knowledge can be appreciated. Alternatively, in perhaps a larger organisation,
there must be some people who, like general practitioners, know how to use and
interpret specialist knowledge in the context of the whole. Without these linkages,
misunderstandings arise, disintegration follows, and the long hoped for quality
becomes unattainable.

Quite naturally aptitudes and inclinations vary. Some people prefer to deal with
the whole, whereas others concentrate their interest on the parts. Likewise,
people develop a taste for working at different scales, some only excited when
tackling a grand master-plan, others content with the intimate detail of domestic
construction.

Attempts have been made to measure the subject interests of university students
in the United Kingdom. One such, published by Bron Mikelides in The Journal of
Architectural and Planning Research, Autumn 1989, compares the bias of aptitude between architects and engineers. Predictably the architects put 'aesthetic interests' top of their list, and 'computation' and 'clerical' as their most disliked occupations. The engineers, perhaps more cautious of psychological testing, ranked 'mechanical' highest, and 'music' and 'social service' lowest (though curiously no lower than the architects). Overall this study suggests that vocational aptitudes are more strongly developed among architects than engineers, and conversely engineers have more in common with other groups, such as commerce.

The problem at present is that the part is usually studied as an end in itself unrelated to the whole, i.e. the building - structural engineering and services engineering being primary examples. Each part is studied unrelated to the underlying needs and considerations of shelter, place-making, celebration, 'belonging' etc; ecology, energy, pollution etc.

It is important that we educate in a way that allows each part or discipline to see its contribution and role within the whole - not just as problem solving but also at a problem-defining level.

7. **Education for the Built Environment**

The real problem facing education for our professions is the subject boundaries. Often the contents of lecture courses (and exams which follow) lack any appreciation of context. Particularly in engineering such courses rely on standard procedures and Codes of Practice for solutions, and they rarely challenge the students to think through an open-ended problem posing all sorts of questions. Again in engineering there is a reluctance to give enough weight in terms of marks (the currency students understand) to project work which, of necessity, cuts across subject boundaries. In architecture, technical understanding is sometimes perceived by students as a hindrance, rather than an aid to real creativity. These attitudes die hard, but our teachers should be encouraged to challenge them. In universities, opportunities to learn come in two broad categories:-

- Lectures, laboratories, tutorials (under staff control).
- Private study, studio (under student control),
Engineering courses have relied largely upon the first of these, with staff deciding content, setting the pace, actively doing the teaching, assessment and feedback. Arts and architecture students are more used to learning outside the place of formal teaching, developing their own study skills and a capacity to think and express in written and spoken language. We believe that the style of university education strongly influences people; the future expectations of graduates are reflected by their course of study. Too narrow a focus with too much emphasis on detail may stifle creativity and interfere with real understanding. Likewise, too broad a course without any depth or rigour is just as unsatisfactory.

8. Nature of Design

Designing and making are two fundamental human activities involving art and science. A visit to the exhibition rooms at the Design Council in the Haymarket shows how every manmade artifact, from a screwdriver to a skyscraper, has been the result of a design process. The whole process, from initial ideas through prototypes, production and market research is amply illustrated. New products are born out of old ones, and design development is just as important as the original concept. Our sources of power and wealth are no longer a real constraint. The problem is now one of deciding what should be built and which resources should be used. A related problem is determining how these decisions are made and by whom and the role of the designer in these decisions.

Whereas a painter or sculptor has almost unlimited choice to create whatever he or she pleases, the practitioner of design has limits which restrict the freedom of choice. Certain practical criteria must be met - the design must be functional, components must fit together, have sufficient strength, be accessible and, perhaps, replaceable. Cost and appearance also matter. Design is not a subject which can stand alone in its own right. Rather, it is more of a strategy for linking a cycle of steps together: problem-posing, creative synthesis, analysis, and decision-making. Different mental attitudes are required at each stage, and as Richard Chaplin from Reading University (Ref.4) has argued, the bias towards convergent thinking in engineering, at least, may be inhibiting the development of true design potential in the engineering profession.
A skill of the designer is to have the foresight to see which alternatives work best, and, more importantly, how these have an advantage over and above the existing well-tried, well-tested solutions.

Different modes of thought are required during design:

- Inductive - Deductive

Intuition, usually gathered after years of experience, gives the mature designer the confidence to go directly to a solution, only later proving it to be right.

A more systematic, logical and exhaustive approach will be favoured by those entering a new design area for the first time. Computer systems and expert systems tend to use this more deductive approach, yet curiously the very latest developments in computer-aided design theory are far more intuitive and even try to imitate human thought patterns.

- Divergent - Convergent

In his book 'Contrary Imagination' Liam Hudson identifies two types of people, convergers and divergers. Convergers are good at traditional I.Q. tests - (e.g. multiple choice, odd-man-out, numerical series) - puzzles which have one right answer. Divergers, on the other hand, are better at open-ended tests - the sort that ask you to think up as many uses as possible for an object (like a brick), or the meanings for a given word or captions for a cartoon. The converger, logical, rational, cautious, and sometimes defensive, is inclined to pursue a career in the science or engineering. The divergers, by contrast, favour arts or architecture.

The natural designer is both diverger and converger, but not at the same time. The creative steps are separate from the analytical and decision-making ones; so designers must be able to flip from divergent to convergent thinking at will.

- Problem - Solutions

Though the act of designing may usually start with problem identification, coming up with ideas and the search for lots of solutions is often neglected, specially among engineers. Sometimes professionals thrive on bogus problem-solving, diverting lots of intellectual energy to analyse and solve something complicated.
while failing to notice another far simpler solution. Solving problems by design, rather than analysis, is an attitude to encourage. Sometimes in this process new relationships and new rules are discovered, and instead of working through established methods, some real innovation is achieved.

However, it is important to recognise that in considering these contrasting modes of thought, we are concerned with the interplay of the intuitive and the rational, and ultimately with the interplay of the arts and sciences. Unfortunately our education system, particularly at the secondary school level, continues to propagate that mutual suspicion and fear, with its roots in the nineteenth century, that on one hand intuition and individual creativity will be weakened by knowledge, and on the other rational thought will be undermined by intuition and creativity. The evidence from science, the arts and technology is that the two modes of thought are mutually interdependent. Sir Leslie Martin put it most clearly with reference to A.N. Whitehead: 'It is speculation that makes rational thought live; and it is rational thought that gives speculative invention its basis and its roots.' (Ref.5)

The point is sometimes made that in designing we are often working with the conventional and rarely in an innovatory manner. We would argue that all design operates on a basis of 'pattern recognition', and on a basis of knowledge and analysis of precedent (even though this may not be overtly stated or recognised). However, rarely can the convention be adopted ab initio as a preconception without banality, for each design problem arises anew. The process is one of rediscovery, even in some senses re-invention, of a convention, leading to new understanding. The convention, pattern, or pro-forma (Ref.6) is often transformed and extended leading sometimes to it being classified as innovation. We stress these points as we believe they are fundamental to education, both within the various disciplines and as the various disciplines relate to the understanding of architecture and buildings as a whole.

It is important that all who are involved have some understanding of the whole, both in respect of the overall intentions and the role of the various parts within the whole.

it is important that all can contribute to the whole.
This is not gained by trying to make everybody a 'mini-whole' from the beginning, which is the expectation and intention of the 'tree' theory of multi-disciplinary foundation course education. This is because it takes a lot of time, maturing and development to begin to understand and deal with the 'whole': neither, as we have argued earlier, do all students have the inclination and aptitude to deal with the 'whole'. An ability to contribute to the whole from the perspective of the discipline-based part is gained by educating those dealing with the parts so that they can see the role of the part in the whole and so that they can partake in the designing in a way which contributes to the whole. For this to occur it is important that education for the part must be set in the wider cultural, social and architectural contexts and that education for both the whole and the part should stress the morphological and conceptual basis which deals with patterns of form and structure and enables the development of a common language of pattern and form to develop beyond the spoken word (for instance, the hierarchy of primary and secondary engineering structure which is also fundamental to the ordering of architectural elements, spaces and forms - the same elements and forms often being both structural and architectural).

It is also important that the various disciplines explore their own use of spoken language, not forgetting how to explain their own jargon to each other, their clients and the public. For instance, the very word 'design' means different things to different professionals. For architects it means all aspects from the conceptual stage of playing with ideas, forms and structures through to the smallest detail. For engineers it often means only calculating and sizing components. Both steps are necessary and the one informs the other. There are both tedious and rewarding aspects of design, and teachers should promote a balanced diet of activities for their students. How easy it is for engineers to focus only on calculations simply because assessment of numerical work is seen by teachers as easier, fairer and more exact. Architects, on the other hand, may sometimes prefer to assess a design portfolio of drawings and models, giving not enough weight to technical matters.

9. Implications for Engineering Education

The Engineering Professors' Conference keeps a close eye on curricula, both in sixth form and university. Efforts to adapt both to meet the needs of industry and compete with other professions are always on the agenda. Professor Sparkes's
paper entitled 'Quality in Engineering Education' has much of value to say about teachers and learning. It is having an impact and the mood now, for engineering teachers at least, is to reduce the amount of factual material taught and place more value on real understanding. Assessment methods should change and become more closely matched with the learning goals. Examination questions should be less of a memory test, and instead might ask:

- How to tackle problems rather than actually solving them;
- To compare given solutions or correct deliberate errors;
- Compose questions to elucidate a given topic.

In the Department of Civil Engineering at Leeds, the proposed vision of teaching design to engineers coincided with much that had already been written (e.g. Engineering Design Education, Report to Design Council, 1976, A.E. Moulton), yet never implemented. Design is a powerful unifying force for integrating the different subjects within civil engineering. Although design projects have been used in engineering teaching for a decade or more, often they seem remote and quite separate from the lecture courses and exams. Progress towards a more project-driven curriculum seems the next logical step. In our experience students welcome the chance to use design projects as a test-bed for analytical procedure taught in lectures, finding meaning and purpose for theory, and an opportunity to make informed decisions with ever-growing confidence.

Both groups and individual working should have a place in any project curriculum. In industry, people are constantly forming and reforming working groups in order that inputs can be made at many levels and among many disciplines. Cooperation, anticipation, communication and management skills are the obvious products of group working, but in design there are also the sparks of innovation, the brainstorming, and sharing of experience which are equally important. Individual work, unaided and untaumished by the contributions of others, is easier to assess, and more truly measures ability to work alone - a highly prized quality in all professions.

If the intellectual equipment needed by engineers is changing, then the style, approach and content of our university teaching must also change. Some attitudes which are changing include:
• Finding Out for Oneself
Knowing how and where to look for sources of information is a vital skill. Problems should stimulate enquiry. Resources must match a more open-ended approach to problem solving.

• Thinking as Designer
Developing a feel for structural behaviour, and rewarding ideas ought to run in parallel with the formal teaching of structural theory. While at university, students should be encouraged to design from first principles, rather than quote formulae from Codes of Practice.

• Visualisation in 3-Dimensions
Most engineers learn about 2-way structures, but few exploit the virtues of 3-dimensional structures. Spotting structural models within 3-dimensional forms requires mental agility and an ability to visualise solid objects. Freehand drawing and geometric exercises can help.

• Values and Judgement
Much of engineering is concerned with making value judgements, yet students (and staff?) often shy away from the unquantifiable. Perhaps our curricula should create space for arguing a case, defending a point of view, or comparing incomparables.

10. Implications for Architectural Education

The following implications arise. They are concerned with quality and approach and with product rather than curriculum content. In this respect the analogy of Performance Specification for education in terms of possible products or ends is preferred rather than the Bill of Quantities approach which would put the emphasis on curriculum content or means. The former leads to variety, the latter to conformity.

• A greater emphasis on the contribution of the various disciplines (rather than professions) in the design of buildings is required, from the point of view of their form-giving, form-discovering, form-testing potential as creative not restrictive.
factors. This is the general philosophy in schools of architecture at present but is often difficult to achieve in the present cultural climate where in Ernst Gombrich's terms the glass of fashion holds sway over the mould of form.

- Related to the above, a greater emphasis on formal structures and the possibilities of structure, environmental control, construction, materials etc. in relation to formal languages is needed. In other words, we need a morphological and conceptual approach in which all disciplines can partake. This is the means by which the various disciplines can be encouraged to contribute at the blank sheet of paper stage rather than waiting for the architect to make a mark which is then either subverted or blindly followed.

- A wider discussion and exploration needs to be developed with other disciplines concerning the aims and values in architecture and the nature of architecture itself in respect of the frameworks of thought outlined earlier in the paper.

- A principle and common means of multi-disciplinary education should be analysis of existing buildings with students of other disciplines so that a common language and understanding of quality, aspiration and possibilities can be explored, together with a mutually informed investigation of the ways in which buildings are ordered and structured.

- It needs to be recognised that whilst architecture is essentially a design based discipline, contributions of architects to the design of buildings can take many different roles. Our educational system should be able to respond to the wide variety of aspiration and interest of students. Only a proportion of students will go on into practice as active designers; many others will have contributions to make in the non-building design aspects of practice and it is important that the potential of these students is recognised and nurtured. In these cases, it is the quality of architectural thought, aspiration and understanding
which is of significance, rather than of basic building design ability.

- Following on from the above, the education system and the profession should look to educating architects with areas of specialist expertise which may branch between disciplines.

- The ever-expanding curriculum and the need to obtain new specialisms throughout a career emphasises the need to see education as a life-long process. The experience of practice and the maturing of individual potential and interests should lead to the provision of continuing education on a multi-disciplinary basis so that building professionals can increasingly work in the overlaps between disciplines.

We set out below some of the means by which some of these implications can be achieved. However, we believe that despite the need for continuing education within the overall pattern the complex cognitive processes and interplays of modes of thought, together with the ability to integrate the various formal, cultural, social and technical considerations demand an initial five year, or full-time equivalent, formation period for architects.

11. Diversification and Specialism

We have considered ways of educating professionals for the built environment in their initial education so they have a greater understanding of their roles and contribution and there are a growing number of courses, for example at Leeds and Manchester, which have been set up specifically to bridge between specific disciplines where this is appropriate. However, there are many roles to play within the umbrella terms of architect and engineer, and this should be recognised in architectural and engineering education and by the professional institutes. Thus there should be the ability to qualify as an architect or engineer with specialist interests (for example management, conservation, urban design, etc.) though perhaps not necessarily with full architect or engineering status. This should be achievable through:
- diversification/specialisation at the upper end of initial education.

- or through postgraduate course.

- or through continuing education.

The diagram 'a Network and Ladders' shows such an approach. It is an abstracted version of existing architecture and engineering courses at the Universities of Manchester and Leeds. Within the final year of initial formation a student can specialise as appropriate in an aspect of architecture (such as urban renewal, conservation, acoustics or low energy design), or engineering (such as construction, or public health or contract management) in order to be able to bring this specialism to bear when they enter the increasingly wide world of practice.

Such a specialism can be extended into a higher degree through further full or part-time education. The experience of the specialism gained in initial education may give credit towards the higher degree. As these specialist aspects are taught on a modular basis they can become available through continuing education programmes for all other interested disciplines. Thus branches and interconnections can be made between the various disciplines which constituted the 'wood' with which we started; these interconnections occurring at the upper end of initial education or in postgraduate education or continuing education.

Professionals can return to Higher Education, full or part-time throughout their career to accumulate further specialisms and qualifications, or they can gain them on a credit basis through continuing education. Thus continuing education can be offered on a multi-disciplinary basis widening its market and increasing the opportunities for mutual understanding between disciplines.
Education for the Built Environment

Diagram 2

'AND NETWORK AND LADDERS'
12. Learning in Practice and Learning on Campus

There is a need to define what is best learnt on campus and what is best learnt in practice. Currently higher education is becoming clogged with topics better learned in practice, or if not in practice then in continuing rather than initial education. The result is that we are not teaching the things which should be taught in higher education as well as we should be and hence, criticisms are arising. However, part of the definition of what is best learned in practice must also take into account the ability of practice to teach and of the students' ability to learn in the practice situation. If the benefit of learning in practice is to accrue, then neither of these can be left to chance and the obligations of the practices must be more clearly defined and their abilities in this respect developed.

13. Campus Learning from Practice and Practice Learning from Campus

It has been argued by Martin Symes (Ref. 7) that whilst the study of design processes in architectural practice by academics has informed teaching methods, the potential for practice itself learning from the attention paid to understanding these design processes has yet to be realised. In other words, the interplay between higher education and practices can be to the benefit of both as well as the students.

Such an interplay is slowly being established at the level of practice and contract management but not yet at the level of design which is equally a social and managerial activity particularly in respect of multi-disciplinary design. Much further work is needed to understand design practice and practice culture especially for multi-disciplinary practices and between mono-disciplinary practices. We also need to carry out this work on a transnational basis to understand commonalties and variations. It is essential to understand design as a social as well as an intellectual and technical activity, in other words to understand the sociology of interdisciplinary design. From such an improved understanding we can improve both our initial education and also improve the performance of established practices through continuing education: the experience of that continuing education process in itself providing further knowledge of the design processes.
14. Education and Training

It is only at this very late stage that we introduce the word ‘training’ which was included in the title of our paper. It is argued vehemently by some that education and training are synonymous and equally vehemently by others that they are different but either opposed or complementary. We believe it is a case of Tweedle Dum and Tweedle Dee and the words will mean what people want them to mean. However, what underlies the arguments is, we believe, something akin to the mutual suspicion of intuition and rationality which we referred to earlier. Education we take to mean, from its Latin origin ‘educare’ - to lead out; a leading out from ignorance through knowledge to an ability to question on the basis of knowledge and skills. This some feel could subvert or undermine the ‘correct’ development of skills and habits of thought and practice gained through instruction in the course of training. We would only say that we see no difference between good education and good training! - but both are necessary!

15. Research

It should be recognised that research is a central part of design as well as an extension of primary knowledge. Research skills should be taught to all building professionals whether they are to go into practice or research. Such a move will also promote a greater flow of individuals and information between practice and academic based research. Research should be more problem orientated than discipline orientated. Research should be more broadly based having a greater understanding of the quality and nature of knowledge required in practice. The more and more about less and less syndrome should be replaced with more about more in order to be of relevance to practice and in order to understand the nature of the problems being faced in practice.
16. Concluding Thoughts for the Arup Foundation

We have covered much ground, some of it provocative we hope, but all with conviction. Essentially we have argued for:

- A wider basis of secondary education both in general in combining arts and sciences and with respect to the built environment.

- A discipline-based but problem-orientated approach to higher education for the built environment.

- A much more flexible approach with regard to the nature of and overlaps between disciplines in education and the professions.

- A much greater recognition of the role which the different disciplines can play within the various parts of the whole problem of the design of a building or other aspects of the formation of the built environment.

- The need for a more goal orientated approach to education and practice in respect of the quality of the built environment which needs a broadening of attitudes, aspirations and intentions in initial education for the built environment.

- The need to learn from international experience in interdisciplinary education of the built environment.

- A better understanding of the teaching and learning methods required for students of different personality and background so they may make a fuller contribution.

- The need to develop a morphological and conceptual approach in education in the various disciplines so that they can work together in a process of invention and discovery rather than proposition and response. For this to develop work needs to be
done on the nature of pattern recognition and morphology underlying design.

- The need to understand better the culture of practices and in particular, multidisciplinary practices with regard to design processes both in the U.K and trans-nationally.

- Changing attitudes to research and the development of a research mentality and skills amongst students in initial education.

References:


(3) The requirements and objectives are based on those set out in the B.A.(Hons) with Architecture Degree Handbook at Manchester University School of Architecture.


Education for the Built Environment
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AN ENGINEER'S VIEW OF THE FUTURE FORMATION
OF ENGINEERS, AND THE RESOURCE
IMPlications

Patrick Dowling

ARUP
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AN ENGINEER'S VIEW OF THEIR FUTURE FORMATION
AND THE RESOURCE IMPLICATIONS

Patrick J Dowling

1. INTRODUCTION

The majority of professional engineers working in the building construction industry are graduates from the civil engineering courses of UK universities and polytechnics. Over 100 such degree courses are on offer from some 60 Higher Educational Institutions (HEIs) employing an estimated 1100 full time professional staff supported by perhaps as many technical, administrative and secretarial staff. The bulk of the approximately 2,500 students who graduate annually from these courses go to supply consultants, contractors and public authorities with the future engineering professionals for the construction industry, (although in recent years a significant percentage of the top graduates were lured into commerce because of the higher salaries which have been on offer in banking, accountancy and insurance).

Of course, these potential chartered engineers provide only part of the corps of people required by the building industry - they work alongside and liaise with other key personnel including architects, architectural technicians, builders, engineering technicians, surveyors and quantity surveyors, materials specialists, engineering geologists etc. A key role is played by the architects emanating from the 35 HEIs which graduate some 1250 architectural students each year.

There are also about a dozen undergraduate courses in building and a half dozen courses dealing with building services providing professionals for the built environment. However, the total number of students graduating in these
educational disciplines is less than 20 per cent of those from the traditional civil engineering courses.

There is now a general concern shared between professional institutions, national contractors and indeed HEIs that the education and training of professionals for the built environment needs to be reassessed urgently although there is as yet little agreement as to what exactly needs to be done.

In the writer's opinion the following items should be amongst those of most concern:

- the need to improve the quality, quantity and balance in numbers between the various professionals required by the building construction industry.

- the need to improve the interface between architectural and engineering input to the building design and construction process which is nowadays focused on what is often a highly sophisticated and integrated product, the modern building.

- the need to upgrade the management of the human and material resources involved in the building process.

It is therefore very timely that this Seminar should address the subject of shaping professionals to help secure the future position of the industry. This paper offers some thoughts from an engineer's point of view on what is needed in the longer term to improve the situation, what immediate steps might be taken, what resources are available and finally what implications there are for these resources in following the suggested lines of action.

2. CURRENT EDUCATION AND TRAINING OF CIVIL AND STRUCTURAL ENGINEERS

Whilst the traditional courses in civil engineering, in common with other branches of engineering, have been subjected to a lot of criticism (not least from some engineering professors themselves) for being "highly analytical", "too
crammed" and "too rigid in pattern" it would be very foolish to ignore the fact that the courses relating to this most broadly based of the engineering disciplines have, on the whole, served the construction industry well to date. They have provided the engineers who have been responsible for designing and constructing some of the world's most outstanding projects both at home and overseas. However as we are concerned here to examine their suitability to the future needs of the building industry it would seem sensible to review briefly the current scene.

The normal duration of the civil engineering undergraduate degree is 3 years, with the 4 year courses available so far providing only some 5 per cent of the total number of graduates each year. The core subjects of most courses are materials, structures, fluids and soils. It is generally acknowledged that a good basic understanding of these subjects, preferably acquired in the context of their use in the design process and backed up by a sound understanding of mathematics, is the essential foundation of a civil engineering degree. The potential influence of the computer on the teaching of these subjects is very great indeed and should make it possible to teach them far more efficiently than is generally the case at present. A good appreciation of economics and financial matters relating to the construction industry is also considered to be an essential ingredient of the well balanced modern undergraduate course, as is a thorough training in communication skills.

Of these core courses structures, materials and soils are often the ones given the greatest emphasis and are amongst the key subjects required by graduates going into the building sector. In many cases graduates can elect to specialise to some extent in the final year of the 3 year course and structures frequently figures amongst the elective subjects chosen. In certain cases the emphasis on structures is reflected in the title of the degree, e.g. Civil and Structural Engineering.

The influence of the Joint Board of Moderators (JBM), which includes representatives of the Institution of Structural Engineers and the Chartered Institute of Building Service Engineers as well as the Institution of Civil Engineers, on the continuous evolution of the undergraduate curriculum should not be underestimated. This is frequently overlooked in reports referring to "traditional" civil engineering courses with the inference that traditional implies there has been little change to their form and contents for a very long time. On
the other hand, neither should the JBM's influence to date be overestimated -
and this is a theme to which the writer will return later when proposing some possible future action.

As a reaction to the tendency to cram more new material into 3 year courses, which are generally regarded to be already overcrowded, many of the courses are currently being revised to reduce the quantity of knowledge of the core subjects to the essentials and to leave more room for project work and self teaching. The temptation to replace space so gained by the insertion of yet more new 'essential' material has to be resisted if the courses are to be made more attractive and useful to both students and industry.

The ever closer relationships, including the interchange of students, being forged by leading UK civil engineering departments with the elite continental civil engineering institutions has been a primary consideration for a handful of them (including Oxford, Cambridge and Imperial College) opting to concentrate on four year courses in the future. Other considerations affecting this change in policy include the effects of changes in the school curriculum on the standard of entrants, the wish to include elements of industrial training within the course, as well as desire to embrace the study of languages and/or humanities. It might be remarked here that the "over emphasis" on mathematics and engineering theory in UK engineering schools criticised by some home based observers looks distinctly anomalous when the course contents of the top continental engineering schools in France, Spain, Germany and Italy are compared with their UK counterparts. Yet it would be readily acknowledged that the performance of their professionals in the built environment is at least equal to, if not better than, ours! One can be fairly certain that neither the government nor the UFC are likely to encourage any great expansion in the number of four year courses supported by public funding in a climate where educationalists are being asked to consider the viability of two year rather than three year courses because of constraints on the public purse. It is unlikely therefore that the number of civil engineering graduates from 4 year courses will exceed 10 per cent of the total for the foreseeable future.

One worrying aspect of the combined effects of reduced government funding of HEIs and the shrinking pool of students with the traditional pre-university qualifications is the tendency for HEIs to provide an ever greater variety of
options to attract students (civil engineering with everything!). By combining engineering studies with large components of currently popular subjects such as management, computing, environmental studies and languages within 3-year courses, they reduce further the engineering content. Although few will admit it, the more worrying aspect is the gradual lowering of entry standards. This latter trend is defended on the basis of answering the call of government and industry to increase access, but the suspicion cannot be resisted that, in some cases, it is being used to prop up weak schools and unpopular courses.

It cannot possibly be in the construction industry's interest to opt for quantity rather than quality for its future stock of chartered engineers. Nor, indeed, should quality be sacrificed for any of the professionals working as part of the building team. Surely the objective of UK industry must be to offer superior quality rather than inferior prices - if we increase recruitment by lowering standards we will eventually reduce the demand for the services of our construction building industry.

3. **COMMENTS ON EXISTING RESOURCES**

Before proceeding to consider how changes might be made to match engineering courses more closely to the needs of the building construction industry it is pertinent to comment on the currently available resources. Whilst it is difficult to quantify matters within this paper, the following observations are based on some thirty years' experience of the educational sector.

In terms of the physical resources of buildings, laboratories and equipment, the major problem is that although probably adequate in the total quantity available, they are spread far too thinly. (It is also true that most of the building stock has been poorly maintained as a consequence of a decade of financial cutbacks). By comparison with most other EEC States there are more degree level civil engineering schools per head of population in the UK. As it is generally felt by industry that it is the duty of government to supply the basic infrastructure of education from the public purse the rationalisation of these resources seems to be the most likely outcome of any detailed government/industry studies of the way forward. This would, of course, be highly controversial and would entail amalgamations and closures, but it is a nettle which will have to be grasped sooner rather than later. Indeed it is true to say today that there are very few
of the existing civil engineering departments that offer the full range of expertise over the key subdisciplines of the quality encountered in some of the top continental civil engineering elite institutions where resources have been concentrated, e.g. Delft. The commitment of the current government to selectivity points the HEIs in this direction but so far has been slow to deliver.

A major problem relates to the equipment and laboratories needed for teaching engineering. Much of the current stock dates from the expansionist days of the 60s and urgently needs replacing. To replace it adequately in all 60 institutions would be very costly and most unlikely to happen in the current or foreseeable economic climate.

As far as full-time staff is concerned, numbers have dropped drastically since the beginning of the squeeze on HEIs in the 80s. A further worrying trend has been the difficulty of attracting good staff to the HEIs throughout the 80s because of the relatively poor conditions on offer. The staff scene is compounded by the fact that few home students are undertaking higher degrees and so the traditional source for new staff is drying up rapidly. The result is that many new staff appointed are recruited from overseas engineers, in most cases of excellent quality, but who cannot be expected to have the same long term commitment to the HEIs as home graduates.

To compensate for the shrinking cohort of full-time HEI staff, departments are making increasing use of part-time visiting staff. Not surprisingly the difficulties encountered here are that staff most likely to be made available for this purpose are not the ones most needed by the HEIs and those most wanted by the HEIs are unlikely to have much time to give! Nevertheless, the industrial input at staff level is generally beneficial and very much to be welcomed. It is also likely to play an even more important role in the future.

4. FUTURE ENGINEERING COURSES FOR THE BUILT ENVIRONMENT

This writer feels strongly that one of the most unsatisfactory aspects of the current educational scene spanning universities, polytechnics and technical colleges, is the great imbalance between the number of candidates being prepared for the chartered engineer role and those being prepared for incorporated engineer responsibilities and the responsibilities of engineering
technicians. All of these occupations are essential to the industry and are therefore of equal merit and should attract equal respect.

On the one hand the concept that the vast majority of university and polytechnic courses should exclusively aim to produce only chartered engineers, despite the gross disparities in the standards of intakes and available human and material resources within institutions, needs to be challenged. On the other, industry needs to establish its manpower requirements at each level. Studies are already in hand by the Construction Industry Standing Conference (CISC) which aim to identify the range of human skills and qualification likely to be needed within the industry. It can be anticipated that this will point to a reconfiguration of the current courses across the HEI spectrum drawn on the wide variety of expertise and facilities available within the system to match more closely the required spread of skills and talents needed throughout the construction industry.

In drawing up the new configuration of complementary courses for all relevant professionals for the built environment it would, of course, be foolish to concentrate on the engineering sector separately from the architectural sector. The CISC study will hopefully estimate the proportions of the various practitioners needed within the building sector, which it is not possible to do here, but again it is confidently predicted that they are not those which currently exist. It would not surprise this writer to find that we need proportionally fewer chartered architects and chartered engineers together with many more incorporated engineers, architectural and engineering technicians and building and building services engineers. The need for more crafts persons is likely to be compensated for to some extent by the increasing use of automation in construction together with the introduction of new building techniques.

Key qualities required of the top tier of engineers and architects are creativity and understanding, the first of which would be regarded as the highest talent whether it be in the context of architectural or structural form, or methods of construction. It is this talent which is in shortest supply amongst most people but which must be attracted and nurtured if the UK building industry is to compete successfully on the basis of quality. Whilst understanding is required at all levels the breadth and, perhaps, depth, of understanding necessary to
perform the job satisfactorily narrows as we move across the spectrum of the building team from architect and engineer to unskilled operative.

Another essential ingredient needed to ensure our industry's survival is good management at every level of the complex interdisciplinary team associated with building projects. It is a matter of debate whether good managers are born rather than made, but there is no doubt that some exposure to the essential tools of project management is necessary at undergraduate level for our future engineers and architects - from which pool project managers will normally be drawn. This does not, of course, preclude the possibility of drawing managers from other sectors, although the good manager will usually not only have qualities such as leadership, organisational ability, judgement, decision making ability etc., but also an understanding of design, construction, contractual procedures and other relevant technical matters. Above all the good manager needs breadth to manage successfully a building project which extends across the disciplinary boundaries of architecture and civil, mechanical and electrical engineering to name a few.

This leads us naturally to consider the future education of the top tier of professionals with a view to improving the interface between two of the key professionals, the engineer and the architect. The immediate questions to be answered are whether it is feasible to integrate the education and training of these two professionals, at what stage is it appropriate to do so, and finally what resources are needed to carry out any suggested actions.

5. INTEGRATION OF EDUCATION FOR ENGINEERS AND ARCHITECTS

The possibility of successfully educating people who are both engineers and architects inside a single course is a remote one in the writer's opinion. Although there are some people who combine the talents needed to be outstanding in both spheres, they are rare and unlikely to exist in sufficient numbers to consider such a course as benefiting the industry in other than a peripheral manner. An examination of the intellectual and personality characteristics of the most successful proponents of each calling leads one quickly to the conclusion that, in general, they are most usually found in very different types of person. The best one can aspire to, therefore, is to improve the understanding each one has for the other's contribution to the building
process. To do this, their contributions and responsibilities need to be clearly understood and in this respect it is possible their current role within the UK may need some adjustments subsequent to a detailed study of the skills needed and who best can perform them.

With the growth of engineering technology the trend has been towards educating engineers in various specialist disciplines, such as civil, mechanical and electrical engineering. A smaller number of engineering science departments have coexisted alongside the much larger number of specialist departments for some time. The risks of over-narrow compartmentalisation of engineering are all too clear and the attempts to reverse or at least balance that trend, by promoting more broadly based engineering courses concentrating on the essentials of the so-called 'key technologies', have been made by the Engineering Council and others recently. Provided such courses attract very high calibre students then, just as some of the industry's top managers have been drawn from the elite engineering science schools, there is no doubt that because of their innate quality and education they could form a very useful input into the building industry team. (The cynical might say that the most highly talented people are likely to do well anyway, despite their training!)

The recent contractors' sponsored report, Building Towards 2001, argues for the first two years of an undergraduate course aimed at professionals for the built environment to be shared by architects, engineers, surveyors and construction managers. A Bachelor degree for engineers, architects, surveyors and builders would be awarded at the end of the third year of specialisation, whilst a Masters' degree would be awarded at the end of a further year. These courses would, of their very nature be more focused on the building industry than the normal civil engineering courses but could be criticised for being even narrower than existing courses.

This seems to be an impractical proposition, unlikely to provide sufficient educational foundation for either chartered engineers or chartered architects. Nor is it likely to attract the support of the professional institutions and the JBM charged with accrediting such degrees. A variation on it in which the first year is shared, followed by a further two years of specialisation might be an appropriate basis for future chartered, or possibly incorporated, engineers or their architectural equivalent.
A similar system is already in operation at Bath where engineers and architects share a common first year. The outcome of this initiative is awaited with interest and could provide valuable pointers to the future. Design project work shared by engineering and architectural students at appropriate stages of their undergraduate careers is another device already in operation in several UK universities and polytechnics and one which is likely to lead to a better understanding between these key members of the building team. Both of these initiatives are ones to be encouraged, monitored and emulated if, as is likely, they are shown to be successful.

One small step towards the goal of improving the architect-engineer interface could be taken by using the influence of the JBM to encourage engineering departments to explore ways for their staff and students to work jointly with their architectural opposite numbers on structural design projects. The concept of the common first year is likely to present greater difficulties, although a limited number of departments could be encouraged to explore such a possibility and report back on the perceived difficulties and advantages of adopting this course of action.

Initiatives such as those described can be most easily accommodated within the existing system provided architectural departments coexist with civil or civil-structural engineering departments within the one institution. This is the case for about half of the institutions offering the appropriate engineering courses. Indeed one of the main recommendations of the Building Towards 2001 report is the establishment of centres of excellence in the built environment by linking complementary departments from various contiguous institutions. It would be a mistake to limit this worthwhile initiative to those HEIs which host both architectural and engineering students on the one campus, as in many cases a more appropriate twinning would cross either institutional or binary boundaries, or possibly both.

The Japanese experience of the education of engineers is of interest in the context of integrated studies for the building sector. The first two years of their four year courses are normally taken in common by engineering students wishing to enter civil engineering, architectural engineering and construction. Only in the final two years do students specialise in civil engineering (which concerns itself with all products of the construction industry other than
buildings), architectural engineering (which confines itself solely to building construction) and construction engineering (which focuses on practical aspects of construction management). Architects are educated through separate degree streams but do share courses with architectural engineering students in the final two years.

Such a scheme appears at first hand to be attractive for engineers entering the building industry. It focuses the attention of engineers on the building sector and includes specialist subjects related to building construction not normally encountered in UK civil engineering degree courses and also has an element of collaborative work between architects, engineers and construction managers at undergraduate degree level. On the other hand it could be criticised for producing engineers who are too narrow and not flexible enough to be useful in a construction market, such as the UK is accustomed to, which is subjected to cyclical variations in fortune and emphasis and which many might argue would best be served by producing broadly based engineers who can cope with interdisciplinary projects varying from urban building construction at one stage of their career to bridge or offshore construction at other stages. It is, in any case, worth studying the advantages and disadvantages of the Japanese system in more depth than is possible here whilst recognising that the introduction of such a radically different system into Britain would entail major readjustments of the current system and almost certainly the provision of sizeable resources which are unlikely to be made available from public funds. Recognising the reality of the situation in relation to the history of the construction industry's relatively poor support for education and research, and its current weakened position in relation to the possible provision of resources it is potentially worthwhile examining more pragmatic approaches to the drawing together of the professionals during the education and training process.

6. INTEGRATION AND COLLABORATION AT POSTGRADUATE LEVEL

There is much to be said for seeking integration and collaboration at postgraduate level. Consideration needs to be given to mounting a number of product (e.g. commercial office buildings, leisure complexes, hospital buildings, smart buildings, rehabilitated industrial buildings, office buildings converted to domestic usage) orientated modularised courses at a selected number of
HEIs. These courses would involve a combination of interdisciplinary subjects including architecture, structural engineering, foundation engineering, building services, construction methods, contractual procedures, value engineering, project management, control systems etc., and would access engineers, architects and other members of the professional team. These courses would need to be put on in collaboration with the building industry using advisors, lecturers and project supervisors from the industry alongside academic staff as appropriate. Ideally, modules of the course could be taken as stand-alone CPD courses or credits could be accumulated, and possibly transferred between centres, leading up to a postgraduate qualification of master's standard. Students on such courses would normally be expected to have had some exposure to practice and therefore be capable of contributing by their own experience to the course by working on interdisciplinary projects and assignments.

Such an environment in the selected centres would quickly help the staff to identify topics for research and development on which joint industry-academic interdisciplinary teams could work. Examples of areas needing interdisciplinary research include aspects of energy efficiency in buildings, clean technology, environmental monitoring, integration of services, buildability, applications of automation and robotics to construction. The feedback from such research would in turn not only be fed directly across to practice but would also continuously update the postgraduate courses and eventually, by downwards filtration, begin to open up new directions for undergraduate courses more suited to the future needs of the building sector of the construction industry. Furthermore, this top-down approach would build on the current system with little difficulty, require significantly less resources than more radical solutions at undergraduate level and would be likely to meet with greater success in the long run.

The selection of the appropriate centres to initiate this scheme would, above all, be based on the proven excellence of existing engineering and/or architectural schools (preferably both) already known to attract high calibre students and output high quality graduates. It would also require due attention to be paid to the available human and physical resources within such institutions and their capacity to mount and sustain the envisaged postgraduate courses. A geographical spread which services the main catchment areas for
potential participants would also be important in the identification of appropriate centres.

Funding for such courses could be sought partly from the appropriate government bodies such as the Science and Engineering Research Council, partly from the construction industry itself, and partly from the individuals. Such courses would need appropriate recognition and encouragement by the Professional Institutions in the context of the training needed for attainment of chartered status or its equivalent. This would be the most effective mechanism to encourage individuals not only to participate but to contribute to their costs. Financial support to pump-prime the scheme could be sought from the Ove Arup Foundation which has as its objective "the advancement of education directed towards the promotion of, furtherance and dissemination of knowledge of matters associated with built environment".

7. SUMMARY OF RECOMMENDED ACTIONS AND THEIR RESOURCE IMPLICATIONS

The spread of courses based in HEIs and relating to the construction is unbalanced and needs adjusting to cater for the proportions of professionals and other members of the team more in keeping with the real needs of the construction building sector. These numbers are in the course of being quantified but are likely to lead to a demand for rather more engineering and architectural input at the incorporated and technician level and probably somewhat less at chartered engineer and architect level. A more rigorous application of the influence of the Joint Board of Moderators in its existing form, or perhaps extended to reflect a broader representation of the construction industry, could be used to affect this spread whilst at the same time protecting the quality of the intake into the top tiers of the construction professionals. This would clearly need the cooperation of the HEIs but should be easier to achieve in the proposed new environment in which the binary system dividing universities and polytechnics will be dismantled. Resource Implications: In the writer’s opinion the case for the rationalisation of the resources of some 90 departments of civil engineering and 35 departments of architecture will become much clearer within the new university network and inevitably lead to the amalgamation of some and the closure of others, thus releasing resources to help reconfigure the variety of complementary courses needed to serve the
UK's construction industry more efficiently. A sympathetic approach by the construction industry to the problems of rationalisation within the HEI sector, accompanied by the provision of real resources in cash or in kind to sponsor or provide staff, is likely to be well received by whatever government is in power at the time, by the new overseeing body for the combined universities and polytechnics and by the HEIs affected by the changes.

Encouragement to those HEIs charged with educating engineers and architects for the construction industry to seek more collaboration between staff and students, particularly on relevant joint design projects, would prepare the bottom layer of the higher education system to receive the benefits of the top-down initiative suggested in the next section. Such collaboration can be encouraged through the activities of the JBM. In addition, studies should be commissioned exploring the advantages and disadvantages of a joint first year course for engineers and architects in a limited number of centres as well as the pros and cons of initiating a small number of courses along the Japanese model of 2+2 degrees for architectural and construction engineers.

Resource Implications: There are very few resource implications attached to these proposals apart from the cost of a commissioned study on the various types of integrated degrees.

The main initiative recommended is the introduction of modularised postgraduate courses of a multidisciplinary nature in a selected number of HEIs which have established reputations of providing quality graduates for the construction industry and have a geographical spread covering the main catchment areas for construction industry professionals. These centres would need to have the potential to provide the correct multidisciplinary environment to nurture research and development activities binding together the professionals in the solution of problems of direct interest to the building industry. From these activities would flow the ideas and material to keep the postgraduate courses fresh and stimulating and those ideas, subjects and new directions needed to match the training of our future undergraduates more accurately to the needs of the building construction industry. The cooperation of the professional institutions, and other participants of the CIC, in shaping the requirements for professional qualifications in a way which encourages participation in these courses would be an essential ingredient of the plan.

Resource Implications: The government, through its agencies such as SERC, could reasonably be expected to contribute to such a scheme. The SERC
integrated Graduate Scheme would seem a suitable vehicle for it to cooperate with the industry in funding the courses. It might also be expected that some contribution from the participating students would be forthcoming if the courses were designed and seen to lead to their direct advancement within the professional qualification process and up the career tree of their organisation. Finally, the pump-priming funds needed to draw up outline courses, select centres and underpin courses initially might be most appropriately provided from the funding source named after one of the most eminent persons to combine both architectural and engineering skills, the late Ove Arup.

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RESOURCES

Peter Reed

ARUP
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RESOURCES
Professor Peter Reed

1. Resourcing Higher Education

There are three main sources for funding higher education: the individual who benefits from it (or his or her family), the public purse, and the commercial world (firms of one sort or another). There are also charities, and given the occasion of this seminar, I will have something to say about their possible contribution towards the end.

Different political systems may shift the balance between one source and another but, irrespective of party, years of sub-inflation central funding for higher education have forced institutions to turn more to industry to support their programmes for teaching and research, while means-tested maintenance awards have required greater contributions from the families of students. The introduction of student loans by the Conservative government has increased the contribution to be made by the individual, ostensibly to create wider access to higher education (a non sequitur) and also, or so it has been suggested, to inculcate a sense of responsibility in the student.

Although with political changes there will continue to be adjustments to the pattern of funding, certain things can be taken for granted about the next decade or so - no matter what government is in power - that will have serious implications for the overall resourcing of higher education. The first is that there will be increasing numbers entering the system - all major parties are so committed, and we have already in place mechanisms on both sides of the vanishing binary divide designed explicitly to promote this policy (and, it should
be noted, at little extra cost). The second, which follows in some part from the first, is that there will be proportionately fewer tax-payers to support public expenditure. Not only will educational institutions be taking in more of those who might otherwise be entering employment, at the other end of the demographic scale more people will be living longer beyond the age of retirement. So in the public sector, higher education will be in increasingly severe competition with other services, such as primary and secondary education, pensions and health care, which, on current evidence, enjoy greater favour with the electorate. Only with much enhanced economic growth are we likely to see a real increase in public funding for higher education. A much more likely scenario is that we will have to continue to do more with relatively less. This will mean progressive reductions of unit costs (known as euphemistically as "efficiency gains") and, I suggest, continued examination of the justification for longer courses, such as architecture, or, at least, for their public funding over their full length.

2. The Squeeze on Architecture

Over the last year or so architectural education in particular has been experiencing the early turns of this financial screw. The government has questioned the need for five years of full-time funded academic education for architects, and has suggested that some of this time might be better spent in practice. The argument has been presented as a matter of educational appropriateness, but it also has the implication of shifting some of the financial burden for training onto the profession. Coincidentally the government also found that it had been acting "illegally" in making mandatory maintenance awards to students on Diploma or second Degree courses, and immediately introduced in their place a discretionary bursary scheme, which, although reasonably benign in its implementation, was seen to be a mechanism for control over future spending.

The reaction of the academic body was predictable, that of the profession (as represented by the RIBA) somewhat less so. Heads of Schools of Architecture were (almost) united in arguing the need for the five-year funded academic course and collectively condemned the new financial arrangement. Evidence
from Europe (confused, in my opinion) and elsewhere was used to support the need for the longer course; the curriculum as embodied in the EC Directive was shown to be congested enough as it is; and practice, in general, was found to be incapable of substituting for full-time academic study. Unfortunately these arguments, valid as they may or may not be, are dogged by the taint of vested interest.

The RIBA might have been expected - given its support for the ‘Esher’ Transbinary Working Group proposals of 1984, which looked to stabilise the number of architects entering the profession through a reduction in the number of schools and the imposition of quotas on students entering both Part I and Part II courses - to have found some virtue in a governmental strategy that would have the inevitable outcome of limiting numbers if only through financial stringency. But presidents come and presidents go, and so do members of the council, and to its credit the RIBA in 1990 resisted - to the point of taking successful legal action - the conduct of the DES in withdrawing mandatory grants from Diploma and second Degree students. It should be noted, however, that the outgoing President, while insisting on the inviolability of the five-year course, has since advocated something like the Esher programme for the formation of fewer and larger schools, this time on the questionable assumption that there are not enough good teachers of architecture to go round (another non sequitur, I suggest, unless he is also proposing fewer students or a drastic deterioration in staff-student ratios).

The victory, though not pyrrhic (fortunately for the RIBA’s exchequer), may be short-lived. Given the political will, changes will follow, and - if my reading of the economic future for higher education is correct - these changes will mean that the present structure of architectural education, the means by which it is supported, and the didactic tradition by which it is effected, will all come under such increasing pressure that a radical reformulation of the system will become inevitable. What neither the academic body (at least collectively) nor the professional institution seems to have recognised in reacting to the recent emergency are the longer-term changes in the economic scene which will set the context for what is termed, in the present jargon, the ‘formation’ of architects into the next century. No matter what we, the academics and
professionals, propose as an ideal model for architectural education and training, the outcome will be determined by these wider social forces.

3. The Architecture Curriculum

This Hadleyley Seminar is an opportunity for a radical appraisal of the future, which should begin with certain questions about education and training: What does it, and should it, comprise? Where is it best done? When? By whom? For how long? At what cost? And who pays?

Some of the earlier questions are dealt with by other contributors to the seminar and I will not trespass on their domain. But from my own experience as a student (long ago as that may be), as a practising architect, as a teacher, as an external examiner at a number of schools in this country and as a visitor to several abroad, I am convinced that a significant part of the curriculum which all schools here essay cannot by its very nature be effectively taught and learned in the lecture room or studio. I refer principally to much of the technology of building. That is not to say that students cannot or do not produce convincing drawings and models - often tours de force in their own right - illustrating the means by which their designs may be materialised, but there is a world of difference between the constructional diagram or the services study produced to impress an examiner and the working drawing or specification made with an eye to cost and for which the author carries responsibility onto the building site. Since few would deny that that particular kind of consciousness is an essential part of good design, my criticism has a deeper implication for our didactic method, but the point I am seeking to establish here is that we should not insist that we have the best of all possible systems of architectural education, and that, merely because the government is proposing it, we should not dismiss the possibility of a more fruitful relationship with practice and through it with the processes of building. Incidentally, I do not think this particular issue can be addressed by the common foundation course for all building-related professions, unless that, too, has its feet firmly on the solum.
4. **Resourcing and the duration of the Course**

Since this is a paper about resources I want to concentrate on the last of my questions: Who pays? I hope it is clear from my opening argument that I do not believe the country can or will afford to continue funding higher education at present levels per capita. Whether or not the government dictates a reduction in the length of architectural courses, I foresee two lines of financial attack leading to the same conclusion. The first is that in some way, and to an increasing extent, the beneficiary will have to pay - be it through loans or graduate taxation or some other system yet to be devised. This must increase pressure on longer courses such as architecture. Schools will have to be quite sure - and to demonstrate it to the satisfaction of the students who will be incurring extra debt - that the in-house fifth year is an essential experience for all would-be architects. The emphasis is on the word all. Once we recognise that we have known not a few final-year students who have learned about as much as we had to teach them and who would have profited more from a year in practice than from that last year spent under our tutelage, then the unjustifiable inflexibility of our present system becomes quite obvious.

The second pressure will arise from worsening staff-student ratios. Studio-based learning, with one-to-one tuition over the drawing board, is at the heart of the British method of architectural education. It is, in my opinion rightly, defended as the best means of ensuring the quality of our graduates, and it is the envy of continental schools, such as those in Italy, which can afford neither studio space nor sufficient staff to adopt a similar system (and how, by the way, our economising government must look to such places with gleeful anticipation when we cite them to justify the duration of our courses, for it is well known that although many continental students take longer than five years to qualify, since they have little or no maintenance support from public funds, their academic careers are necessarily interspersed with long periods of outside work to finance their progress). But if unit costs are to be progressively reduced there will come the time when either we will have to forsake this labour-intensive mode, which most of us, and particularly our students, would regret, or we will have to give up those parts of the curriculum that may be effectively experienced at an appropriate time in practice. This again leads to the
conclusion that the length of the course cannot be sacrosanct, and that practice has to play a greater part in our educational system.

5. The Role of Practice

It will be gathered from what I have said so far that I am arguing that there are good educational as well as financial reasons for shifting the balance in providing for architectural education and training, with a much greater contribution to come from architectural practice (and, by extension, from the building industry in general). But can practice take this on? The evidence, such as that produced in a recent report (SCHOSA 1990a) is that under current circumstances practice generally cannot even fulfil its present obligations to employ our graduates in a sufficiently appropriate way for Part III qualification. This is not simply a matter of the slump that is now with us, though of course such fluctuations of the economy have sudden and profound effect on the construction industry and the professions that depend upon it. In my opinion - and this view will not be at all popular with students - it is because practices pay our new graduates too much. Consequently, even in the best of times, the immediate needs of the office inevitably come before the further training of the architectural assistant. And with our current straitened economy we are seeing the effect, in significant graduate unemployment, of the boom years of inflated salaries paid by offices to assistants yet to qualify as architects, so that even our present structure of years-in and years-out is beginning to crack. It will be interesting to see how the schools (with an eye to their FTEs) react this year and next when large numbers of students have failed to meet their requirements for practical experience before entry to Part II courses.

I suggest that it should be borne in mind that new graduates, particularly those between Parts I and II, are still students, and they should be paid accordingly, say at the level of Research Council studentships. This should enable practices to sustain employment during lean years and to invest in education (and in research too) when times are better. If our graduates are engaged as students, then, of course, they must have students’ rights to work to an approved office-based curriculum and to be adequately supervised. There
would need to be some form of contractual commitment from the offices, and if not all offices are able (or willing) to provide appropriate training and experience, then it will be necessary to designate as recognised practices those who can.

Because opportunities for office and site experience vary considerably throughout the country, I doubt that a single blueprint for an alternative to our present system, even if it were desirable, could be achieved. It would be for schools and local practices to work out the most productive relationship available to them, and which their separate economies could sustain. The curriculum would need to have a credit-based structure, incorporating work experience in specified areas. The idea of a minimum duration of the full-time course would then become irrelevant. The emphasis would shift to the level of achievement necessary for entry to the profession rather than the time it takes to get there, and the student could pass from school to practice and back again as the need arose. There should be then a smooth transition to CPD thereafter, in which the schools would be expected to play a prominent part, with short courses and postgraduate programmes based upon their particular profiles in research and higher scholarship.

6. Research and Advanced Study

Such a division of responsibility would challenge the schools to assume the kind of intellectual leadership that is provided for other vocational disciplines by institutions of higher education. That they fail to do so - with notable exceptions - is due to a number of reasons, not least to the demands of labour-intensive mundane teaching of undergraduate material that is best learned on the job. Moreover the relative failure of the construction industry and of the professions to invest in architectural research (and thereby give direction to it) has meant that signaly little of the work that is carried out in the schools has had much effect in the field. Research Council funding in this area is also especially meagre in comparison with the nation’s vast investment in the building construction industry.
Of the resources allocated by the UFC for architecture about 30% is intended to provide for a base level of research in the subject area. Research Councils (prominently the SERC) provide additional support for approved projects, and there is some element (the DR factor) to offset the overheads on these projects. Research in universities is therefore dual-funded. Non-university schools, however, receive no base funding for research, though some have Research Council contracts (but without DR). It would be a revealing exercise to compare the present research output of the schools in the two sectors. To date only the universities have been subjected to research appraisals - which have determined to some extent their funding from the UFC.

All this is soon to change. The DES has signalled its intention to shift the boundary in the dual-support system, with less money for base research in the universities and more to be distributed competitively project-by-project through the Research Councils. Furthermore all major political parties have advocated a "level playing field" across the system of higher education. Polytechnics and Central Institutions should not rejoice too soon, however, for experience in Australia (which has recently gone through a similar upheaval) has shown that the greater selective element has meant that those departments with established research records have prospered even more, while there has been very little money left over to promote a research base where it did not already have acknowledged strength. A similar outcome here ought to mean a general concentration of research funding in the university system - given its present privileged position - or, rather, in some parts of it. This in time could lead effectively to the 'R,T,X' categorisation of institutions of higher education (and therefore of their schools of architecture) advocated for universities a few years ago, by which they would be deemed as funded primarily for research (R), teaching (T), or, exceptionally, for both (X). It should also be borne in mind that the CVCP has calculated that the real cost of research carried out in the universities far exceeds the funds provided through the dual support system - in other words research is heavily subsidised through their teaching programmes. If in the future the Research Councils are to bear all true costs of the projects that they support, then there will be a good deal less research taking place than there is now. It could be of course that the DES will provide more money, but if it were to do so, for the reasons already given I believe it would mostly come from elsewhere in the higher education budget.
The prospect of enhanced funding for architectural research from current sources is therefore most unpromising. I assume that this is a matter of concern. We need only to look at the poor performance of many buildings put up since the war to recognise the dreadful waste - social as well as economic - that may result from ill-prepared construction programmes. It therefore behoves the professions, the schools, and the building industry (with or without government support) to foster advanced study and research into the design, construction, maintenance and management of buildings - perhaps, as has been suggested in a report by Professor James Powell (SCHOSA 1990b), through the agency of an independent Architectural Design Research Council. And if I may suggest it in the context of this seminar, the Arup Foundation might make a suitable contribution here - first in helping to form such a body and then by influencing its programmes in accord with the philosophy of its benefactor.

7. Interdisciplinary Education and Research

Following this cue, in the last part of this paper I want to turn to the matter of joint architecture-engineering education and research. Over the last two or three years the case for some form of common educational base for all professions engaged in the building industry has been gaining ground, with support in government circles. The most recent manifestation is the CNA report Interdisciplinary studies in the Built Environment (CNA 1991) which argues that academic institutions should recognise the needs for:

"a common culture for all students studying on built environment courses ... course organisation that allows flexibility and movement across and between courses ... rationalisation of courses to avoid overlap and duplication ... greater opportunities for students to interchange between courses and defer their choice of specialism ... more advanced levels of specialisation to be developed ... enhanced opportunities for research and postgraduate study".

And it goes on to recommend that there should be "courses which are able to gain exemption from more than one professional body".
It is not part of my brief for this seminar to argue for or against this kind of proposition. It has had a generally hostile reception from the heads of schools of architecture, notably from Professor Peter Carolin who is making his own clarion contribution to our symposium. I should say, however, that my own department runs two parallel undergraduate courses, one orthodoxy architectural, the other, established four years ago with earmarked funding from the (then) UGC, multidisciplinary. The latter is recognised by the professional bodies of architects (for Part I), civil engineers and services engineers. There has been no shortage of applicants, who have the same high entry qualifications as those coming into the architectural mainstream. This year it has produced its first cohort of graduates. We have yet to see, of course, how they will be employed, or what further qualifications and specializations they will seek. It is my hope that the present debate will foster other like experiments alongside the revisions to the structure of architectural education on the lines that I have advocated in the earlier parts of this paper, but I fear the outcome is now more likely to be an imposed uniform system. Our paymasters will call the tune. Deep in the psyche of the DES (if that body can be said to have a mind and soul) is scepticism about the value of much of what we offer as architectural education, and no doubt at all that it is too expensive. I am not sanguine that the working group set up to review the curriculum by the RIBA, following the meeting of the President and the Secretary of State, will divert the government from its cost-cutting intentions, and I believe the government will find in the common foundation course an academically respectable argument for a condensed and therefore cheaper system. It will not matter if the professions require something beyond this, for then the professions, or the individual, or both, will have to pay for it.

With this scenario (and, indeed, my own), as the CMAA report confirms, attention shifts to postgraduate experience (and CPD) for the further formation of architects and engineers. It is not difficult to formulate a wide range of appropriate courses, for many are already in place in one institution or another. But there is one area that is not catered for as far as I know, and it is one that is particularly significant in the context of this seminar. Few would deny the
need for the architect and engineer each to know more about the way the other thinks, and to appreciate better what the other can bring to the process of design. Two of the papers before this group are specifically on this matter. Whether or not the seeds of such understanding are best sown in a common foundation course, it cannot be doubted that it should be a continuing theme in the further education of the professions. There is a clear need for multidisciplinary postgraduate and post-experience courses focussed on the activity of design - I am pleased to see that Peter Carolin and I are at one on this. In present circumstances postgraduate education generally is handicapped by lack of financial support. For home-based students there are a limited number of Research Council studentships (at generally unattractive levels) and some rare examples of commercial and charitable sponsorships. The Arup Foundation could set the lead here, first in helping to set up such courses at selected centres (and I can offer one in Scotland!), and then in providing adequate fellowships for young graduate engineers and architects to take part in them. Such courses, for which demand already exists, would fit well into the pattern which I believe is soon to come - of something like a four year undergraduate course in architecture (and possibly also in engineering, though I leave that argument to my engineering colleague), resourced much as at present, followed by professional requirements for further education, with very limited funding from the public purse.

I conclude by tying this proposal to my earlier suggestion that the Foundation might have a part to play in fostering research, for advanced study must be related to fundamental enquiry into the subject area. In this case the subject area is building design. While SERC, for example, has funded research into well-specified technological subjects - such as elements of construction and energy conservation - there has been very little support for study in the more nebulous areas of design - such as the multilateral interactions that take place within the building system and between it and its environment. Such research is centred on the progressively refined modelling of the building system from a whole range of standpoints, and, by extension, on modelling the professional collaboration of those engaged in the process of design. The postgraduate and post-experience courses would therefore constitute both the field of study and the testing-ground for the associated research programme. Such a
project. I suggest, is worthy of the attention of the Foundation, and would be a fitting tribute to the great man himself.

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Education for the Built Environment
Madingley Hall Seminar Cambridge
11-13 September 1991

FRAMEWORK FOR THE FUTURE

Peter Carolin

ARUP

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FRAMEWORK FOR THE FUTURE

Professor Peter Carolin

1. Introduction

"I suppose", wrote Peter Duncan twenty-nine years ago, "that we could achieve a lot more by looking again at the way that building designers are trained. It is too late to wait for the architect and engineer to be brought together on the battlefield of the drawing-board. They must grow up together to be better able to understand one another's problems."\(^1\)

Duncan, a partner and later chairman of the Ove Arup Partnerships, did not elaborate on how architects and engineers should 'grow up together' but he must have been aware over the ensuing decades of many attempts at combined education. It is my view that there have been far more of these than our critics — and in particular those pressing for a common first degree — realize, and there is much to learn from them. However, in their determination to impose their highly instrumental and short term approach, these critics (from the professions, construction and government) seem unaware of the lessons of the past and somewhat disinterested in alternative view-points.

In writing this paper, I have found myself well and truly hoist with my own petard for it was I who suggested its title. The task is, of course, impossible because any such framework can only be determined by us as a result of considering all the papers and forming a balanced view on them. To do otherwise would be to fall into the same trap as other reformers. I have therefore restricted myself to outlining the context for the current debate and to identifying some matters on which I believe research and debate are necessary.

\(^1\) Duncan P., 'The Importance of Being an Engineer'. *Twentieth Century*, Summer 1962, p. 117.
With the Department of Education and Science (DES) threat to reduce funding for full time architectural education from five to four years, architecture has become the first design profession in the firing-line. Inevitably, therefore, this paper is written from an architectural view-point. I believe however that most of the points it makes concern, to a greater or lesser extent, not only architects but also engineers.

2. The Unconscious Background

The effectiveness and relevance of education, vocational and non-vocational, is widely criticized outside academia. As a result, contemporary proposals for educational reform tend to open with a statement of the problem in terms of the implications of 1992, the incursions of the North Americans or the impact of the Japanese. However, whilst these are important, they are by no means the only issues which should concern our approach to education for the built environment.

Sixty years ago, in his essay on 'Modern Education and the Classics', T.S. Eliot eloquently encapsulated the dilemma facing those who would determine the nature and form of education. 'Questions of education' he wrote 'are frequently discussed as if they bore no relation to the social system in which and for which the education is carried on. This is one of the commonest reasons for the unsatisfactoriness of the answers. It is only within a particular social system that a system of education has any meaning. If education today seems to deteriorate, it is primarily because we have both vague and diverse opinions about the kind of society we want. Education is a subject which cannot be discussed in a void: our questions raise other questions, social, economic, financial, political. And the bearers are on more ultimate problems even than these: to know what we want in education, we must know what we want in general, we must derive our theory of education from our philosophy of life. The problem turns out to be a religious problem.  

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2 Department of Education and Science paper: Future Funding of Architectural Education: Length and Structure of Courses, August 1990.
3 For an example, see Investing in Britain 2001, Centre for Strategic Studies in Construction, University of Reading, 1980, pp. 8-13.
Eliot was not, of course, writing about vocational education, but he could well have been writing about architectural education— for no art is more political or has a greater impact on life than architecture. And the relevance of his writing to our particular dilemma does not end here for Eliot anticipated with impressive clarity both the nature and context of the current debate—an affair which embraces every stage and type of education—from primary to, in our case, vocational.

Writing in 1950, Eliot foresaw: "...the tendency to a universal standardization in education everywhere... (with) greater and greater intervention and control of education by the State..."— something which while familiar elsewhere has not been the custom in Britain. We have only to look at the current dispute on architectural education and at the work of the National Council for Vocational Qualifications (NCVQ) to see how this centralist, bureaucratic tendency is gaining ground. In the former dispute, the DES (under pressure from a powerful 'construction lobby') is in conflict with virtually every professional organization and educational institution responsible for architectural education. Meanwhile, the NCVQ seeks to determine the function of each of our professions and to set standards for accreditation.

One of the implications of Government control is, as Eliot observed, that 'the social purpose' of education will come to be identified with 'the social purpose of the Head of the Department responsible for education.' But it is perhaps not so much the social philosophy of the Government and those encouraging it that should concern us but their cultural predilections.

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5 Eliot's only reference to the education of architects and 'men of a scientific bent'—engineers, perhaps?—stated that it was 'more readily susceptible of precise determination' than that of a man of letters! See Eliot T.S. To Criticize the Critic and Other Writings, Faber 1988, p. 154.
6 Ibid p. 96.
7 Ibid, p. 97.
'Culture' is phenomenally difficult to define. Eliot described it as something of which we can never be wholly conscious — there is always more to it than we are conscious of; and it cannot be planned because it is also the unconscious background of all our planning.'s But he did try to define it and his definition, if you accept it, has chilling implications. 'Culture' he wrote 'may... be described simply as that which makes life worth living... it is what justifies other peoples and other generations in saying, when they contemplate the remains and the influence of an extinct civilization, that it was worth while for that civilization to have existed.'

What then, shall we select for our descendants to contemplate? What would be truly representative of the aims and achievements of Government today? To what, in the boom years of the 1980's, would the contracting side and its most articulate organ, 'Building' magazine, have pointed as a demonstration of what it could achieve? There is only one possible choice and it is London Docklands and the Isle of Dogs in particular. If its vulgarity, insensitivity and waste already shocks our more thoughtful foreign visitors what effect is it likely to have on future generations? Like it or not, the values embodied in Docklands form the unconscious background to all the pressure for change from the National Contractors Group (NCG), the National Economic Development Organization (NEDO) and the DES.10

3. The Market

It is easy for industrialists and politicians to suggest new paths towards public and corporate prosperity. Their focus is narrow, their aims clear and their attitude single-minded. But, as the industrialized housing disaster of the 60's and 70's so poignantly illustrates, the preferences embodied in their solutions can be very different from society's. Aware of increasing international competition, lacking sufficient graduates, and carrying the burden of a substantially de-skilled industry, it is the large contracting firms who are taking the initiative in the formulation of educational policy for the

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8 Eliot T.S. Notes towards the Definition of Culture, Faber 1991, p. 94.
9 Ibid, p. 27.
10 More discriminating developers have exerted considerable pressure for a more appropriate form of development in the later phases.
construction professions. Others also pressing for change include some of the large firms of consultants who have to work closely with these large construction firms. Both these 'sides' of the British construction industry experienced an influx of foreign competitors — primarily North American — during the recent 'boom'. And both groups play a part in NEDO and can thus influence Government education policy.

On the evidence so far, there can be no doubt of the partial and short term approach towards education adopted by these groups. The National Contractors Group report 'Building Towards 2001' falls, for example, to consider or even discuss the role of design in the building process. And in their consultative document on the length of the full-time architectural education course, the DES focus on 'the realities of contemporary practice'. Both the contractors and the consultants representing, as they do, the larger units of their kind, may overlook the fact that both contracting and consultancy are made up of a few (increasingly) large firms and a mass of small ones. Moreover, the large firms very often specialize at specific periods on particular building types such as fast track offices. Such building programmes have very particular demands which do not apply to the bulk of the industry and may not even recur.

But if short term needs should be ignored in initial education (and are best dealt with by continuing joint education), long term trends cannot. Building design becomes even more complex. 'Pour Ledoux, c'était facile; pas de tubes', Le Corbusier is claimed to have said - but today even the 'tubes' are disappearing as architects and environmental engineers struggle to do more with less. Jointly creating both the form and the setting of low-energy buildings. Mutual understanding and a close working relationship are essential.

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11 This has been done through a series of reports sponsored by the National Contractors Group and produced by the Centre for Strategic Studies in Construction at the University of Reading from 1988 onwards.
12 Under the chairmanship of D.Y. Davies, NEDO are preparing a report on architecture education. One of the architectural profession's strongest critics in the Chairman of NEDO's Construction Group, Sir Christopher Foster. An edited extract of his speech to the recent RIBA Education Conference was published as 'Masters of Buildings?'. Building Design, 5 April 1991, pp. 16-17.
14 Richard MacCormac commented on this in his recent RIBA Presidential Inaugural Address - See 'Back to blue shirts and bow-ties'. Building, 5 July 1991, p. 4.
Our relationship with our more expert clients is also changing. The better developers, corporate clients and public authorities have not only done their research but have probably more experience of their particular building type than their design team.\textsuperscript{16} And the shift towards the hoped for certainties of design and build\textsuperscript{17} and the long term attractions (for both customer and contractor) of total service seem inexorable.\textsuperscript{18}

In response to such external pressures, architects are specializing to a far greater extent than in the past. Some architects are responsible solely for feasibility studies or conceptual design and may be required to collaborate with other firms more expert in construction or space planning. Some observers will interpret this as a perfectly logical development which should be reflected in the specialist courses available for 4th and 5th year architecture students. Others will see it as part of the de-skilling of the architect and quote it as yet another manifestation of the profession's continuing relinquishment of responsibility - a process which began 150 years ago and which has left it in a far weaker state than, for example, the engineers or surveyors.

It is very difficult not to concede that there are many - and in particular some of the large contractors - who would be happy to see this reduction of the architectural profession to the role of design - only sub-contractors continue. Indeed, the 'Building Towards 2001' report even proposes that engineers and constructors should be called 'architect - engineers' and 'architect - constructors'\textsuperscript{19} - a piece of cosmetic image correction which any self respecting engineer proud of his profession's traditions would surely reject.

\textsuperscript{17} The number of design and build contracts as a proportion of all forms of building procurement continues to grow each year. \textit{The Architects' Journal} has been focussing attention on this in the issues for 3 July 1991, pp. 5 and 55-53; 10 July, pp. 57-60; and 17 July, pp. 52-53.
\textsuperscript{18} Ridout G., 'All-in-One Outfit', \textit{Building}, 17 May 1991, p. 66 Leader on p. 5.
\textsuperscript{19} Reading, Op cit, reference 13, p. 6.
Rather than celebrate the distinctive nature and the creative tension between the two design disciplines, the authors of the 2001 Report would sink us in a sea of harmonious uniformity - the first stop on the route to mediocrity and a certain way to discourage many talented young applicants.  

4. Educational Concerns

The design professions do not generate new demands, they anticipate or respond to them. In his book, 'The Image of the Architect'\textsuperscript{21}, the architectural historian Andrew Saint shows how pressure from the client has been responsible for the continuing redefinition of both the scope of architecture and the architect's role. The same is surely true of engineers. The pace of such change has become even greater and, given the time-lag between education and practice, it would be folly to educate purely for 'the realities of contemporary practice'. Some far less specific approach concentrating on developing adaptability to change and supplementing this with post graduate and continuing education courses related to current developments would seem more appropriate.

It may surprise some critics, but I believe that architectural and engineering educationalists are among the persons most aware of the need for change and development in vocational education. In architecture, the very nature of project work demands a degree of change and the existence of a majority of teachers who are also practitioners (70% in the case of my Department) brings first hand awareness of change straight to the student. Conclusive evidence of the innovatory change can be found, for example, in the numerous examples of interdisciplinary studies recorded in a recent report from the Council for National Academic Awards (CNAA).\textsuperscript{22}

But there are problems. Architectural educators have found it extremely difficult to find a middle route which both inspires the students and provides

\textsuperscript{20} Student representatives at the recent RIBA Education Conference strongly rejected the common first degree option.


\textsuperscript{22} Collier A et al, Interdisciplinary studies for the built environment, Council for National Academic Awards, 1991.
effective learning opportunities in work outside the studio. Similarly practice has often found it very difficult to fulfil its obligations in pre and post qualification training23 (engineers seem far more effective at this). And within the architectural profession, there is a failure - exacerbated by the technical press — to recognize changes in the architect's role. Over and above all these issues and affecting both the profession and the students is an unwillingness to 'reconstruct (our) professional ideology in the light of (our) true position.'24

Attempts at improving our courses and introducing opportunities for interdisciplinary work must continue: change must remain the order of the day. But the groundwork for such change must be carefully considered and prepared. The difficulty with the current debate is that it is all too often based on hunch and half-truths and fuelled by pride, prejudice and a desire to retain or secure power.25 Essential distinctions are not made, previous experience is not considered and some of the basic data is simply unavailable.26

This is no way in which to reshape education. Rather than suggest a 'Future Framework' for joint education, I will therefore identify some subjects on which research and/or balanced debate is required prior to formulating proposals for the evolution of our existing frameworks for education and training. Some of these will, I imagine, have been referred to in previous papers. These subjects can be grouped as follows:

Discipline differentiation

- Agreed core discipline definition
- Recognition of differing 'mind casts'
- Acceptance of the value of creative tension.

23 This is confirmed by the Standing Conference of Heads of Schools of Architecture (SCHOSA) Report of the SCHOSA Working Group on 'Practice and Education', February 1990.
25 This applies to all parties. For an example see The Architects' Journal, 17 July 1991, p. 9.
26 The architectural profession has only just commissioned the first detailed survey of the profession since 1960. The results will be too late for those working on the new curriculum to be presented to the DES next year.
Educational methods

- Clarification of the difference between education and training
- Establishment of a more balanced weighting of the synthetical and analytical components of design teaching
- Identification of alternatives to a common first degree

Educational context

- Research on previous attempts at joint education
- Examination of the benefits of different kinds of institutional environment
- Study of implications of changes in funding.

Core discipline definition

The central cores of our two disciplines and the extent to which these are unaffected by change must be defined and articulated with far greater clarity than hitherto.

Current discussions on architecture (and, for all I know, engineering) education get side-tracked by concerns over current developments in demand, technology and building procurement. And yet, the fundamental role of the architect is unchanged - he or she is concerned with 'making places for people appropriate to time and place, and forming those critical judgements about making the familiar special, or unfamiliar, or the unfamiliar accessible and intelligible.'

We must find a more effective way of explaining the objectives and methods of our educational process. The time-lag between a development in practice and that by which a student-trained-architect or engineer has an opportunity to put any related learning into practice must be made clear.

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27 This definition was suggested by Clare Frankl at the recent RIBA Education Conference.
Casts of mind

Research on the differing 'mind casts' of architects and engineers must be disseminated more widely.

The inherent differences between the 'mind casts' of architects and engineers are not widely appreciated amongst some critics. There has been research on this subject\(^{28}\) which is already being used to develop more appropriate learning methods.\(^{29}\)

Combined or collaborative education can be positively counter productive if this factor is ignored.\(^{30}\)

Creative tension

The significance of creative tension between disciplines needs to be made clear.

There is much talk of adversarial attitudes and little of the creative tension which, both between and within disciplines, contributes to better design. Among the many panaceas offered are new methods of procurement and the introduction of the continental architect-engineer.

What is the role of the architect engineer? Is architectural engineering necessarily an effective substitute for collaboration between our two disciplines?

Education and training

The difference between education and training must be clearly articulated and responsibilities apportioned for each.

The current debate on architectural education is bedevilled by a failure to agree on what is best taught in full-time education and what is most appropriately and effectively learnt through experience in practice.


\(^{30}\) As is reported to have occurred in the Brunswick Experiment at Leeds Polytechnic in the 1990s.
Education provides 'a foundation of principle and precedent upon which to base future action'\textsuperscript{31} over a lifetime of practice and is the responsibility of the educational institutions. Training in 'the realities of contemporary practice'\textsuperscript{32} is the responsibility of practice or industry.

This matter is not, one suspects, a problem for the engineering profession - but it is a very serious issue for architects.

**Synthetical and analytical components**

*The desirability and method of achieving a more balanced weighting of the synthetical and analytical components of design knowledge should be more widely debated.*

There is frequently in architectural education a division between those 'courses that are taught through mathematics and courses which deal with the creation of architectural form'\textsuperscript{33} - in other words between the lecture theatre and the studio. Others, more knowledgeable than I, state that the concentration on calculation and the analytical approach in engineering is equally damaging.

Effectively linking the lecture theatre and studio can be enormously costly. At a time of reducing resources, the temptation to adopt the continental method of teaching through the lecture theatre is all too often the easy solution.

**Alternatives to a common first degree**

*Alternatives to the common first degree must be identified and evaluated.*

Ignorant of or ignoring some of the unsatisfactory experiences in joint education, the proponents of radical change favour the universal introduction of a common first degree. The alternatives - such as the growing number of collaborative projects, post graduate courses, and the possibility of post qualification courses have not been considered. Nor, in

\textsuperscript{31} University of Cambridge Department of Architecture: *Information for the Visit of the University Grants Technology Sub-committee on 17 November 1986*, Volume 1.

\textsuperscript{32} DES, *Op cit*, reference 2.

\textsuperscript{33} Allen E., 'The Two Priesthoods', circulated in 1991 as an unpublished paper submitted to the *Journal of Architectural Education*. 

7.11
the case of architects, has the introduction of mandatory site or workshop experience similar to that required of engineers.\textsuperscript{34}

Past experience suggests that these alternatives might be far more effective and far less risky than the introduction of a new form of course.

**Combined education experiences**

*A study of previous attempts at combined education - and in particular combined undergraduate courses - needs to be completed and disseminated as soon as possible.*

Combined education for architects and engineers started in Britain at London University's Bartlett School of Architecture over a hundred years ago: it was unsuccessful. More recent failures occurred at the University of Edinburgh in the 1960s and Leeds Polytechnic in the 1960s. None of these experiences are mentioned in the recent CNAA report on interdisciplinary studies.\textsuperscript{35}

There must be a certain amount of documentary evidence available on some of these failures\textsuperscript{36} and the participants in others are still active.\textsuperscript{37} It would surely be unforgivable to launch further combined courses without considering their evidence - alongside that of those who have launched successful courses.

\textsuperscript{34} Architectural students in Denmark have, for many years, been required to have site or workshop experience. A somewhat half hearted attempt at providing similar experience was introduced by the Bartlett School of Architecture in 1963.

\textsuperscript{35} Collier, Op Cit, ref. 22.

\textsuperscript{36} Peter Stringer is said to have prepared a report on the combined Edinburgh course and a number of articles on teaching aspects of these courses were published in the 1960s and 1970s including:

- Hillier W, 'Architects and Engineers - where joint education could begin'. *RIBA Journal*, May 1965, p. 183. This reviewed 'integrated and inter-related courses for disciplines serving the building industry' - a report compiled by the RIBA and published jointly with the ISE and RICS.


\textsuperscript{37} In particular those at Leeds Polytechnic who have been involved in subsequent course restructuring.
The institutional environment

The case for different kinds of institutional environment should be examined.

The provision of architectural and engineering education has developed in an ad hoc manner in Britain. The centralist tendency and a shortage of financial resources suggests a gradual shift to a combination of all-construction-related teaching in very large faculties of the built environment. ³⁸

But there is much to be said for the links and choices which some of the existing arrangements offer for both staff and students. Variety also provides a natural framework for an evolutionary approach. Any rationalisation should take such factors into account.

Funding

A study of the possible long term implications of transferring much of the cost of education from the state to the student must be considered.

Such a change could well bring about pressure from the students to shorten the period of full-time education. It could also hasten the introduction of, in architecture, at least, a two-tier profession similar to that in certain other countries.

It may well be, however, that there are too many imponderables here for a useful study.

5. Conclusion

The industry of which we are a part is continuing to undergo massive change. It is inevitable that this should affect education and training. The NCG have done the industry a considerable service in creating a debate which extends beyond the boundaries of any single discipline. In the present climate they and representatives on NEDO form a highly influential force: they should not therefore be surprised if those of us who are aware

³⁸ 'Investing in Britain 2001' (Ref. 3) suggested that all education for the construction professions should take place in just four centres of the Built Environment each located in a single University and Polytechnic. The latest NCG Report 'Building Towards 2001' (Ref. 13) suggests a less rigid network approach.
of their views (as most in the design professions are not) and disagree with some of them speak up.\textsuperscript{39}

One of the authors of the education and training section of the NCG '2001' report, Professor Derek Croome, has elsewhere\textsuperscript{40} presented a very sympathetic introduction to the report's proposals. Whether or not his introduction and the methods and objectives of the NCG are compatible is a matter of debate. And yet, as he clearly recognizes, this issue is central to our problem - for, unless we can establish some kind of unanimity about such fundamental issues as our attitude towards, for example, technology, ecology and economic values, we shall remain in conflict.

In concentrating our attention on building design, we should not forget construction. The sponsors of the '2001' report clearly hope that its proposal for a common first degree will contribute towards resolving the problem of the graduate intake into the contracting side. But many academics and professionals believe the common first degree to be deeply flawed. It is therefore incumbent upon us to suggest some alternative resolution of the contractors' problem. My own, perhaps naive, belief is that the contracting side desperately needs more engineers and engineering leadership. Every effort must be made to convey the attraction of the challenge of building construction - an industry in which the process of production is the very antithesis of the production line.

An occasion such as this, generously sponsored by the Ove Arup Foundation, is a beginning - an opportunity for clients, critics and constructors as well as architects and engineers - to try to form some shared vision of the future. For, if 'culture is the unconscious background to all our planning', then a vision is the conscious foreground. Subject to research and debate on the issues in the preceding section, my own vision would include the following:

\textsuperscript{39} My own contribution to this debate consists of part of an article 'Unity is Strength' published in \textit{The Architect's Journal}, 28 November 1990, pp. 24-26 and another article provisionally accepted for publication in \textit{Building Design} on 13 September 1991 in which I focus on the proposals for a common first degree.

\textsuperscript{40} Croome D.J., 'Educational futures for the construction industry', \textit{Industry and Higher Education}, March 1991, pp. 35-46.
• a common first degree course (as at Strathclyde) for those who do not yet know which discipline to adopt,
• post-graduate joint education opportunities for those (the majority) who have completed a single-discipline first degree,
• site or workshop experience for all architectural students as a condition for qualification
• recognition that management and business training is a pre and post-qualification activity,
• extensive interdisciplinary continuing joint education opportunities linked to research and related to contemporary building needs,
• the strengthening of the links between individual (single discipline) educational units and all sectors of the construction industry through collaborative continuing education and research.

Rather than run the dangers of standardisation and inflexibility, there would be a wide variety of courses (albeit at fewer institutions), continuous research and experimentation and sensitivity to external needs.

In this way, the wish expressed by Ove Arup at the conclusion of his 1962 RIBA lecture on the architect/engineer relationship would be fulfilled: 'So I end with a plea for a closer understanding, interchange of ideas and collaboration between our two professions, starting at the University and not ending - ever - until death do us part'.

Education for the Built Environment
Madingley Hall Seminar Cambridge
11-13 September 1991

LETTER FROM ONE PROFESSOR OF CIVIL ENGINEERING
to another

Jacques Heyman

ARUP
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LETTER FROM ONE PROFESSOR OF CIVIL ENGINEERING TO ANOTHER
Professor Jacques Heyman

My dear Bill,

The Education of Engineers
or
Universities, vocational training, and the Chartered Engineer

You wrote me a letter enquiring about syllabuses for your proposed new four-year course; in particular, you wished to discuss the question of how far the course should be 'academic' and fundamental, and how much it should expose and teach rules-of-thumb so necessary for the practising engineer. I find this question very difficult, and this must be my excuse for burdening you with a long reply. Since, as you will see, this letter has a hortatory content, perhaps we should start with a text: 'Those that can, do; those that cannot, teach.'

A Professor of Engineering writing about the education of engineers is under a double handicap, one self-imposed and one imposed from without. As a Professor, he has already chosen, apparently, not to do, but to teach; the general world outside, and this specific smaller world of professional practising engineers, will inevitably regard him with suspicion. He then deliberately chooses not in fact to teach, that is, to get on with doing what he is presumably more or less good at, but to write 'philosophically' about what he thinks he ought to be doing. Any views he will express will be regarded with contempt by his younger, brighter and more active colleagues; the very expression of such views indicates to them the onset of senility. Such time as they themselves have to spare from the teaching duties imposed by their professor they devote to research, to scholarship and to the advancement of learning.
However, educational programmes must be questioned from time to time, and such questioning may well be more comfortable if it arises naturally and within a school. Moreover, there are also uncomfortable external pressures for a re-examination of what we teach. These pressures arise from several sources, and are to some extent perennial: in the 1980's, the now-completed expansion of the universities, the relationship of the universities to the polytechnics, and the relationship of engineering education in the UK to that in Europe, all make the pressures acute.

You will realise that the remarks made in this letter are written against the background of engineering education here, in my own University. I should also make it clear that the views expressed are entirely personal; indeed, anyone acquainted with this University, as you are yourself, will not be under any illusion that a collective view might be in danger of being formulated.

The first background fact about this University is that the students are very bright. Almost without exception students have an A-level score of at least AAB, and a great many in the Engineering Department have AAA (of whom some indeed have AAAAA). No matter how these students are messed about by our University system in general, and by the courses arranged by this Engineering Department in particular, they will stay bright, and will be justifiably sought after by engineering firms. When they make good in these firms, the belief is reinforced that this University is a good one in which to study engineering.

We have here, then, a benevolent spiral: we are known to produce ‘good’ engineers, and so good students want to come here. This does not make me feel smug; on the contrary, I feel keenly the responsibility of arranging courses for these very bright young people. My experience is that they can be taught almost anything you please, and very great care must therefore be taken not to abuse the teacher/pupil relationship. I have gone on about this because of course there are differences between the Universities in this country. The University of X, for example, (and I am not disguising a reference to your own University!) attempts to maintain an entry of CC at A-level for its engineering students; in fact, a great many enter with a score of DD.
As you know, our own bright students pursue for their first two years here a general course of instruction, in which we take great pride. Intending civil engineers must take as much thermodynamics as intending mechanical engineers, and the electrical engineer must learn as much fluid mechanics as the structural engineer. Now, the 'vocational' material presented to the student during these first two years will hardly be used by him at any time in his professional life. Our aim is to teach the scientific basis of engineering, and the Second Law of Thermodynamics will not figure largely in the day-to-day work of the consulting civil engineer. Conversely, the wide spread of subjects means that all are taught at a level which, technically, is too shallow to be of help with practical problems.

To be specific, the intending civil engineer will, in his first two years, hardly deal with slope stability, with shearing stresses in thin-walled steel boxes and with the initiation of fatigue cracks from notches, to give but three examples where ignorance at a really elementary level has led to well-known engineering disasters. Moreover, he may never learn about these things should he, for example, decide after two years to devote himself to 'management' subjects, where he may acquire some worthwhile professional skills but will not widen his technical and theoretical background.

Professional training is in fact acquired after leaving the university, in the traditional master/pupil relationship in industry. The apprenticeship over, the pupil's knowledge is tested by the Institutions, and he is admitted as a Chartered Engineer. From his point of view, the examinations set by the University have had only marginal relevance to his present practical expertise; they have, in essence, been a set of hoops through which he had to jump, just as he was required to jump through the A-level hoops to get to the University at all.

Indeed, this pupil's eye view is not incorrect, at least for the pupil who knows that he wishes to become a consulting engineer, or a contractor, or to join a large industrial organisation as a professional engineer. His successful negotiation of the A-level hoops has already established that he is bright, and there is no need of the university hoops to confirm that fact; his time would be better employed in learning specific intellectual and practical skills in his chosen branch of engineering.
None of this, you will say, is surprising. In the debates as to whether or not the universities are the proper places for vocational training (that is, should engineering be taught at universities at all?), it seems to have been largely unnoticed that many universities do not actually give vocational training. A university is a home of scholarship, of learning and of research, and its teaching is directed towards the creation of scholars who will carry on these activities. This is quite clear in such subjects as history or English; some of the top 15 or 20 per cent who get first-class degrees may in turn eventually teach in universities, having first undertaken a course of research, and a few of the others may teach in schools, but by far the largest number of graduates in these subjects will enter professions where little use is made of what they have been taught.

This pattern is true also of the engineering schools in universities, but with one difference. Engineering courses are laid out as tests for determining the next generation of engineering scholars; some of those who pass these tests, that is, not more than 20 per cent (the first class) will go on to do research and may hope one day to advance the science of engineering. The 80 per cent who fail the tests, that is, the typical products of the university, go on, in the case of engineering, to practise engineering. This is the apparent difference between a professional school, as engineering, and an arts school, as history: in engineering, the average graduate becomes an engineer. In either case, however, the average graduate does not make much use of the greater part of his university instruction.

(It may be noted, in passing, that there is perhaps some evidence that a lower-than-average performance in the final engineering examination correlates to some extent with a better-than-average performance in a real life as a practical engineer; certainly a scraped pass degree should be by no means despised by industry. This may be no more than a slightly unfortunate consequence of the fact that engineering courses are not designed for the training of practical engineers.)

For the successful hoop jumpers there is the possibility, in the last two years of a four-year course, of really, and for the first time, getting at the fundamentals of a chosen branch of engineering. This involves the mastery of some fairly deep theory, which can cause distress to some not in the top flight of the class. However, there are compensations; time is now available not only for fundamentals, but for the description (both mathematical and phenomenological) of slope stability, of shear stress and of fatigue. Not only the potential scholar, but also the potential professional engineer who
has braved the rigours of the four-year course, will begin to dig deeper in his understanding of a particular branch of engineering science.

The University of X also teaches in this way, despite the fact that in a bad year they may have no student of first-class calibre (and they maintain very jealously their standards in this respect). The fact is that professors are very keen to teach their subjects in depth, and my cursory historical reading leads me to think that this has always been so. Ever since the establishment of engineering schools in the eighteenth century, the criticism has been made, fairly justly, that professors teach what they find of interest rather than what is necessarily useful. A useful practical course is, of course, very dull, and will be given as a chore by a second-rate teacher and received with boredom by even a first-rate student.

We are now very near the heart of the matter. On the one hand we may have a university, like my own, with bright students who respond to the teaching of the science of engineering; or at least 20 per cent respond, and the 80 per cent who become practising engineers are not too badly damaged. On the other hand, the University of X cannot deny their one or two bright students the possibility of at least being exposed to a scientific course; the staff would in any case leave if they were not allowed to teach at a fairly deep level. However, the majority of students at the University of X is really quite unsuited to an academic course; the learning of specific skills would be of more value to them personally and to the profession than the mastery of rather difficult theory.

But as long as we are talking of universities in general I believe there is really no choice in the matter. It is the duty of all universities to advance knowledge, and in the final analysis this comes down to teaching 'academic', fundamental, scientific courses in engineering, rather than teaching 'practical' courses in the manipulation of the Codes of Practice.

There then, is an attempt at an answer to your question as to the subject matter of a four-year course. The answer may be disappointing and it is certainly conservative; it also seems totally and inescapably wrong. If you in fact, have a class of students determined, most estimably, to become practical engineers, then you are wasting their time, to put it as kindly as possible, by digging deeply into the science of engineering. I conclude from this that it is the educational system that we are trying to administer that
is at fault, and not your courses or the students. We should be asking different questions at a different level.

Here I can only begin to sketch the outlines of the problem. I suspect there will be many solutions, but we must at least start by establishing some common ground of agreement. For myself, I take it that there is a body of knowledge called the science of engineering which is different from the knowledge required to practise as an engineer (although of course one is essential to the other); further, I take it that this science of engineering must be taught. Second, my own experience is that a great number of bright students do not, in one way or another, really wish to master this science, and I believe that there is a large body of students at present at the universities which in fact cannot master the science.

This is a view from within the university. Viewed from outside, it is clear that industry needs a large number of bright engineers, and also a large number of not-so-bright engineers, but not necessarily engineers deeply versed in the science of their subject. I am suggesting here that for the successful running of industry what is needed is clever engineers well trained in their profession, but that perhaps relatively few 'scientists' are required. These scientists will presumably be grouped in universities and research establishments, although there will always be a few in industry; in any case, their number will probably always be larger than that actually needed by the profession both because of the inherent attractiveness of the academic approach and because there will be a minimum size for a viable group.

If the data of the last two paragraphs are put together, then possibilities arise of rather different training programmes for engineers. As a single example, I believe that the basic engineering knowledge required by a civil engineer can easily be taught in two years, and I would be perfectly happy if a first (and for most engineers, final) degree were given at this stage. The graduate would join a firm of consultants or contractors as at present, and would in due course qualify as a Chartered Engineer.

The teaching of the science of engineering would then be reserved for only a proportion of these graduates. Those who obtain first classes at the end of two years (and perhaps the upper half of the second class) could study for a further two years for a second degree, and then in turn acquire practical skills in industry. In fact, there would be a case for reverting to the mediaeval tradition for the training of master engineers; the first degree should be followed in all cases by work in industry, and further academic training given to engineers who are already Chartered.
However, as I said, there are many possibilities for solutions once the problem has been stated clearly. In particular, I think that the respective roles of universities and of polytechnics might emerge rather more sharply than at present, and we could more easily weigh our own professional engineers against those of Europe.

Yours ever,

J. Heyman
Education for the Built Environment
Madingley Hall Seminar Cambridge
11-13 September 1991

PRE CONFERENCE PARTICIPANTS PAPERS

ARUP
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Competence and Professional Standards

The papers prepared and offered for discussion at the Arup Colloquium are very comprehensive in their coverage of the strategic and tactical issues facing the education of the Built Environment Professional (BEP) today. The subjects discussed impinge directly upon many aspects of the work in which we are all engaged. It will of great value and interest to take part in a discussion with such a distinguished and experienced group.

There is little point in reiterating or questioning in this note, prior to our meeting, the issues raised in the several papers.

There are two areas of concern in which a general exchange of views would be helpful. — the possible move of Governmental responsibility from the DoE to the DTI and the emphasis being placed upon the vocational definitions of competence implicit in the work of the DTI sponsored NCVQ. These both raise questions as to the role of the Professions in society, and the responsibility of Professional Institutions for assessing and confirming the skills, understanding and competence of their members.

To assist in the work, the DTI have sought to identify Industry Lead Bodies for each sector. At present the Construction Industry is represented by two such organisations, covering different levels of skill application, the Construction Industry Standing Conference and the CITB. The work of these organisations already shifts a great deal of responsibility for the efficiency and performance of the Construction Industry away from the DoE towards the DTI. In addition the blurring of the divisions between the Universities, the Polytechnics and the Colleges, the opening up of access to courses at all levels, and the emphasis on vocational education and training (VET) also challenges the authority of the DES in controlling and directing the work of some areas in the Higher Education Institutions.
Professionals claim to have a greater ability than their clients in some specialist areas of service, developed by appropriate education and training. The importance of this strategically is emphasised by Muir Wood and Duffy in their paper. The Professional does not work simply by applying given formulae or practising particular intellectual or manual skills. An ability to reflect upon all aspects of a situation without any preconceptions as to its nature is necessary and assumed in Chartered Professionals.

The identification and investigation of particular problems requires an ability to explore, to interrogate, to create abstract models and to test them. This reflective mode of practice requires an objective interrogation both of others and of one's self. At the same time the professional needs to have competence in a particular specialism.

The capable professional needs both reflective skills and technical competence. Conventional education and training focus mostly on the development of technical competence, to the neglect of the personal skills required in the interrogative mode, which are only discovered painfully in practice, sometimes at the expense of clients. These issues, together with the need to encourage and develop the multidiscipline team skills for work in practice, are addressed well in several of the papers, notably in those by Cooper/Stonehouse and by Carolin.

But current Trends in setting educational and training standards is focusing even more attention on technical competence, a need having been identified to improve the skills and abilities of the sub-professional trades and crafts and to encourage the take up of post school education and formal training. The DTI has been encouraging this development since 1981, in various ways, under the general heading of the 'New Training Initiative'. From this has evolved the NCVO, with its focus on National Standards, initially for 'Levels I, II, and III, but recently approaching the professional level via work on 'Levels IV and V'.

Whilst this emphasis may be very appropriate for the general field of 16 - 19 year old development, it has the effect of deflecting attention away from the important area of education and training for the decision making professionals, or, even more disturbingly, of assuming that methods of accreditation and standard setting which may be appropriate for craft training can also be applied to professional training. The present attention to competence based methods of assessment encourages the belief that technical competencies are much more important than general skills. The
difficulties of assessing progress in these general skills further encourages their marginalisation.

It may be of great help in considering the education and training of the 'BEP' to consider how the distinctive, but difficult to define, elements of professional development appropriate to Chartered Professional status could be described and assessed. This problem is not unique to our professions, but has been recognised elsewhere. The present programme of work by the CISC is leading to the development of draft standards for the construction industry by about February of 1992.

I am acting as Project Manager for the working party set up by (CISC) to explore the area of 'Design' for all the built environment professions, and would much appreciate some discussion on the special case of professional qualities and their possible definition. There is a very real danger that these may become down-graded in importance because they cannot be defined in Standards terms, and therefore, according to some, cannot be assessed or taught.
Any discussion about education and training for the construction industry has to take into account the constraints under which we operate in this country. Early specialisation at school often means that students are science or arts oriented very early on. This sows the seed which develops an outlook that sees Architects as non-numerate and Engineers as numerate, whereas in reality both have to deal with problems that require consideration of social and economic issues, as well as technical ones. The Higginson report 1988 recommended that A Levels should be broadened in line with continental practice. There is an increasing number of UK students who are studying for the International Baccalaureat. Architects and Engineers need to have some common understanding about human, economic, social, technical and aesthetic values. Education carries on throughout life and so it is necessary to look at the pattern as a whole covering diplomas, BTec, Degrees at Undergraduate and Postgraduate levels, as well as Continuing Professional Development. Most people will probably agree that at some time some common courses should be taken, but the question is at what stages should this occur. Perhaps periods of specialisation need to either work in parallel with common elements of courses, or perhaps there needs to be alternate periods of study in specialists groups and interdisciplinary groups.

Japanese Universities pay much greater emphasis on general education than we do, in common with the educational traditions of other West European countries, such as France and Germany. Japanese undergraduates must achieve one hundred and twenty-four credits by the end of a standard four year course. Seventy-six of these are devoted to specialist areas of work, eight have to be achieved in a foreign language, four in health and fitness and thirty-six in general education. The general education is concentrated in the first two years of the course.

The construction industry involves Consultants, Contractors and Component Manufacturers. Buildings originate from teams of professionals, including the client, which operate at many levels. There needs to be an understanding about the balance of strategists and tacticians that the industry requires. Graduates are normally thought of as being the likely strategists of the future and technicians and operatives as being...
involved in the tactics and fine detail. One of the most innovative aspects of Japanese higher education are the special training schools developed in 1976 to train a new breed of technicians; they offer general courses open to anyone regardless of qualification. There also needs to be a wider interpretation of the word ‘design’ which not only means conceiving the original building form, but also the process of construction, commissioning, maintenance and building aftercare. Everyone should be educated and trained to be a professional throughout this process; the use of the word professional has been too exclusive in Britain.

If access to courses is going to be easier for people from different backgrounds at all ages, then we have to evolve a less rigid approach to courses. Already there is a trend towards modular courses with national and international credit transfer schemes between institutions. Another aspect of flexibility is making courses more accessible for part-time education. For example, masters courses can be composed of Continuing Professional Development modules so that people can study for extended periods of time, but can also ‘dip into’ courses for appropriate modules. Courses also need to take a broader view of the international scene, especially with regard to work that involves decision-making processes. Tradition has its value but entrenched views are often blinded by caution and open approach to other ways of doing things. It is not only that we need to take an interest in foreign languages from the cultural point of view, but also to see how other countries tackle quality and value for money, besides social and environmental questions.

Britain is again distinctive in suffering from short-termism to an acute degree. The nature of the built environment means planning for the long term as well as the short and medium term futures. These words, however, have different interpretations and long term can mean anything beyond twenty years in Japan, whereas in Britain it is more likely to mean a period of about five years. The financial institutions have a power that sucks away a need to plan for the long term future.

Another aspect of rigidity that we encounter is the professional institutions. Few will doubt the value of having learned societies, but this has to be offset against the power of the separate identity so selfishly guarded by many of the major professional institutions. As regards a development of understanding about interfaces between disciplines they have not been successful. As centres knowledge in specific disciplines some have been more successful than others. As industry and educational establishments examine their ways of working so professional institutions need to do that also.
It is perhaps worth pondering on some of the questions that have been recently raised by the Engineering Professors’ Conference on the quality of engineering education. What are the differences between science and engineering? Should each Engineering Department prepare a clear mission statement of its educational aims? Should educational methods make more distinction between skills, knowledge and understanding? Are methods of assessment relevant to the capabilities that we expect of students? Can the results of certain research into how students learn be brought to bear on the educational strategies that we adopt? Do we overload curricula and force students simply to soak up knowledge rather than digest it and understand it? Do we concentrate too much on analytical subjects like thermodynamics, stress analysis and control theory? Are we using Information Technology effectively in our educational methods? Can we employ quality assurance methods effectively in engineering education? Clearly these are questions that have parallels for architectural schools too.

In Japan engineering is the second most popular subject after social science, but one has to remember that the word engineering has a wider span of meaning and includes architecture, for example. Nevertheless, engineering has a much higher status in many other countries and especially those that are our major competitors. In Britain engineering is not attractive as a profession or as a course for study as perceived by many young people. In Germany it has been accepted that the arts, science and engineering are the three foundation blocks from which fountains of knowledge, skills and understanding have their source. In Britain the foundation blocks are only the arts and natural sciences. Rationalist thinking in Cartesian terms is the hallmark of most science courses. Discovery is largely controlled by experimentation and analysis is a major part of the scientific process. In science the search is for causes of effects. Engineering is about invention, design and production and the search is about processes. Synthesis and evaluation, as well as analysis, are important and engineering is about the creation of successful artifacts and systems to meet peoples’ wants and needs. Scientists try to reach conclusions based on good theories and accurate data, whereas Engineers attempt to make good decisions based on incomplete data, and approximate models. Diversification in education is important so engineering courses may take a more scientific pattern or may be more applied in nature. The distinction is not only one of the course content, but it is also reflected in the teaching methods that are used. Engineers can learn from Architects about the value of project work, whereas Architects can learn something from Engineers about the power of seminars, laboratories, as well as lectures.
The Construction Industry Sector Group of the National Economic Development Office has recently issued a report on professional education and training in the construction industry. It concludes that there is a growing amount of evidence to indicate that the UK uses more resources, manpower, time and money for a given amount of construction output than overseas competitors. The Sector Group set down a series of principles for discussion, which included the following:

- The education process must give all graduates knowledge about the construction industry.

- All Undergraduate Courses for the Built Environment should contain core modules to give an appreciation of business skills.

- There is a need for more industrial experience as part of the education process.

- There should be flexibility in courses so that students can change the emphasis of their work in the Built Environment.

- Academic institutions should review their course content in light of National Vocational Qualifications.

- There should be a facility for students to take a break in their education.

- Industry and academia must improve their working relationship.

- A range of Postgraduate Degree Courses are required to develop specialisms.

- Professional institutions should review their role in the industry.

- A major review of skills needs to be carried out jointly funded by the Departments of Education and Science, Environment and Employment with inputs from industry and the professions.
Designers and Contractors are responsible for the resource demands of the environment they create, whereas owners and occupants are accountable for the waste products they produce. Society is demanding that buildings should increasingly be designed to take into account ecological principles, such as the reduction of pollution, sustainable growth, recycling of waste and energy, energy effectiveness and conservation of resources. The design and construction of buildings is a major part of civilisation and progress in technology should help us to deal with the environmental impact that buildings have on the external and internal environments with no sacrifice of aesthetics. New decision-making systems will have to be developed which acknowledge that social, as well as financial profit, is important. Analysis, synthesis and evaluation will be vital if a holistic approach to environmentally responsive building, engineering and architecture is to be achieved.

In education there is no room for dogmatism but it is certain that the differences between Architects and Engineers have been very much emphasised in education and by the professional institutions. Some have sought evidence from Psychologists that Architects and Engineers have different types of mind and, hence, need to be separated early on in their careers. Others would argue that our systems of education emphasise the left hand side of the brain through writing, reading and arithmetic and tend to ignore the more open ended nature of the right hand side of the brain. The Japanese Violin Schools show clearly that many more people can play the violin for enjoyment even though they may not be of sufficient standard to become a professional. There needs to be a common system of values about the built environment which Architects and Engineers appreciate at an early stage of their development. Course structures and use of the word professional need to be much more comprehensive. The effects of the short termism on the building industry needs to be reviewed with a view to change. A dynamic system of interaction between institutions and industry needs to be derived based on Centres for the Built Environment. There is evidence already that these are being developed in various ways.

Engineers – and these include Consultants, Contractors, Surveyors, Builders – have for too long indulged in narrow technical, commercial and capital perspectives to the exclusion of social and cultural issues. Too often Architects have enjoyed the creation of visual imagery to be exclusion of functional and technological requirements. Neither have put sufficient emphasis on human and wider social needs. Some common ground in education and training is needed at various stages in the education
and training of Architects and Engineers. This requires a more flexible approach to the design of courses by educational establishments, and also requires industry and education establishments to work more closely together. For too long the words 'building, construction, engineering and architecture' have moved uncomfortably together and yet distinctions between aesthetics form and function are arbitrary to say the least. Humani thought and life need the stimulus of proactive and reactive forces to give them creative movement. Education and training have a vital part to play in this process and can only successfully achieved if professionals and educationalists reject entrenched views, tightly specified professional roles in the traditional sense and are open to other methods and ideas, which can enrich the education process.

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Glossary

Educate - Educare (Latin) - to rear
Train - Trainer, traîner (old French) - to drank
Engineer - Ingenium (Latin) - skill, mother wit
Architect - Architekton (Greek) - master builder

Engineering

"Piecemeal social engineering resembles physical engineering in regarding the ends as beyond the province of technology."

The Poverty of Historicism III, 21, Sir Karl Popper.

Builder

"No person who is not a great sculptural painter can be an Architect. If he is not a sculptor or painter, he can only be a builder."

Lectures on Architecture and Drawing (1863), 61, Addenda by John Ruskin.

Education

Education is what survives when what has been learnt has been forgotten."

Education for the Built Environment  Madingley Hall Seminar, Cambridge

Andrew Derbyshire

1. **What is the UK construction industry for?**

To deliver a product that satisfies customers, provides good value for money and creates beautiful and memorable places. An efficient and productive contributor to the national economy — competitive internationally and environmentally friendly. Must cover maintenance and refurbishment, large complex structures, overseas work. Must recognise community needs. Contribution to balance of trade must become positive.

2. **What sort of people does it need?**

A broad range of pre-entry qualifications. Physics essential. Rich mixture of skills — craftsmanship, applied science, art, finance, management. **Nothing if not a design industry.** Strong informal communications across the spectrum. Common attitudes to quality and productivity.

3. **What kind of organisation structure will they work in?**

Wide variety — one man bands, multi- and mono-skilled consultants, public/private mixtures, design and build organisations — in response to the diversity of demand. The trend is likely to continue towards greater integration, large size and functional and geographic diversity at one end of the scale, to small niche practice at the other. Polarisation inevitable. Architects and engineers must penetrate project management.

4. **What are the implications for education and training?**

Variety, integration of skills, common visual and verbal language. Design studio at the core. Emphasise mutual interest rather than differences — they will look after themselves as a product of personality. Art and science both present at all times in different proportions depending on skill. Maximum mobility. Industrial experience essential. Need for stronger research base and closer

Sponsored by The Ove Arup Foundation Organised by The Cambridge Programme for Industry
relationship between the practising industry, undergraduate and post
graduate research. Distinctions between education and training irrelevant.
By far the most serious problems are in contracting and building services
engineering — how can we help?

5. **What can this Conference achieve?**

Papers show high degree of consensus in principle. Intellectual authority of
sponsors and contributors will command respect. Output could be strongly
influential at a time of great change. What are the vehicles we need to
influence? Government and Opposition attitudes to the industry and its
education, training and research needs. Professional institutions — limited role.
Construction Industry Council (CIC) influential. NCVQ and CISC an
opportunity and a threat. HEI's — how do we make better connections?
Building Material Producers and National Contractors Group — not connected
at present to CIC — a problem.

6. **How do we set about it???

The key issue for the meeting.

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the Floor — both Penguin

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Donal Schon 
The Design Studio — An Exploration of its Traditions and
Potentials — RIBA Publications
Bryan Jefferson

'The Ark was built by an amateur – the Titanic was designed by professionals'.

This rather feeble joke exemplifies a deeply ingrained British distrust in experts and professionals. This distrust is not new – perhaps it had its origins in the British establishment's underlying belief in the superiority of the generalist. This attitude still pervades the British Civil Service and has been well documented by others attending the Conference.

The post-war years saw a deep polarisation between organised labour and big business. The professionals found favour with neither, and a similar lack of interest has been evident in successive Governments. More recently, we have seen the growth of the third force – that of the financial establishment. Most worrying has been examples of design organisations attempting to reflect this pattern by the formation of publicly quoted conglomerates struggling to serve three masters – the client, society, and the unseen shareholders.

Thus the biggest educational problem is with Society in its client role. Somehow, public understanding must be heightened to expect and require more of design professionals.

What can we do to improve our abilities to respond to this challenge?

The Construction Industry in the UK is arguably slower, less efficient and more litigious than most in the developed world. How far do existing educational patterns contribute to this dismal performance? Has formal education kept pace with the growing army of specialisations. For example, is the concept of training large numbers of generalist 'architects' really what is needed? Has technological/design education been left to too great an extent to the professional educators?

Many aspects of the problem will be discussed at this Conference. For me, the chief area of concern is to re-examine boundaries – between professional disciplines and also between formal teaching and practice.
For me as an ecologist the key word in the title of the seminar is environment, and there is a disappointing lack of treatment of the environmental aspect of education in the papers submitted. Several authors are calling for a wider basis for education and it is to be hoped that this includes the environmental aspects of building. At least one author comments on the difficulties of separation of professions in education at the age of 15 leading to failure to recognise complementary completeness. The natural environment is a complete network of symbiotic interactions and we can therefore learn from nature around us. Future education of those involved with the built environment must include the need to combine the concrete and bricks with the biological rather than their isolation into separate incompatible compartments.

The environmental crisis which we face today is real and serious in spite of the exaggerated claims of the media and certain extremist environmentalists. The future of building needs to pay greater attention to such items as energy conservation, the use of passive solar energy and the benefits of a green and aesthetically pleasing landscape. The newest building at Kew, the Sir Joseph Banks Centre for economic botany, is half underground and has earth shelter to provide insulation. It also has heat pumps connecting the heating system to the underground water table, which means that it uses far less energy than most buildings of comparable size.

The young are happily much more aware of environmental issues and are ready to be educated. It is only a balanced education which presents development and conservation, the built environment and the natural environment together, that will produce a future quality of life that we would all want to maintain. Failure to think in environmental terms will produce extremists who are unable to produce the equilibrium that is a fundamental rule of nature, and upon which our ability to survive on this planet depends.
Robin Wilson

The formation of the professional in the built environment in the UK generally comprises a period in full time education leading to an approved academic qualification, structured training, continuing part time education and professional experience. Professional qualification is by peer review.

Wider access to higher education courses for those who have studied broader less specialised subjects at school is welcomed but must, if the same degree standards are to be achieved, lead to longer University course. University courses should concentrate on the principles of the subjects taught rather than technical knowledge which has a limited shelf life; even so courses may need to be further extended. Not all those entering a course of full time study will the ability or inclination to complete an honours degree course: it should be possible through a system of credits or otherwise to achieve an intermediate award in a lesser period appropriate to an incorporated level.

The professional in the built environment needs to be financially aware and have management skills in order to play a part in today's Construction Industry: engineering science should be taught in the context not only of design and construction but also of management.

The Construction Industry Standing Conference is currently identifying the skills and levels of competence required for the various tasks undertaken by the professional in the built environment. It is likely that the various professions in the industry will be found to have more in common and less specialised interests; this must lead to a core of common teaching in higher education.

Whatever changes evolve in the education of professionals in the built environment, the range of skills required in conceptual design, engineering construction and project management will not be achieved through a stereotyped process. Variety in the talents of man require variety in his education and training.
Andrew Derbyshire

Post Conference Reflections

Introduction

Looking at my pre-conference paper in the light of the actual event I see no point in trying to cover the whole field - the Conference Report will do that.

We shall not change the structure of the industry and its educational foundations overnight. At this stage in its evolution we should therefore place our hopes in variety and experimentation - not at random, but converging towards the long term aim of a greater degree of integration. Meetings like Madingley will help.

A shared language

Whatever finally emerges there is a fundamental need for better communications and a common language shared by all the constituents of the industry. I see this as based on three elements of knowledge and experience:

- applied science;
- industrial exposure;
- design

Applied Science

There is a major weakness here in architectural education. It should be dealt with by including A Level physics or applied maths in minimum entrance criteria or, if this is not acceptable, a first year crash course - very much a second best. This should be followed up by building technology courses taught by engineers.
Industrial exposure

Most courses include extra-mural activity. But an architect can qualify and start designing without ever having worked on a site, and a builder can start managing a project without ever having worked in an engineering or architectural office. This should be put right as a matter of urgency.

Design

We are essentially a design industry. Architects of course recognise this, perhaps to the dangerous exclusion of other aspects. Engineers confuse design with analysis and few of their courses embody exercises requiring the identification of a design problem, the evaluation of different solutions, and the detailed working up of the final choice. Constructors have allowed the design professions to relieve them of design responsibility during the last century and a half, just as the designers have divorced themselves from construction.

Constructors therefore find it difficult to know when and how to intervene creatively in the design process and designers are often disappointed by the negative nature of their contribution. It is not surprising that our response to the customers' demand for a design and build service is confused and hesitant.

What should we do?

I'm convinced that the only way to understand the design process is to try and do it.

The design project done in the studio as a mimic of real life has been an essential part of architectural education in this country for at least a century and has proved its worth. As a speedy way of bringing science and technology to life it is unparalleled. Professor Donal Schon of MIT has argued convincingly the merits of the design studio as an educational technique of wide application.*

We saw and heard examples at the Conference of the application of this method to engineering education at Leeds, Strathclyde, Manchester and Bath. These were mainly concerned with structural engineering however. What I would like to see is the extension of this educational technique to schools of services engineering, surveying
and building. And of course architects should be employed in these schools as they are in the above examples.

Conclusion

If we could encourage these changes as a matter of priority during the next few years, we might all be talking the same language and working much more productively and harmoniously together in a generation or two.

* Donal Schon - The Design Studio - An Exploration of Its Traditions and Potentials - RIBA Publications
Post-Conference Thoughts

Although there was little about the environment in the pre-conference papers or even in the discussion, I found that many of the architects and engineers present are deeply concerned and involved in environmental issues. I am sure that pressure from your students, who are growing up in a generation concerned for these matters, will ensure that, in future education for the built environment, you include all such issues. I would encourage the Ove Arup Foundation to use some of its resources for this area of interest. The students have an opportunity to stimulate interaction between the built and the natural environment and to address the issues involved. The areas of the natural and built environment were brought together in many ways during the conference.

A useful theory was propounded by biologist Gordon Orians of Washington State University: that the species man evolved in the open savanna landscape of Africa. His study of our ideal garden or landscape showed a distinct preference for the open, savanna-like appearance. It is vital for the built environment to consider this aesthetic side of man's taste. We have had riots in several cities this summer. Among several factors involved is the fact that we have created unnatural and unpleasant built environments as homes for many people in our inner cities. Attention to the Orians theory might help to alleviate this problem.

The garden planner has to think long-term about the trees that are planted. The recognition of this has been forced upon us at the Royal Botanic Gardens, Kew as we replant the trees lost in the storms of 1987 and 1990, and we are planting for our great-grandchildren. This is not quite as far ahead as the North American Indian who constantly thinks of the effects of his actions upon the seventh unborn generation! The built environment must plan long-term in many ways, whether it is in the aesthetic effect of a building, the economic value of building it in an energy-effective way or the practical longevity to avoid the extravagance of frequent replacement.
One of the most important biological principles is that what we do in one part of the ecosystem affects the others. The deforestation of Amazonia affects the British weather. We need a much greater international perspective, whether it is in biological conservation or the building or a human environment. It is all bound together in an intricate web of ecological interactions and we need to heed this biological principle and have a worldwide international perspective to the built environment.
ARCHITECT AND ENGINEER IN PRACTICE

M J Long

We make the mistake of assuming that the roles of the architect and engineer remain roughly the same whatever the nature of the building they are designing. I believe that this assumption is wrong.

The strategic aims for the building and the type of building will have a significant effect on the relative roles of the professional team.

Over the last couple of generations, the role of the services engineer has been changed beyond recognition. He is now responsible for something approaching 50% of a building budget, and he is taking on some of the role of the client; briefing the design team on energy issues.

As a result, the relative roles of the architect and the engineer need careful attention. In my own experience, misunderstandings about the scope and timing of their work have led directly to frustration and inefficient working between the services engineer and the architect and this is bound to have some effect on the quality of building that results.

THIS OR THAT

I shall begin by trying to define some of the strategic aims that must be explicitly identified by the architect and the engineer early in the design process, and then move on to the effect of those early decisions on the pattern of collaboration between them on that job.

What is the nature of these strategic aims? The architect and engineer must between them be explicitly clear about the sort of building they are trying to make. Is it a THIS or a THAT? For instance:

Is it an articulated building or a smooth building? Is it a building in which the parts are sculpturally differentiated one from another, or are they generalized into a more undifferentiated form? In Robert Venturi's writings, this question takes the form: "Is it a duck
or a decorated shed?" (basing the specific question on identified differences within ephemeral highway architecture).

The general form of this question can take many (more specific) forms.

Expression of Units v. Unification of Form:

Stirling's Engineering Labs at Leicester make sculptural events out of the difference in spatial configuration of labs, offices and lecture halls, whereas Rogers' Centre Pompidou subsumes library, art gallery etc. within a single rectilinear volume.

Addition v. Sub-division:

The building can be thought of as a series of units added together to make a whole, or a whole sub-divided into its component parts. Louis I. Khan insisted on the conceptual and visual integrity of the spatial (and constructional) units of a building. The structural system often coincided with a room which then became the spatial and constructional building block of the scheme.

One Style v. Another:

Stylistic propensities carry with them suggestions about the relative 'articulation' of a building. As an example; the English Free School (Shaw, Burgess, etc.) introduced to the world ideas about the "organic" picturesque asymmetrical massing of buildings. It was partly a reaction to the branch of Beaux Art designs which tended to establish large facades behind which the relationship of interior spaces bore little relationship to the facade.

Is it a heavy building or a light building?

Much of twentieth century architectural experimentation has used steel to make lighter and lighter buildings whose weight, precision of manufacture, and assembly techniques can be measured against other industrial products. This in turn has led to the development of cooling systems, shading systems, and sophisticated insulation and cladding materials to counteract the loss of mass.

Answers to these general questions provoke others about the specific role of the mechanical and electrical ingredients of the building:
Are they exposed or are they hidden? At the Centre Pompidou it is the ducts themselves that give the colour, texture, and sculptural quality to the building rather than the components which more usually play that role (doors, windows, walls, columns).

Are the mechanical components constructionally independent of the rest of the building, or are they part of the fabric of the building itself? At Zanuso's Olivetti factory the hollow beams, the distributory ducts.

Where the mechanical and electrical components are visible, are they a demonstration of technical pragmatism (as in a traditional factory) or is there a technical romanticism at work calling attention to the specific formal qualities of those components? The careful composition, detailing, and colouring of the external mechanical components of the Centre Pompidou is highly romantic.

Sometimes a mechanical unit forms part of the basic anatomical identity of the building - as at Louis I. Kahn's Richards Laboratories where the external towers are mechanical units. Where the architectural expression revolves around the identification of a structural unit (as at Frank Lloyd Wright's Johnson Wax building for instance) the visual impact of the mechanical systems is usually played down as much as possible.

This description of alternatives should not suggest that the answers to such questions are immediately obvious, or that they are largely dependent upon the whims and prejudices of the design team. On the contrary, it is only possible to address them sensibly in the light of the particular location, context, client, programme and budget.

For example, the projected life of the building and the strategy for growth and change are critical in the 'articulated v. smooth' argument. One strategy for growth is to identify the different kinds of function which might require future expansion and give each its own identity and expansion space. Another is to make a building within which the functions can play 'musical chairs' when changes in areas and uses are required.
The projected life of the building of course colours this set of decisions. If the building is expected to have a short life, the measure of speculation about its future use is reduced. If the building is to last longer it must survive into a less predictable future. And the mechanical and electrical components are likely to reach the end of their useful life (and require replacement) long before most of the constructional elements of the building.

Cost is also an essential part of the argument, both in absolute terms and in the likely proportional breakdown between constructional and services budgets. A formal strategy which requires an unusual degree of finish or special shaping of mechanical components probably won’t survive in a low budget building with simple environmental requirements.

Having suggested that the design team needs to understand its strategic aims, I will look briefly at the process of design.

THE DESIGN PROCESS

It would be easy to believe that designing involves making a sketch and then making the sketch work (justifying and confirming it). Students spend a good deal of time designing in this way. I believe that a much more constructive model for the design process is Karl Popper’s description of scientific method: you make a hypothesis, and then you test it. You test it (if necessary) to destruction. And if it survives that application of critical judgement (refined - transformed perhaps in the process) it has value as an architectural idea and becomes the touchstone against which detailed development continues through further testing.

Attempts were made in the ’60s to subject the design process to rigorous analytic techniques but these never proved useful in the synthetic operation of design. The judgements involved in the design process are not about linear logic, but about value, and the system of values against which these judgements are made is related to the kinds of issues raised in the previous section of this paper.

This brings us back to the design team. An architect working on a small job on his own is well able to manage the complexity of this operation, because he has all the variables in his head. But a larger building requires a larger team, and the process becomes cumbersome. The “first idea” in the design process can come from a variety of sources. It
can be an idea about environmental control; it can be a diagram of functional relationships, or constructional logic or civic symbolism.

The final design must deal with all those issues and more but there is no single 'correct' order in which they should be considered. The system of logic that links these variables is not a linear one, although each in itself may be susceptible to linear reasoning.

It is usually the architect who makes the first move. He is usually also the one who co-ordinates the 'testing' process. In order to do this effectively on a technically complicated building, he must develop a good understanding with the engineers on the team. Otherwise the redundancy of effort (which is to some extent inevitable in design) will begin to take up too high a proportion of design time to the frustration of the whole team. Good knowledge of each discipline involved is important, but there are bound to be limitations to this knowledge. The hypothesis and its underlying principles must be clear to the members of the team and must be used as their touchstone for testing it (developing the scheme). It is no good testing an architectural proposition with single line mechanical diagrams if the proposal stands or falls on the detailed three dimensional knitting of services. On the other hand it is not wise to expect three dimensional services co-ordination drawings if the terms of engagement do not allow time for such an exercise.

The members of the team must be clear about the timing of decisions in each discipline. Services issues cannot be left so late that the spatial character of the building is changed by late dimensional changes in services, but equally the architect must not, through nervousness, ask too much detail of the engineers while changes in design continue to make that work abortive. Some information will not be available until shop drawings appear, and the programme for design decisions must therefore extend into construction.

The distinction between Architect and Engineer is not very useful here. The real distinction is between the development of the hypothesis and its testing, between strategy and tactics. Both Architect and Engineer can do both. This is not to say that there is no difference between the contribution of architect and engineer to the design process. I believe that the collaboration is productive in direct proportion to the way that they can make constructive use of the differences in their expertise, educational background and points of view.
WHO DOES WHAT

Some examples of specific design issues which must affect the distribution of responsibilities in the design team may be useful here.

I once knew a mechanical engineer who had worked for the Brooklyn Navy Yard during the Second World War designing the mechanical and electrical installations on submarines, destroyers, and minesweepers. His drawings were largely three dimensional: showing ducts that changed in curvature and cross sectional shape as they tracked down the length of the hull.

In that situation it was the extreme precision of spatial demands (not the quality of surface finish) that made the components special. The mechanical engineer (not the naval architect) did full three dimensional co-ordination drawings of all services pre contract, drawing and specifying exactly what was required. Where dimensional tolerances need pre contract confirmation in order to avoid too many post contract variations, something like this service seems to be required of the mechanical engineer (and in the US is in fact more usually accepted as a normal part of the engineer's service).

The development of CAD systems have made it possible for architects and engineers to work more closely together on the production of three dimensional information and the early detection of likely conflicts between construction and servicing.

Where time is of the essence and (or) where the client wants maximum scope for competition at tender stage, the building can be designed with a looser fit between construction and services so that components can be chosen on the basis of tender price. The fact that the physical shape, size and access requirements of the components will not be known until the shop drawings appear is allowed for in building dimension tolerance. In such a case, the mechanical engineer will probably produce single line mechanical diagrams and performance specs.

Then there are the strategies in which the appearance of the services is important to the architectural quality of the result, and here it is more appropriately the architect rather than the engineer also does three dimensional services co-ordination drawings. Where the budget allows and the significance of the component justifies it, the architect is likely to select a component manufacturer, develop the design with him, and include it as a specified item in the contract. Where the budget is limited, the components will have to
come from a standard range. In order not to frighten the tendering general contractor, the design team will have to frame the tender documents in much the same way as if the services were hidden from sight. In this case, the architect will usually want to do co-ordinated services drawings post contract using the components assumed by the successful tenderer. There are bound to be some 'surprises' in this process, and only a good understanding between the architect and the engineer at specification stage can ensure that the surprises lie within architecturally acceptable limits.

Sometimes one member of the design team will be particularly adept or equipped to carry out particular kinds of drawings, and this can be a reason for his doing a particular part of the work. The general point to be made is that services drawings can be done at any stage during the design process. And they can be done by the architect, the engineer, a contractor or a combination of all three. The correct distribution of responsibility for design and three dimensional co-ordination will vary from one job to another and should be directly related to the type of building being produced and particularly to the following characteristics:

- the degree of sophistication of the services

- the tightness of 'fit' between space and services and the acceptable dimensional tolerances

- the extent to which the services are visible in the completed building

- the number of components which require special design or manufacture

- the degree of integration of structure and services

- the size of the budget.

**APPOINTMENT OF THE DESIGN TEAM**

At the present moment, the plans of work and recommended fee scales of the professional institutions do not take any of this into account. The amount and distribution of work of the disciplines is assumed to be the same on all jobs. This poses real problems for both architects and engineers. Detail of mechanical services is often required by the architect earlier in the design process than the mechanical engineer's fee allows. Where the
architect does services coordination drawings, his fee is badly strained to cover it. There should not be a severe fee penalty for designing to save building and services cost.

It is always open to the team to argue for extra fee for unusual services, but I do not believe that these services should be seen by the client as 'extra', but as appropriate to a particular distribution of work and money for that job.

It should be possible to describe a building strategy and design a programme of work appropriate to that end. It would surely help a client understand that time and money spent in one way can save time and money which might have been spent in another. (Balancing time and money spent pre contract against the expense of instructions post contract, for instance).

There are of course firms like Arup Associates which combine all disciplines, ask for a fee for the job and distribute it appropriately among the design team. But it should not be necessary for all professionals to work as members of multi-disciplinary organizations. There are decided advantages in being able to bring a new team together to do a particular job and often the result can have a heightened inventiveness because the team members start without preconceptions about their pattern of collaboration. It is also important not to make it difficult for small firms to survive, and they depend on being able to work in different combinations and associations to make sense of shifting amounts and types of work.

RECOMMENDATIONS

The Conditions of Engagement of the professional team should be scrutinized by the professional institutions. I believe that for each job:

- The team should be asked to do an initial investigation (feasibility study including the early stages of preliminary design) aimed at setting the strategic aims for the building.

- A combined plan of work for that team and that job should then be agreed making it clear how the work will be distributed at each stage (including post contract).

- The proposal for fee should accordingly be related to that specific programme of work and related to the client's overall pattern of expenditure.
I believe that only by doing this will the professionals use each other's talents constructively and the client see that this is being done with reference to his particular requirements.
Corelli Barnett

I was one of the two "laymen" invited by Sir Jack to take part in the conference in order to offer an outsider's perspective on a professional get-together.

In the first place I would judge the conference to have been a general success, measured by the intensity of conversation and argument inside and outside the formal sessions. There was every evidence of people freed for a moment from immediate and narrow professional concerns exchanging ideas, meeting each others' minds, and broadening their outlooks.

Some more specific considerations:

1. I was struck by the frequency with which speakers from the rostrum and the floor tried to divide tollers in the built environment into separate categories with neat professional labels. I overheard one delegate ask another: 'Is he (whoever 'he' was) an architect or an engineer or an applied scientist?' Surely what matters is what 'he' is actually doing. I had a very strong sense of the divisive nature of the established British professions and 'institutions', which sometimes reminded me (during discussions) of the old shipyard unions and the who bores what hole disputes of the 1960s.

2. Except for some speakers such as Patrick Dowling and some comments from the floor, the conference seemed to me very Britannocentric and parochial. There was not enough sense of 'best practice' in the world scene, and the need to match it. Much of the rostrum and floor utterance also struck me as short-term and tactical rather than strategic vision.

3. There was a clear division between academic speakers like the two Cambridge professors grinding the axe of a high academic approach to professional formation, and other speakers who pointed out that it was fallacious to draw an absolute distinction or dichotomy between 'education' and 'training'; and that moreover the British problem lay in having too many highly educated 'chiefs' and not enough well-grounded technical 'Indians'.
4. I have to say as a professional writer that with some notable exceptions, the written papers seemed to me somewhat waffly and full of long jargon words, whereas the basic meat could have been expressed with far greater economy and clarity. What does this say about past and present professional education for the built environment?

5. I liked those who pleaded for greater breaking down of the professional boundaries in working to contribute to the built environment, and also of subject boundaries in education and training ... in particular Cooper’s call for more project work in education and less of the formal lectures and exams, which he reckoned (I would think rightly) were a poor test of general design capability.

6. To sum up, that education for the built environment and the ultimate practice should be product-led rather than category (i.e. professional and institutional) led.
The organisation was excellent. The selection of attendants very good, especially to ensure that the captains of industry treated the occasion with high priority. Eric Ash chaired the conference well but debates were not pressed home, sometimes on account of diversions to instruct the chairman. Any follow up should be chaired by a perceptive private or public developer so that the fundamental objectives of contribution to an improved built environment remain paramount.

It was good to have external critics but a pity that Correlli Barnett had to be so belligerent - this possibly stems from being a military historian; sympathy with fellow-victims of saturation attacks overwhelmed condemnation of defects displayed by legitimate targets.

One important lesson to me is that we continue to use words in different ways. Until there is better understanding of this feature, there will not be a meeting of even those minds which wish to meet. The outstanding example, among many, is the word 'design'. My definition which follows in the well trodden paths by the several reports of, for instance, Alex Moulton, Bob Fielden, Bob Lickley is that design represents the continuous thread through all aspects of engineering (including construction) (planning, investigations, design, building, marketing with iterations between each), using the term in a much wider sense than 'engineering design'. Although well accepted across manufacturing industry the concept is less familiar to civil engineers (e.g. when, two years or so ago, the statement that design should be seen as the centre of engineering education was floated to the Institution of Civil Engineers by the Engineering Council, the word 'design' was changed to 'design and construction' thereby losing the whole point of the sense of continuity that was intended). I believe that it is of quintessential importance that we drive home this concept; it would be easier if we did not have the term 'design' in so many different ways but the English language is full of comparable problems. Once it is agreed that quality of design should be assessed on such a basis, then the inadequacy of the architect's education and training for the built environment - rather than styling of buildings - seems very obvious. The major defect of the engineer's education is, except where efforts are made for compensation, the expectation that all decisions are based on calculation.
This seminar started from the basis of the need for improvement in the education and training of PBEs. Although papers addressed the end product, emphasis was on the process without relating this too clearly to the need of the market (the 'intelligent market' I hope). My belief is that the most urgent need is to articulate the market and coordinate the activities of those who are to contribute to satisfying such requirements. Sometimes I felt that we (and I certainly contributed to this) were criticising the behaviour of the developers (who certainly contribute to the present problems) without attempting to analyse why they have adopted certain of their present practices. While some of these are muddle-headed and accountant-driven, there is an element of rational reaction to inadequacies, and worse, of the services rendered by the PBEs. This is the area of critical importance for attack. After the symposium I know little more about the answers but feel considerably more confident about defining the problems.
Education for the Built Environment
Madingley Hall Seminar Cambridge
11-13 September 1991

REPORT ON DISCUSSION

Christopher Padfield

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ARUP

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1. Strategic issues for the industry

Participants at the seminar were unanimous in observing that British public policy often displays a general lack of strategic thinking with regard to the built environment. In such an environment it is the more important that professionals exhibit a strategic sense, seeing issues both in the round, and in the long view (caring for the interests of the 7th unborn generation, Ghillean Prance’s potent image from his experience with South American aboriginal peoples).

Problems facing the industry have longer time-constants than those characteristic of the democratic process. Compared with systems in ecological equilibrium, the evolution of the industry is highly dynamic.

There was much comment in discussion, and uneasy acknowledgement, that the professional groups most concerned with the built environment — architects and engineers — had responded to the short term climate with rather narrowly focussed sights, ignoring a number of important influences that have a longer time constant, and that threaten to overturn many of the certainties upon which long-standing practices are based.

In particular there was comment that much of the discussion was concerned with internal demarcations, and with very little thought given to studying the approach of others in the world, with a view to learning from and adopting world “best practice”.

Constructors felt that professionals tend to be inward looking and not focussed on major changes in the industry that are changing the rules of the game. Design-and-build is one example. The power-base is shifting to follow trends in the financing of projects, and the growing transparency of international markets. They were disappointed at the apparent lack of urgency displayed by professionals at the seminar, in response to what they saw as massive and rapid changes: better informed clients, lower ambient fee rates from foreign competition, europeanisation, globalisation, and better informed perceptions of quality. A second example cited of an agent for major
change, and one that should be receiving detailed attention now, is the increasing ubiquity of expert systems to complement, and at times replace, professional opinion.

Constructors revealed, as the seminar discussion developed, that they are increasingly concerned about the quality of service they get from design professionals, and its cost effectiveness. The observation on cost effectiveness related both to the cost of the service, and the extent to which designers have a real understanding of construction and the whole life costs of a building.

The constructors were not inclined to lay the responsibility for this on the universities, though universities mirror and perpetuate the divisions that fuel the problem. There is a need for more people in the industry who have a fully developed understanding both of construction and the professional inputs of analysis and design. Increasingly constructors are equipping themselves with their own professionals, organised in multi-disciplinary teams.

While engineers were seen as the most readily inclined to take a narrow view of the range of their competences, architects were seen as most in need of real-world awareness. Unless the professions adapt rapidly, there was seen to be a real possibility that they would be sidelined by newer developments in practice, and rendered uncompetitive by foreign competitors, who play by different rules.

Architects had their own worries on the same lines, fearing that a creeping remoteness from the realities of construction would render inoperative the design cycle, and accelerate the divorce of architecture from form and structure, with a consequent loss of public esteem and exposure on unfavourable terms to foreign competition.

Some felt that there was a role for the Institutions here outside the narrow qualification and entry issues, covered in Section 5, in setting the standard for a multi-disciplinary approach, including an understanding of construction and design.

Engineers were seen as considerably more advanced in this particular respect, with well established practices in initial training for extended placements in different branches of the industry, and comparatively little sense of class distinction between constructors and designers. Many engineering graduates would choose to work for constructors or public authorities, whereas the majority of young architects would expect to work in a design practice, without any industrial placement.
Constructors observed that British architectural fee levels were very high in comparison with international competition, and particularly also with regard to the quality of output delivered. Architects need to find ways of operating profitably at perhaps half their traditional overall fee levels.

Associated with this point were two strong themes:

- the additional cost of working with a fragmented team of diverse professionals, where from the client's point of view a seamless web of professional advice is required.

- the extent to which British architects can be characterised as focussing on creativity rather than serviceable buildings

These matters, and the circumstances that give rise to them are covered in Sections 2 and 3.

2. Does the industry see itself consistently as one industry?

Considerable time was devoted, throughout all the sessions, to a self-examination of whether those present, and practitioners in general within the built environment, genuinely felt themselves to be, and behaved as though they were part of one and the same industry. Are there in fact antipathies and class distinctions that may be more or less deeply rooted? Are the distinctions justified or helpful, and if helpful, to whom are they helpful? Clients need to tie all the elements together: are the professionals helping them, or forcing them to do it for themselves? A subset of this theme is covered in the Section 3.

Some felt the problems were at the joins between different professional or discipline areas, while others felt that to make real progress a much more thoroughgoing examination was needed of the overall institutional structure.
The discussion may be divided into two sub-themes:

- **Divisions between professionals on the one hand, who see their main function as design, and on the other hand, constructors.**

One of the main concerns here is the awareness of short and longer-term costs. Constructors feel that there is little understanding of what is known in manufacturing industry as “design for manufacture”, which integrates concerns of buildability, economy and functionality. There are no quantity surveyors in most other countries because professionals there integrate cost awareness with design.

There are dangers for the client and threats to the survival of the British industry if construction continues to be separated from design. The entire process is a continuum. Constructors increasingly resolve the issue by developing their own multi-skilled teams of professionals in-house.

The demarcations are rooted in people from an early stage in education and training. Construction and construction management issues cannot simply be taught, as universities and schools of architecture often try. They also have to be learned from practitioners, and they have to be learned by taking responsibility for actual site practice. A structured relationship is needed linking studio and site throughout the education and qualification process. Engineering Departments and Architectural Schools rarely have a developed understanding of the whole industry. Some felt that there was little evidence of any enthusiasm for collaboration between Engineering Departments and Architectural Schools, though some notable exceptions were cited.

A suggestion was made that constructors should be invited into Schools of Architecture to teach, and to conduct studio crits of students’ work. Constructors always have a role to play in design, ranging in scope from total responsibility, as in design-and-build, to their need to understand both the design and the principles upon which it is based in complex and highly serviced modern buildings.

Professionals were concerned that competitive tendering tends to distort relationships. In the same way constructors are concerned that competitive tendering based on final designs tends to ignore the expertise available in their organisations, and to lead to a stereotyped relationship on two sides of a professional fence, possibly to the ultimate cost of the client and the British public.
divisions between professional groups, most particularly engineers (services and structural), architects and quantity surveyors.

A major theme here was the set of restrictive practices that each profession defends, concerning fees, concerning liability, and particularly concerning entry to the profession.

The industry was portrayed in discussion as substantially fragmented, with very few design practices adopting a multi-professional team approach. The outcome was illustrated as individual professionals appearing with their armour on, aware of their own share of fee, and ever aware of the possibility of litigation. There was general agreement that the quantity surveyor and the lawyer are winners, the industry and the public were losers. Differing views were expressed about how to proceed.

Most felt that the preferred route would not be to combine the professions as architect-engineers. At its best, the two offered compatible and complementary skills. A constructive tension was evoked. The preferred way involves an education and training system that fosters mutual understanding, respect and complementarity, and adequate mechanisms to organise the terms and inputs of the constituent members of a professional team.

The industry tends to adopt static practices, that fit ill with an increasingly dynamic market. Universities have a role to play in preparing people for this rapidly changing professional environment, rather than encouraging them to see themselves in a particular role. Engineering Departments and Architectural Schools tend to orient themselves towards one institution each, perpetuating the problems. Universities are traditionally slow to adapt, and are anyway inclined to allow their professors to follow their own sense of what is important, rather than forming an institutional response to changing markets. An example of this is the shortage of engineers graduating with qualifications relevant to building services engineering.

There are structural issues involved, particularly in that the RIBA delegate to the Schools the authority to qualify students to professional status at Part I and Part II levels. Engineering Departments need to convince the relevant engineering institution of their calibre, so that their students are exempted from the institution's own qualifying examinations, but they do not dispense professional qualifications.
There was a focussed discussion on the practices adopted by the architectural profession to restrict entry. It was observed by many different participants, from all parts of the industry, that there was a virtual block on entry to the profession, other than through the traditional route of study at Architectural School through Parts I, II, and III. There are no accelerated routes to chartered status for those with highly relevant professional experience, and very few opportunities for people to rise from construction practice into the profession, even if they had taken one of the available combined engineering and architectural Masters courses.

This was contrasted strongly with the practice of engineers who had opened many routes. It was felt that this input of construction skill into the profession must be good for relationships. This issue overlaps in an uncomfortable way the issues of class distinctions within the profession, and the desire for status within the community and the industry. It was felt however that status could no longer be promoted by restrictive practice. On the contrary, unfavourable comparison was drawn with the stricken shipyard unions, that all-but brought down that industry.

On qualification for architects, it was felt that the profession should re-examine whether certification might not once again be centralised; that entry requirements might not include a requirement for substantial site experience with a contracting organisation; and that peer professionals might not be involved in qualifying individuals for chartered status. This was seen as important if the industry is to retain self-regulation, and freedom from government intervention.

The threat of intervention is becoming increasingly real with the development of National Vocational Qualifications at professional level (Level V). These were thought to contrast with current entry procedures that often require a degree of process (attendance for a prescribed period of years at architectural school) as well as demonstrable competence.

There was discussion about possible alternative qualifying routes to the Part II level. RIBA would be likely to prefer to maintain a pure category of “architect” (a legally protected name), with a cluster of supporting specialisations that might be accessed by non-standard routes. There was a feeling that this would not resolve the problem of unhelpful distinctions and demarcations.

There were seen to be too many qualifying bodies, and not enough real educational opportunities for non-standard personal advancement. Little progress would be
achieved until the institutional issues had been grasped. Qualifications should be seen as part of a matrix of opportunity that encourages multi-skilling and mutual respect. It was equally felt that at their best, the Institutions were invaluable, offering a forum that had no equal elsewhere in the world. While great changes were needed, there was no call for their abolition.

It was seen as useful that technicians would shortly all be graduates, as this should be seen as raising the level of the profession as a whole. This issue is pursued further in Section 5.

A suggestion was made that the Foundation could with benefit sponsor some penetrating research and analysis of the industry and its institutions, with particular reference to its sociology and practices. Research of this kind has been initiated before, in Birmingham Polytechnic, but this was felt to be inadequately rooted in the relevant history.

There was a suggestion that if the institutions prove incapable of adapting, the constructors would have to create their own, particularly if the current trend towards integration of financing, construction and design into single organisations continues.

As an aside, and in connection with the funding of research, it was remarked that it would be difficult to obtain money from the CEC until and unless the industry is able to speak with a concerted voice.

3. Are the professions adequately client-centred?

Several themes in the discussion centred around the subject of the service offered by the industry, and in particular by the professions, examining the extent to which they were client-centred (cf. self-serving).

Contrasts were made between British practice and that of other nations, including Germany (higher standards of finish, higher quality of components, more standardisation, greater state control of every aspect of construction), and the USA (“In Britain they design architecture, here we build buildings”).

British architecture was characterised as being more focussed on creativity than many other cultures. The downside of this is arguably higher design costs and the possibility
of problems developing in the medium term as the faults inherent in new systems are tested in the building. Every building is a prototype, even to the point that routine design was identified as a form of research. In contrast, German and American practice was seen as offering less creative buildings, but being based on tried and tested components, they were cheaper to build and to run.

The question was asked: which would an intelligent client prefer?

Good professional practice involves working with a client to tease out the details of the brief, but this kind of relationship is under threat with the increasing use of adversarial competitive tendering, profession by profession. Contracts with professionals are getting damagingly complex.

Clients in general want to achieve world best practice, and as most are commissioning a building for the first and only time in their lives, there is perhaps a need for the industry as a whole to direct considerable attention towards raising the level of understanding and awareness of the built environment within the general community. This might include the conscious provision, for example, of short courses, specifically for clients. One of the features that contribute to the problem in Britain, more than in some other countries, is the small number of architecturally qualified people who opt to work in organisations that are likely to commission new buildings. Most join an architectural practice.

4. The importance of multi-disciplinary capability

While there was very little enthusiasm expressed by any participants in the seminar for the fusion of the two main professions, there was enthusiastic support for exploring ways of developing the multi-disciplinary awareness and competence of individual professionals, and their ability to pull together in multi-disciplinary teams on projects. A central agency in this movement would be the encouragement of serious multi-disciplinary post-experience continuing education provision, covered in Section 5.

The Institutions could play an important part, by organising multi-disciplinary meetings, and going to some lengths to make sure that they are properly attended by professionals from other branches of the industry, including construction and manufacture. There was considerable concern about the extent to which the institutions were becoming a serious constraint upon the ability of the industry to
respond to new circumstances, and multi-disciplinary activity was offered as one way in which the institutions could move into a new set of roles, outside the narrow and restrictive entry and qualification issues.

It was pointed out that teamwork between different professionals groups works particularly well on projects undertaken overseas. This needs to be extended to the home market.

5. Issues of qualification

Three main issues ran throughout the seminar:

- Whether the current system of accreditation to professional status in the different professions was the best, or even adequate, for the industry.

As discussed in Section 2, worry was expressed that the route to professional qualification for architects is very much more rigid and exclusive than it is for engineers, and that process tended to dominate competence. There was discussion about the wisdom of delegating much of the responsibility for certification to the Schools, and the lack of peer-professional review of competence in practice, prior to qualification.

There are very few non-standard routes into and up within the architectural profession, and it was felt that this significantly weakens the profession, by shutting the door on significant talent and experience, and ignoring the need to integrate within the industry rather than maintain an independent purity. There should be many more educational opportunities and routes in and up, as part of a scheme common among the different professions.

There were suggestions that the processes should be harmonised, and that in arriving at new procedures, an analytical eye should be cast over international, and particularly European trends, to ensure the greatest possible degree of convergence.
How to respond to the increasingly felt need for a more clearly articulated grading within the professions, from chartered technicians through to full engineers and architects?

There were felt to be too many chiefs, particularly in engineering, and not enough technicians and incorporated engineers. Highly talented individuals need to be identified early, and accelerated through the profession to maximise their contribution and motivation. By contrast, much technician-level work is currently undertaken by fully chartered engineers and architects, with a consequent de-motivation of the individuals concerned, excessive costs, and a devaluation of the general professional status. The problem is becoming more acute with the increasing adoption of CAD systems. Those professional staff who are only moderately talented at design could previously be employed at the drawing board. Now they are not needed there, and new roles need to be assigned to them in the short term, and new patterns of recruitment and staff development adopted for the future.

In architecture, there was very little in the way of a ladder of professional qualifications, and many of the remarks made above apply, concerning the mismatch between qualification and the intellectual level of work.

The changes in the higher education sector heralded in the recent white paper will result in an almost entirely graduate technician cadre, which should be an asset to the industry as long as the professional qualification ladder is well developed, and well understood by the public. Whereas some feared that this might lead to a further devaluation of the professional status, others felt it could contribute to a general revaluation upwards.

The importance of recognising excellence in technical and design work was mentioned. Often individuals feel the need to move into management, where they may not be so well equipped, in order to advance their careers.
• How to respond to the government’s desire to see open competence-based qualifications become effective even in professional territories?

Unless the institutions respond directly and positively to the NVQ developments, they could find themselves forced into changes without adequate time for proper design and consultation. The NVQ approach consistently values competence above process.

6. Initial education and training

Two questions dominated this theme:

• How should we best pass on experience so that one generation can have a better understanding of the whole business of designing and building?

This has been covered in part in Section 2. It concerns whether the current system teaches an appropriate balance between principles and practice, including creativity, analytical skills, and an understanding of the realities and preoccupations of construction site practice and management. The initial education process must add value in a way that apprenticeship in practice on its own could not. On the other hand, the complete progress towards first professional qualification should involve an integration of experience at school, in practice, and with a contractor.

• Is the difference between the practices of Architecture Schools and Engineering Departments either necessary or helpful?

Some felt that engineers and architects are essentially different groups of individuals, with discernibly different casts of mind. Others were greatly concerned that while there may be trends in this direction, it is more important to develop both characteristics in both groups. The emphasis on difference was seen as one of the major influences leading to the fragmentation of the industry. Both engineers and architects need to master the design cycle, with its expansive and analytical phases. Both need to learn to respect and exploit the attributes of the different halves of their brains. Initial education should introduce concepts, and provide enough techniques, exercises and projects to drive them home, towards the development of understanding.
All professionals should develop a curiosity for parts of the process beyond that in which they are personally engaged. They should neither be obsessed by following rules nor by creativity. Education should relate also to the values of the real world, encouraging a feeling for cost, and for the effect of time, ageing and weather on buildings. Education should result in an individual being able to come to a view in an issue.

The differing practice in Architectural Schools, that typically teach by project in the studio, and Engineering Departments that teach largely by lecture and worked example, received a substantial airing. The consensus was that both had a great deal to learn from the other, both as regards the educational value of the techniques used, and as regards the development of personal qualities needed in professional life. Engineers need to develop design skills, and to be able to think "divergently". Equally, architects need to develop analytical, convergent skills. It was observed that students learn best the things that they have found out for themselves, things learned in context. They learn best when work is fun. In some ways things have become more polarised in recent years. For example, it was observed that it used to be more common than it is now for architectural students to undertake practical construction projects.

It is important that the teaching methods adopted should develop both the convergent and divergent qualities latent in both groups of recruits, rather than accentuating the divergencies that have resulted from secondary schooling. This screening is perpetuated by the early subject specialisation prevalent in the British school system, and the perception, often encouraged by the schools and universities, that sciences map to engineering while the arts map to architecture.

It was felt that while many profound changes might ultimately be needed in the initial education at undergraduate level, more could be achieved in the short term to respond to the problems raised by this seminar by developing a matrix of multi-disciplinary postgraduate post-experience continuing education courses. More would be achieved by evolution than revolution; by education, not control. Several participants gave accounts of the enthusiasm with which engineers respond to design-based Masters courses, and the and the previously unrealised flair that they are often capable of exhibiting.

There was little enthusiasm for a general move towards joint courses, though many ideas were floated for different models of collaboration: for example common first and fourth years of study.
7. Continuing Professional Development

Little benefit in the short term was anticipated from overhauling the undergraduate education system. On the contrary considerable advantage was seen in concentrating on the development of post-experience CPD. This would round out an individual’s education, introducing management and business issues, and multi-disciplinary elements essential to fruitful teamwork with other professionals.

Carrot was seen as more important than stick in motivating people to participate, and perhaps the most important carrot was thought to be the accumulation of credit towards a modular part-time Masters degree. Courses should be assessed.

Experience at Kings College (lawyers and engineers) and at Imperial (medics and engineers) has shown that it is possible to run a multi-disciplinary Masters course for diverse professional groups, provided attention is paid at the early stages to getting them all up to speed in the disciplines where they are weak.

These courses should also tap into current research, providing an essential link between research and practice. There should be a substantial amount of teaching by practitioners. They should to a large extent be project focussed, aiming to extract as much learning as possible from the teamwork between the participants themselves.

The institutions could play a part by running multi-disciplinary meetings themselves, as discussed in Section 4, and by consciously cooperating with universities and the Schools for the development of educationally coherent continuing education programmes.
8. Research

There was extended discussion about the apparently very low spend on research within the industry as a whole, as compared with other major engineering industries, and as compared, for example, with the published figures for Japanese industry.

Professionals felt that regrettably few research proposals originate from the constructors or the manufacturers. On the other hand, few research proposals originating from academia were accompanied by thoroughgoing cost-benefit analyses.

Constructors responded that they in fact spend a considerable amount of money on research that is never published, but which maintains their competitive advantage. If Schools and Departments are to maintain an understanding of the workings of the industry however, it is particularly important that mutually beneficial mechanisms be found for partnership between academic departments and industry for the conduct of research.

There was interest among academics in an industrial levy. RIBA exact a small levy, but it tends not to be spent on academic research. CIRIA operates by a form of voluntary levy, and the possibility that CIRIA might extend its range to cover more fully the building industry was discussed.

Architects appeared from the discussion to regard research as a natural extension of practice, but it may be that the term has a slightly different meaning in that context to that generally understood by engineers. There was some discussion of the relatively undeveloped understanding of building performance (including maintenance and running) as compared with first construction, and of the need for a thoroughly worked-out methodology for the definition of how buildings perform, and for the conduct of research in this area.

The mechanisms for "capturing expressions of need" were felt to be poor. This has become increasingly difficult to pin down, as the most interesting research is now often substantially multi-disciplinary, and it is for this kind of research that is often hardest to obtain funding, perhaps due to the fragmentation of the industry.
APPENDICES

1. Seminar Programme
2. Speakers & Participants

ARUP
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PROGRAMME

Wednesday 11th September:

16.30 - 17.30     Afternoon tea available in Dining Hall
18.30 - 19.30     Reception in Hickson Room
19.30              Dinner in Dining Hall

Thursday, 12th September:

08.15 - 09.00     Breakfast (served until 08.45) in Dining Hall
09.00 - 10.45     Society’s Needs
                  Dr Frank Duffy
                  Sir Alan Muir Wood
10.45 - 11.15     Coffee
11.15 - 13.00     Architects & Engineers
                  Ms M J Long
                  Mr Tony Marriott
13.00 - 14.00     Buffet Lunch in Dining Hall
14.00 - 15.45     Teaching, Research and Training
                  Professor Philip Cooper
                  Professor Roger Stonehouse
15.45 - 16.15     Tea
16.15 - 18.00     Resources
                  Professor Patrick Dowling
                  Professor Peter Reed
18.45 - 19.30     String Quartet
19.30              Sherry in Hickson Room
19.45              Dinner in Dining Hall

Friday, 13th September:

08.15 - 09.00     Breakfast (served until 08.45) in Dining Hall
09.00 - 10.45     Framework for the Future
                  Professor Peter Carolina
                  Professor Jacques Heyman
10.45 - 11.15     Coffee
11.15 - 13.00     Discussion
13.00 - 14.00     Buffet Lunch in Dining Hall
14.00 - 16.00     Conclusions and Output
16.00 - 16.30     Tea
16.30 - 17.00     Summing up
17.00              Seminar closes

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After graduating in Mechanical Engineering Tony Marriott worked for several years as a Systems Design Engineer in the aircraft industry. He made the change to the building industry in 1965, to work for G N Hadec and Sons. He joined Ove Arup Associates in 1969. His particular interests have been the optimising energy and resource consumption and in the thermal performance of building fabric. He became a Director of Arup Associates in 1977 and of the Ove Arup Partnership in 1989.
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