The Ove Arup Foundation

Interdisciplinary Skills for Built Environment Professionals

A Scoping Study

Prof David Gann
Dr Ammon Salter

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THE OVE ARUP FOUNDATION

After Sir Ove Arup died at the age of 92 in February 1988, the Directors of Ove Arup Partnership wished to commemorate his life in an appropriate manner. Many ideas were considered, and the one favoured was an educational trust related specifically to the built environment. The Ove Arup Foundation was formed early in 1989, with Trustees drawn from Sir Ove's partners plus an Arup family representative. For the Foundation's advisory committee, The Royal Academy of Art, The Royal Academy of Engineering (then the Fellowship of Engineering), the Royal Institute of British Architects, the Chartered Institution of Building Services Engineers, the Institution of Civil Engineers, and the Institution of Structural Engineer were each asked to nominate a member. The Trustees then considered how to apply its funds. These were subscribed by Ove Arup Partnership over seven years to build resources that would generate about £100 000 pa in real terms. With the organising help of the Cambridge Programme for Industry, a seminar of distinguished invitees from the world of the built environment was held at Madingley Hall, Cambridge in September 1991. Five architects and five engineers were asked to address five topics and give papers about education for the built environment. This event provided an opportunity for people who did not normally get together to discuss such issues to debate education over two days in congenial surroundings. Additionally, it brought the Foundation to the construction industry's attention, and gave the Trustees many ideas to consider. They decided on a policy of spending about 70% of the Foundation's income from capital on major self-generated schemes, with the rest used to fund external applications or to deal with smaller ventures. This policy continues, though it is subject to review from time to time.

Major Schemes

Discussions at the Madingley Conference pointed up the need for a post-graduate course which would enable practitioners of the various disciplines to work together in a studio environment. The University of Cambridge Architecture and Engineering Departments together proposed an Interdisciplinary Design for the Built Environment course, and this was duly launched in 1994 with 15 students. The Foundation provided two scholarships in the first year and has continued to do so for subsequent courses.

Ove Arup's interest in the environment, particularly in his latter years, was well known. In 1994 Mansfield College Oxford requested the Foundation's support for the Oxford Centre for the Environment, Ethics and Society. The trustees decided to sponsor a fellowship in Environmental Risk, and Maurie Cohen was appointed in autumn 1995 on a three-year term.

The third major scheme stemmed from the London School of Economics, who sought support for the establishment of a new department - unique to the UK - bringing together architecture / planning, engineering, and sociology in addressing the problems of the built environment. This initiative, entitled 'City, Architecture and Engineering' launched an MSc course in 1998 and is generating much interest.

Other initiatives

The Trustees were instrumental in initiating the Edge, a forum in which members of the RIBA and ICE debate matters of national importance and common interest. The two institutions host evenings when invited speakers address a particular topic, followed by discussion.

The Trustees have also, with the support of the Royal Academy of Engineering, initiated a scheme to locate Visiting Professors of Design in University Engineering Schools. Whilst continuing to spend most of their time in their own practice, the Professors devote about 30 days a year to an agreed academic agenda. They are responsible for giving students a thorough understanding of the multidisciplinary nature of design, and for bringing into the design studio practitioners of other relevant disciplines. It is hoped that their influence will permeate the departments in which they serve.

The present Scoping Study resulted from proposals made at a second educational conference, held at the Institution of Civil Engineers late in 1996.

Donations

Listed below are some of the more significant donations made by the Foundation:

- Cranfield Department of Applied Energy - lectureship for five years
- Partnership Awards - prize for teaching engineering for three years.
- Building Experiences Trust (providing experience of the built environment for schoolchildren) - four donations
- Research by Loughborough University into 'How children choose technology' - three years
- University College London Lighting MSc - commitment for four years
- Arkwright Scholarships for students studying mathematics, science and technology - four years and further commitment
- Croydon Clocktower Project (providing hands-on construction experience for children)
- Architectural Association seminar on smart materials
- Manchester Metropolitan University - bursary for a student in Art in Architecture.

Our total financial support to date is around £1M. The administrative costs are minimal because Ove Arup Partnership donates the services of the secretary and financial advisor to the Foundation.

Background photograph: Henk Snoek
Front cover montage: Sean McDermott

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Foreword

In March 1998, because of their concern about the state of education in the construction industry, the Trustees of The Ove Arup Foundation decided that, as a first step, it would be beneficial to try to map the scope of education for the built environment, both for undergraduate and taught post-graduate courses. Professor David Gann was invited to undertake the study and so this report was commissioned.

What started off as a survey has, because of the significant nature of the findings, been extended. The report confirms that there are serious weaknesses in education for the built environment and identifies them. The action recommended is far reaching and will not be easy to follow through. Nevertheless, the Trustees and their Advisory Committee urge that action be taken immediately to improve the quality of education and career opportunities for those entering the built environment.

If the action is not taken, the built environment professions will increasingly fall short of the standards to which they aspire and their clients should expect.

The Trustees

Povl Ahm

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16 February 1999

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Professionalism used to be equated with boundary maintenance - keeping knowledge in the hands of those who know best. Innovation is unlikely to be stimulated by such exclusivity. Would the electronics industry have developed as successfully within such constraints? A more powerful idea is that professions such as architecture should be judged not by how much old knowledge they manage to accumulate but by how good they are at developing new knowledge in the context of action. This argument turns exclusivity on its head: the more professionals share, the more they are likely to learn. The more barriers they cross, the more useful their ideas are likely to be. Such free, purposeful, voluntary, open-ended behaviour will, I believe become more and more valuable in what is bound to be an increasingly knowledge based society - distinguishing the role of the professions from the monopolistic tendencies of big corporations, the centralising inclinations of the State and the remoteness and rigidity of the universities.

Frank Duffy, 1998

Summary

1

The built environment professions (civil engineering, architectural design and engineering, construction management, surveying, building services, planning) face a major challenge.The skills of everyone in the industry must be modernised, and to achieve this it is vital that radical changes in education and training are implemented.

These are exciting times. To create and maintain a modern, healthy, sustainable, and attractive environment for us all to live and work in will be a key endeavour for the 21st century. Fundamental to the achievement of this will be the skills of built environment professionals, who in turn will find stimulating and rewarding careers therein. Both within and beyond the UK, new types of buildings and structures will be required to meet changing social, economic, and environmental requirements.

However, design, engineering, and management decisions are becoming more complex with the need to balance many diverging interests. Changes in technologies, working practices, and markets are forcing the breadth and depth of skills to expand. Professionals are developing new specialist abilities to work with emerging technologies, alongside general skills for co-ordination and systems integration. Many require comprehensive knowledge of previous vintages of technology and systems, and structures and buildings constructed in the past. There is demand for rigour within and understanding between disciplines.

The need for technical and managerial excellence has never been greater. Education and training must change so that interdisciplinary skills can develop progressively throughout careers. Our study aims to stimulate debate, recommend action, and propose more detailed research in areas where information is currently unavailable.

Focus of the study

We focused on built environment course provision in the UK, creating and analysing a database of all graduate and postgraduate courses, together with information from practitioners, academics and employers.

The key issues covered are:

- *changes in skill needs caused by new demands on firms, coupled with organisational and technical changes;*
- *changes in the education system and in modes of knowledge production;*
- *the balance between depth and breadth of knowledge and skills;*
- *trends towards both specialisation and generalisation, which are increasing due to the need for co-ordination and integration of more complex products, processes, and services.*

Key findings: education

- *The number of applicants for built environment courses is falling rapidly. Standards appear to be declining: new entrants tend to have lower grades than in the past. The industry's reputation as a poor employer continues to hinder recruitment of high calibre graduates.*
- *Data on demand and supply of graduate and postgraduate built environment skills are poor. Information available to prospective students about course content and quality is extremely variable and difficult to compare. It is often poor in quality and hard to find, making it difficult for applicants to assess which course to choose.*
- *Many universities provide a wide range of built environment courses, with an apparent great variety in course content. Diversity is good because it provides choice, but the current pattern of provision raises questions about whether there is adequate capability and critical mass to sustain high quality and dynamic courses in so many areas and education establishments. In particular, though there are many courses in building services, provision is generally regarded as poor, with low entry qualifications, great difficulty in attracting students, and few centres of excellence.*
- *There are concerns that quality of technical education is declining and falling behind other countries' standards. In some cases courses may have become too specialised or narrowly focused on meeting short-term industrial needs, rather than educating people for a career in the built environment.*

- *Interdisciplinarity is associated with courses stipulating higher entry requirements in large departments that scored well in the national 1996 Research Assessment Exercise. Interdisciplinarity correlates with good departments and good courses. But courses offering a greater degree of interdisciplinarity in lower quality institutions seem to deliver inadequate basic technical education.*

Key findings: the workplace

- *There appears to be great diversity in skill needs across the built environment professions. There are tensions between the mix of specialist and generalist skills needed by small and large firms, and between those working as specialists in design and production and those responsible for co-ordination and systems integration.*
- *In general there is an unmet need for people with specialised professional skills who also have a thorough understanding of management, communication, and business processes. The extent to which this type of interdisciplinarity is achieved varies among different subject groups.*

Recommendations for immediate action

To achieve major improvement in the reputation and image of employment and a career in construction requires more than cosmetic change. Cultural change has been stimulated by the Latham Review and Egan Report, and by new demands from large, well-informed clients. But design and construction processes still need radical change, and the following actions are vital to improve the supply of well-educated built environment professionals at all levels in the industry:

- *Clients and employers should work together to create attractive employment conditions, and develop better links with universities.*
- *Universities have to improve their image and performance by rationalising provision and raising the general level of quality, not by attracting more students through lowering entry requirements.*
- *Small courses which appear to be under-performing should close.*
- *General reforms of the education system must be implemented rapidly to set high standards and attract the best potential designeers and engineers.*

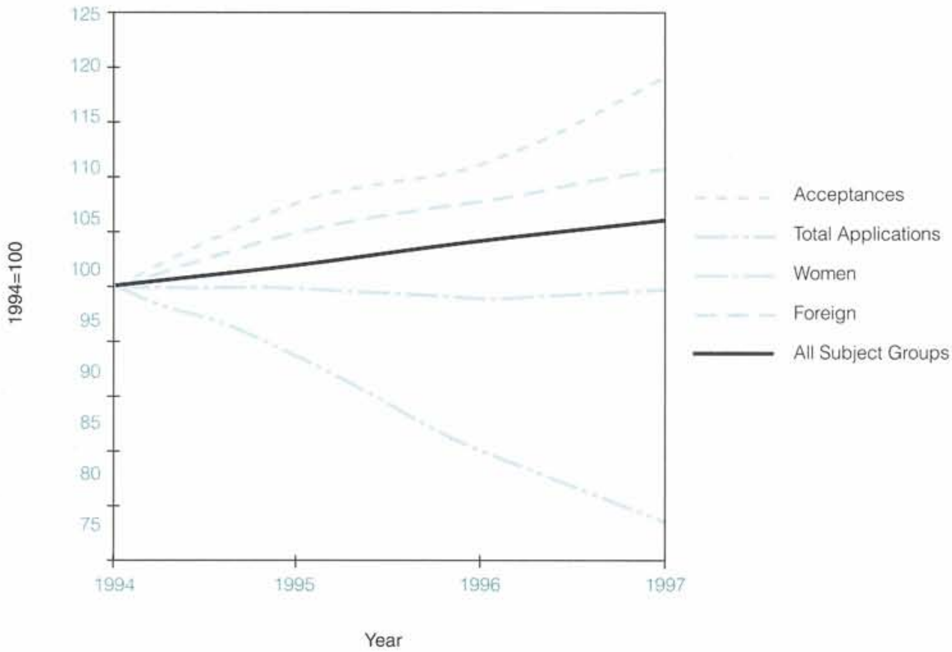


Figure 1: Trends in Enrolment in Built Environment Courses

- *The education system and employers should be more flexible, recognising that people progress at different rates throughout their careers. Everyone must have the opportunity to improve.*
- *There should be a better system for informing potential students about the options available on different courses and how these may be assessed in terms of overall quality and career prospects.*
- *Universities offering interdisciplinary courses should demonstrate how they will benefit current and future career paths. Interdisciplinary modules should be introduced on all undergraduate courses, whilst maintaining basic disciplinary rigour. Employers should sponsor more people to study interdisciplinary subjects in postgraduate courses.*
- *Professional institutions must encourage members to develop new knowledge. They need to take a modern and pro-active attitude towards sharing knowledge across disciplines.*

Recommendations for future research

Data on the changing nature of demand and supply of professionals in the built environment are inconsistent and lack detail. This scoping study resulted in the production of an initial dataset from which the following issues have been identified for further detailed research.

(a) *The changing nature of knowledge and skill requirements is poorly understood in the built environment. We suggest a study which seeks to establish what professionals know and how they know it could be of great merit in helping to align longer-term vocational needs with an appropriate balance of specialist and interdisciplinary education in different skill areas.*

(b) *An understanding of the nature of skills in the context of initial professional practice would show how students apply knowledge on leaving university education in their first workplace activities. This research could track students as they move from education to employment. Over a number of years, they could be followed in their career development to determine what kinds of skills they learnt at university and how these skills were applied in practice. Such a study would assess the knowledge and experience required of course convenors and employers.*

(c) *Not enough is known about the strengths and weaknesses of interdisciplinary education in the built environment, particularly in the context of new postgraduate courses. An evaluation, involving case studies of leading departments could draw general lessons for the development of course programmes.*

(d) *Better knowledge about future demand for professional skills in the built environment is needed to help course convenors and assessors plan new courses and update existing provision. This research should include developing a much better understanding of professional skill requirements in large, medium, and small firms working in a variety of markets and at different points in design and production processes.*

Conclusion

All those responsible for employing and educating people in the built environment need to become involved in modernising the professions. They should challenge professional institutions, employers, and the government to sponsor research and feedback mechanisms. Results are needed to ensure that future provision of education and training attracts the highest calibre people studying the right courses. Failure to do this will lead to a continued decline in quality, inflexibility, inefficiency and inappropriate use of resources. This can endanger the UK's capability to design, construct, and maintain the buildings and structures we need for a healthy, civilised, and prosperous society in the coming century.

KEY ISSUES

- *There is justified concern about the supply of high quality professional skills.*

- *The knowledge individual professionals have of the work of other disciplines appears to be woefully inadequate to meet the needs of modern industry.*

- *Many problems stem from the nature of design and construction processes. There is ignorance and even unwillingness for one discipline to share knowledge, learn from, and understand what another is doing; even the best architects and engineers may not understand how to co-ordinate work in the most effective manner. Specialists do not necessarily understand the consequences of their decisions in the context of integrated systems.*

- *Falling numbers of applicants to courses and a poor reputation for the sector have created new pressures on the UK education system and the construction industry to improve employment conditions and career paths.*

- *Education and training in building services engineering poses the most urgent need for improvement. Expanding markets and increasing technical complexity are creating new demands for design engineering and integration skills at all levels. The education system is failing to cope, with a declining number of entrants, themselves of a low level of attainment, and too many courses with too few students and staff to teach interdisciplinary skills.*

Description of the study

2

Demands on the skills of professionals working in the built environment are becoming more exacting. Built environment professionals have to cope with dynamic environments, whether they are working as designers, engineers, planners, surveyors or production and project managers. New technology and requirements to produce, operate and maintain new types of buildings and structures in changing markets create challenges for educationalists to provide forward looking, responsive courses. At the same time, core skills within the disciplines need to be taught and applied in a rigorous and structured manner.

There is considerable concern that the supply of professional skills required in the production and maintenance of the built environment has not matched the changing needs of the construction industries (Andrews and Derbyshire, 1993). Since the last studies were undertaken in the early 1990s the rate of change in markets, technology, and work organisation has accelerated. New types of skills are required to tackle issues relating to environmental protection and working on contaminated land. Despite strenuous efforts to analyse and cope with the problems of mismatch, it is arguable that the failure of supply of skills to match demand is becoming worse rather than better.

Table 1: Estimates of the number of professionals working in the built environment

Professional occupation	Estimated number
Civil and structural engineers	80 000
Mechanical engineers	51 000
Electrical engineers	43 000
Architects	49 000
Town planners	22 000
General practice surveyors	66 000
Architectural technicians	14 000
Civil engineering technicians	8 000
Draughtspersons	63 000
Building inspectors	8 000
Quantity surveyors	45 000

Source: Unpublished working paper by Stephen Drewer, University of West of England, 1999, based on Labour Force Survey results.

This problem is compounded by difficulties in obtaining accurate data on the number of people employed as professionals in the built environment. The professional institutions keep records of their own members, most of whom have a graduate or postgraduate qualification. But this data does not include all those employed as professionals in the built environment. In Table 1, we have used data from the annualised Labour Force Survey (LFS) for the first quarter of 1997, which includes a more broadly based spread of employment than would be the case within the professional institutions. For example, RIBA claims a membership of just over 30,000, but the estimate of the number of architects based on the LFS data is almost 50,000 (+/- 8000). The total number employed according to this method is 463,000 (+/- 51,000 at 95% confidence interval). This data also shows that 6% of professionals employed were women and 96% were British Nationals: 77% were employed in private business, but only 45% had a degree or equivalent qualification.

Numerous reports and seminars have sought to clarify the educational needs of the sector. But there has been no recent study of the availability of courses for educating built environment professionals, or of the changes in the mix of professional skills required and the quality and quantity of those being supplied.

Whilst construction presents new and exciting challenges to able young people, offering them good prospects in terms of both financial rewards and work satisfaction, its image amongst young people and their parents does not reflect this. The perception is that entry into construction is a more risky choice than entry into professions such as medicine, law, accountancy, or even general engineering. The situation is complicated by the difficulty potential built environment students experience in choosing which course of study to pursue at which university. The UCAS handbook (1998) lists a huge number of courses under a large number of categories at numerous universities. This presents a major difficulty in that it is currently not easy to assimilate what courses are on offer across the board. Neither is it easy to assess which degrees might offer a more forward-looking approach with interdisciplinary courses designed to meet the changing needs of industry. By itself, the presentation of data on courses in the UCAS handbook is likely to be confusing to potential students wishing to make informed choices. The likelihood that a potential student can identify and consider seriously the opportunities in relatively new and exciting areas such as building services must be regarded as remote.

This scoping study was commissioned to provide a critical assessment of the provision of courses in the context of demand for new skills in the workplace. The extent to which needs are met through the provision of new interdisciplinary courses is largely unknown. Moreover, the area is known to be extremely difficult to research because data on both provision and needs is not easy to collect and assimilate.

This report explores the changing nature of education in the provision of professional skills for the built environment, within the general context of a new mode of knowledge production. It asks how we might judge whether the current system meets the sector's future needs. It suggests that there are problems in the current system that need to be addressed, related to the nature of skills, the future of work and the forms of education students receive. It provides evidence about the extent of interdisciplinarity offered in UK universities and explores the relationship between interdisciplinarity and university behaviour. It offers a number of policy suggestions for different actors in the education system to improve the information system for students, the quality of university programmes and relationship between university training and industrial practice. It also indicates a number of future research questions. Answers to these will be necessary to enable professionals, employers and educationalists to plan to meet future needs.

2.1 Research method

This scoping study was conducted by SPRU: Science and Technology Policy Research, University of Sussex, for The Ove Arup Foundation.

Our focus was on graduate and postgraduate education for professionals in the built environment. Many of the issues presented in this report are difficult to research. There is no consistent set of data or informed body of knowledge on current skill requirements. Neither is there adequate information about educational provision. Some of the difficulties of data collection and analysis were unknown and this report therefore represents the results of a speculative quest for new information. We sought to find out whether the current education system provides the right mix of skills for graduates and to what extent courses have been developed which include knowledge of interdisciplinary practices. However, our investigation did not cover detailed analysis of issues such as the value-added through study on specific courses.

In undertaking this study we have carried out the following tasks:

- *created a directory of all built environment graduate and postgraduate courses taught in UK universities (this includes courses in civil engineering, surveying, housing, construction management, building services and architecture); unless otherwise stated, data refer to the 1996 RAE and 1997 course information*
- *provided details where possible of the extent to which interdisciplinary options are available, and where known, the number of students opting for these*
- *made an initial assessment of current provision in terms of interdisciplinarity and concerns over provision of newer subject areas such as building services*
- *conducted interviews to validate the information gathered and to assist in initial interpretation of the directory, identifying gaps in provision, particularly in relation to interdisciplinary education such as in building services engineering*

- *made an assessment of the requirements for a larger, comprehensive study of the demand and supply of built environment education. This assessment may provide the basis for the compilation and publication of a detailed and comprehensive guide for potential student supply and the opportunities offered in British universities, with recommendations for modernisation of curricula.*
- *As part of this research, we explored the literature on skills and education, in design and engineering for the construction industry. The research methods used combined interviews and workshops and the creation of a database of all courses offered in the built environment in the UK. Over 30 interviews were conducted with leading actors in the sector to determine the character of the current system of education for the built environment. Leading individuals from industrial associations, universities and firms in the sector were interviewed. To supplement these interviews, a number of workshops with Ove Arup Foundation Trustees and their Advisors were held to explore the nature of skills in the work environment and the tensions between different actors in the education system. Our initial findings were presented for critical comment at these workshops that included experts representing different professional interests in the built environment.*

Our database was arranged by course. Information about each course was drawn from the UCAS handbook and from course prospectuses. The database also includes the results of the Research Assessment Exercise (RAE) in 1996, conducted by the Higher Education Funding Council for England (HEFCE). The RAE results provide measures of research quality, number of staff and students by department. These RAE results were integrated with course level information to create a composite database for all courses. This database was analysed for particular course characteristics and for differences among universities and subjects of study in the built environment. Other measures of quality of institution were also applied, such as the Financial Times ranking of universities.

The research draws on a considerable amount of knowledge of the education system and skills development in the built environment. Lansley et al. focused on the nature of construction research in universities and mechanisms to support the development of links between universities and industries (Lansley et al, 1994). The Construction Industry Board has recently completed a strategic review of construction skills training (IPRA and University of Westminster, 1998). Gann and Senker have completed a study of construction operatives' skills training (Gann and Senker, 1998), and a Special Issue of the journal Construction Management and Economics presents a series of papers on this subject (Briscoe, 1998). Recent papers have also focused on the need for public funding for research in construction and the role of universities and government institutions in promoting innovation in the construction sector (Gann, 1997). These documents provided background material on issues such as the implications of new technology and business process changes for construction skills.

Concepts of interdisciplinarity

2.2

The concepts of specialisation and interdisciplinarity relate to the division of labour. Adam Smith argued that when economic activities expand there is a tendency towards increasing specialisation (Smith, 1976). This, he said, is because productivity is a function of the division of labour: the famous pin factory example demonstrates how specialisation leads to improved productivity and reduced costs. The tendency towards specialisation is reinforced through technical change that increases the need for yet more specialist technical knowledge in new avenues of technical endeavour. As industry develops, it often creates its own opportunities to introduce new process technologies such as equipment and plant, and Information Technology in today's economy (see Babbage, 1835; Freeman and Soete, 1997).

Yet there are limits to the benefits of increasing specialisation, particularly in markets for one-off, bespoke products. As John Stuart Mill points out, there are diminishing returns to specialisation in markets within which there are high costs to organising a very specialised labour force (Mill, 1968). The tendency toward specialisation creates a tension between the skills and activities of the individual and the need for co-ordination among various actors. In these cases, co-ordination depends upon an understanding of the activities of others and an ability to integrate and manage different sets of knowledge in order to produce successful results. Specialisation has increased in the production of the built environment particularly since the latter half of the 19th century, when specialisms became institutionalised. Professional institutions have acted as the protectors of traditional skills, and have helped to lead the process of accreditation through enforcing mandatory attendance at particular professional training and education programmes. The benefits of this specialisation have been tremendous. Professional institutions have raised standards, supervised new developments in the sector and institutionalised quality control. Yet, such specialisation has also led to a breakdown of understanding between different actors involved in the construction process. As each field became more specialised, they developed their own technical language and understanding. This has hindered communication and the transfer of knowledge across disciplinary boundaries.

Interdisciplinary skills often complement this pattern of specialisation. They provide the means to make connections across disciplines so that processes of design and construction can be seamless. Interdisciplinary skills are particularly important for problem solving in areas where there are a large number of variables, together with high levels of uncertainty and risk. As Nobel laureate, Gunner Mydral commented 'problems do not come in disciplines'. Lack of communication across the professions has hindered problem-solving in construction for many years (Tavistock Institute, 1966). Moreover, new technologies hardly ever function in isolation. Rosenberg, in explaining the interdependent nature of many technological innovations argues that time and again, achieving productivity improvements from a given innovation, depends upon the question of availability of complementary technologies (Rosenberg, 1982, pp.58-60). This is even more the case when considering technological systems, such as construction products and processes, where improvements in performance in one part are of limited significance without simultaneous improvements in other parts.

From a business management perspective, specialist and generalist skills are required. They are not an either/or. For example, businesses specialise in order to limit uncertainty in their operating environment. They also maintain a broader base of more general capabilities in order to manage unknowns when they occur. (Specialist generalists are needed to balance these two requirements.)

In this study we refer to the need for two forms of interdisciplinarity. First, there is a need to understand different scientific and engineering fields. In this sense, interdisciplinarity refers to knowledge across different engineering domains. Second, there is a need to understand knowledge between engineering and social sciences and the humanities. This form of interdisciplinary thinking requires an appreciation of different methods and approaches to problem definition and solving. In both instances, interdisciplinarity involves education which encourages integration of different perspectives into a unified whole. Interdisciplinary work therefore results from the joint and continuously integrated effort to combine two or more specialisms. It involves joint, co-ordinated efforts to integrate lessons from different disciplines (Cooper, 1997).

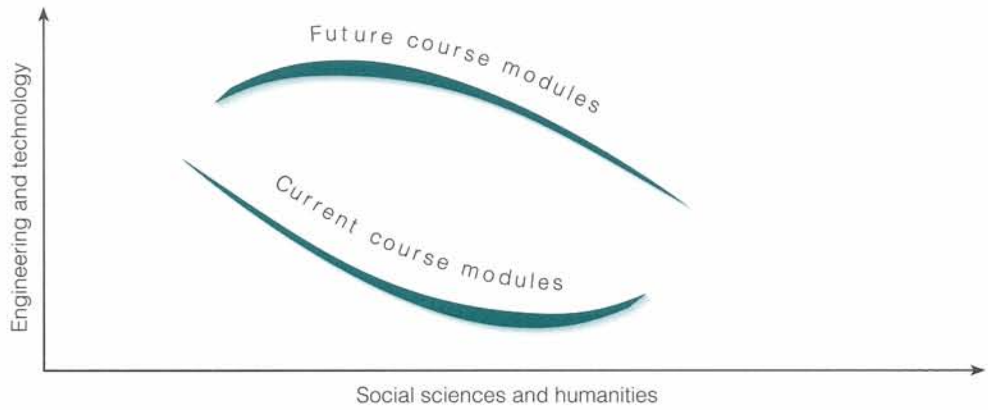
The benefits of interdisciplinary approaches are that they select an appropriate set of concepts, methods and techniques which transcend rather than reproduce the boundaries set by formal (academic) disciplines. In contrast, multi-disciplinary approaches tend to maintain existing fiefdoms of academic knowledge, thus reproducing boundaries. The danger here is that each discipline exports to the collective endeavour its entire theoretical baggage, and not just the slim suitcase that may be hoped for (see Cawson et al, 1990, pp. 9-13).

The characteristics of interdisciplinary courses are that participants (students and educators):

- *are drawn from diverse disciplinary backgrounds*
- *work in joint projects or practices*
- *share perspectives of different disciplines, both theoretical and methodological*
- *are capable of seamless outputs, that is, undifferentiated by discipline (Cooper, 1997).*

The types of courses which may be beneficial to assist in the development of competencies for systems design and integration in the built environment are shown schematically in Figure 2. There are likely to be tensions between subjects which have a strong technical base (eg structural design, soil mechanics, electrical engineering) and those which have a strong social science base (eg economics, management, law). To practise at a senior level as co-ordinator, manager or systems integrator in design and production of the built environment will almost certainly require detailed knowledge of some of these disciplines, combined with a

Figure 2: Tensions between engineering/technology, and social science/humanities in current and future course modules



general understanding of most. It will also require an ability to know the limits of each in terms of their contribution to problem solving. In most cases there is no substitute for a rigorous technical background in a particular discipline, and interdisciplinary skills may often be better taught in postgraduate courses.

Many interdisciplinary programmes are themselves harbingers of new disciplines. As technologies change and new scientific fields emerge, many new combinations of disciplines develop, such as computer science or X-ray crystallography. At first, these programmes are 'interdisciplinary' but, as they develop, they become disciplines in their own right. The line between interdisciplinary and disciplinary can become blurred through time as new fields emerge and develop. That being said not all, new interdisciplinary fields eventually become disciplines. The rise of new fields of study puts pressure on the education and professional system to be reflexive, that is, to respond to new opportunities or developments (Rosenberg, 1994). American universities have in general been more proactive to such opportunities than their British counterparts.

The British system of education and professional institutions can, at times, be inflexible and limit the development of new areas of knowledge. New fields of knowledge can upset the established order and can be a point of controversy. Traditional disciplines often discount the value of new interdisciplinary subjects - for example, electrical engineering's traditional distaste of software engineering. In this respect, the education system needs to allow for some measure in variety, in which variety can be the source of new ideas, disciplines and forms of knowledge. Variety also can act as a counterweight to the centralising tendency of existing disciplines and professional institutionalisation.

The organisation of graduate and postgraduate education in universities appears to be extremely fragmented and there appears to be a great deal of variety from which to choose. Yet most disciplines are governed by professional institutions which exert influence over accreditation of courses. Understandably, institutions are concerned to promote progress, but at the same time defend and protect their own territory.

The nature of organisational and technological change in the production of buildings and structures is such that knowledge requirements cross established boundaries and often render them obsolete. In view of the rapid rate of change, it is possible that the net effect has been that boundaries are defended to a greater extent than the progress of industry has been promoted.

There may be a danger here implicit within the new Standards and Routes to Registration (SARTOR) arrangements (Engineering Council, 1997a). In order to raise standards in engineering, the Engineering Council has promoted SARTOR regulations. SARTOR is a list of regulations about courses that all departments must follow if they wish to have a certified engineering degree. The SARTOR approach focuses on ensuring that only high quality engineering programmes are certified and that certified engineers have a minimum knowledge base. The effects of SARTOR on the UK education system are, as yet, unknown. It is likely, however, that they will lead to the de-certification of many engineering programmes. The consequence of reduction of certified engineering programmes may improve the quality of the UK education system, but such an approach can have costs. SARTOR is regulation from the top-down. It sets out the curriculum that engineering departments must offer to their students. Whilst maintaining high standards in specific areas, such a curriculum may limit opportunities for development of new interdisciplinary courses. New fields of knowledge are often interdisciplinary and the value of these fields is difficult for the current disciplines to recognise. Many initiatives to provide educational opportunities in new areas - in particular, the key and growing area of building services - have been undertaken by enterprising educational institutions with relatively low status and prestige, presumably perceiving new and growing interdisciplinary areas as opportunities. However, they have not generally been successful in attracting high calibre students. Programmes seeking to develop interdisciplinary courses may be excluded from the SARTOR process and this may act to limit innovativeness in course design. Whether such outcomes will occur in the process of raising standards in the UK education system is likely to require further analysis.

The desire to measure performance in research may also affect the level of interdisciplinary research among UK universities. A recent survey commissioned by HEFCE on the impact of the RAE shows that interdisciplinary research is pervasive, involving one in four researchers (Evaluation Associates, 1998). It shows that academics cannot easily be classified as single discipline or interdisciplinary – many are both. The survey shows that there is a widespread belief amongst researchers that the RAE inhibits interdisciplinary research. This perception appears to come from a belief that RAE review panels were discipline-based, and therefore unlikely to recognise the value of interdisciplinary work, the report suggests. The survey results show that academics feel that the RAE has limited their ability to conduct and develop interdisciplinary research. Despite this, the survey shows that interdisciplinary research and teaching is pervasive. Moreover, evidence from HEFCE suggests that interdisciplinary departments won roughly the same scores on the 1996 RAE as single discipline departments. The report suggests that the RAE in 2001 needs to ensure that review panels are sympathetic to interdisciplinary research and include a wide number of disciplines. The results of this study point to the need for continuous awareness of the problem of fitting in interdisciplinary training and research to new mechanisms of regulation or measurement in the university sector. Lessons from this experience for SARTOR would suggest that people with a broad view across disciplines should be appointed to implement the regulations.

We believe that although interdisciplinary skills are important, students need a background in the essential skills of their discipline. Interdisciplinarity is not a substitute for a lack of technical skills. In fact, interdisciplinarity offers a complement to specialised skills. It allows these skills to be more fully developed through their integration with an understanding of practices of others.

In order to understand how these factors are shaping the supply and demand of built environment professionals, better information will be required, particularly if we are to develop policies for managing in a changing world.

2.3 Growing importance of interdisciplinarity

As we have seen, interdisciplinarity is a consequence of complexity. An increasing number of specialisms are emerging, for example, fire engineering, acoustical engineering, space planning, environmental engineering, vertical transportation specialists. Yet working in the modern world of building and construction requires knowledge about how to combine this mix of complex technical, social and economically interdependent systems. The built environment includes many systems of different vintages, often in a continuous state of change. At times, it is necessary to renew existing infrastructures or develop new ones to meet different economic, social and technical needs. To handle complexities of interdependent systems, a significant proportion of professionals need some systematic, integrative competencies to see the connections between different complex systems. Such concerns about increasing complexity and the need for interdisciplinary professionals in the built environment have been raised in a number of recent reports including Madingley and the CIC work, led by Sir Andrew Derbyshire.

Table 2: IGDS courses in construction and the built environment

Course	University
Construction and Developing Innovation by Collaborative Competition	Glasgow Caledonian/Strathclyde
Construction Engineering Design and Management	Nottingham Trent University
Contaminated Land Management: Assessment, Investigation and Remediation	Nottingham Trent/ Nottingham University
Environmental Engineering	Portsmouth University
Intelligent Buildings: Design, Construction and Operation	University of Reading
Non-Handicapping Environments - Design and Management	University of Reading
Corporate Real Estate and Facilities Management	University of Reading
Construction IT	University of Salford

Source: EPSRC.

One profession which illustrates the importance of a rigorous discipline coupled with strong interdisciplinary skills, is that of building services. Building services includes design and engineering of mechanical, electrical and increasingly electronic systems within buildings and structures. These systems are used to control and condition the internal environment, and include: heating, ventilation, air-conditioning, refrigeration, plumbing, electrical supply, lighting, and communications and control. Work for building services professionals includes management of systems integration and assembly, commissioning, maintenance and operation.

Building services work has become increasingly important over the past 25 years. Markets have diversified and grown through demand for more precise control over heating and ventilation, air quality and comfort, fire protection, access and security as well as for interactive communication systems. The cost of building services has increased as installations have become more sophisticated, and in some cases this area of work accounts for a substantial proportion of the initial capital costs of new buildings. The market for building services has expanded rapidly from around 7% of all construction work in 1973 to 20% by the late 1980s (Gann, 1989). It now accounts for almost 25% of the value of work done by contractors (Housing and Construction Statistics).

Systems are being deployed in a wider range of building types, including housing, with the introduction of 'smart-home' and 'telecare' facilities (Barlow and Gann, 1998). When measured over the lifetime of a building, these systems may be replaced three or four times, with more frequent reconfiguration and replacement of subsystems. This adds considerably to total installed costs over a building's lifetime. However, the issue of most importance is the impact of building services systems on overall operating costs. Highly skilled systems engineers can therefore have an important impact on overall costs. Moreover, the need to reduce environmental pollution through energy and emissions control in buildings has been an important driver of change. This has resulted in the need for greater technical knowledge in specialist areas as well as the ability to work across disciplines, such as with architects and structural engineers in design of 'passive ventilation systems'.

Component and equipment suppliers are playing an increasingly important part in overall design and construction processes. Manufacturers of once simple components are providing more sophisticated products and systems. They are also developing new services in order to deliver them. The manufacturing supply-base includes a number of powerful multinational companies and there is a balance of trade deficit in most building services components. This form of industrial restructuring is creating additional demands on the skills of building services engineers, with new competencies required in a wide range of technical areas from computational fluid dynamics and simulation to programming of logic controllers.

Changes in the skills base of building services professionals are typified by two contrasting trends: the need for generalist knowledge in understanding systems; and the need for increasingly specialised skills in particular technical areas, such as lighting, ventilation, or controls. Technological innovation plays an important part in forcing the pace of change in building services. The fusion of mechanical and electrical technologies in new integrated systems gives rise to the need for knowledge spanning two formerly separate disciplines (see Kodama, 1992). This, coupled with the introduction of digital communication and microprocessor control technologies has increased the complexity of work, particularly in markets for so called 'intelligent buildings' (Gann, 1992). In the next century the use of biotechnology products and systems is almost certainly going to increase the areas of expertise – both specialist and generalist – required of building services engineers.

Alongside these trends toward interdisciplinarity in practice, interdisciplinary courses have been developed at UK universities, particularly at the postgraduate level. The EPSRC has sponsored a number of Masters courses aimed specifically at broadening the knowledge of people from different professions. For example, the Integrated Graduate Development Scheme (IGDS) is a part-time modular training programme for Masters level students. It was established in 1979 and now has over 600 participating firms across all industries. Operating in many industrial sectors, including construction, the Scheme is jointly managed by industry and universities. The aim is to encourage professional development in a group of companies in close collaboration with a particular academic institution. Programmes typically include 8 or 16 week modules, spread over two years. The scheme is to end in 1999 and will be replaced by the new, more flexible Masters Training Packages. IGDS courses established in the built environment are shown in Table 2.

The Ove Arup Foundation is also sponsoring interdisciplinary postgraduate courses at Cambridge University and the London School of Economics (LSE). These seek to overcome traditional barriers to understanding design in the case of Cambridge and urban planning in the case of the LSE.

The growth in complexity of the built environment has created the need for increasing numbers of interdisciplinary professionals. It is likely that interdisciplinary education and training will play a key role in ensuring UK graduates have the necessary skills to meet the challenges of working in built environment professions. Further research and evaluation of the courses described above would enable a better understanding of the differences between the interdisciplinary approach and more traditional methods of education.

3 Changing educational and professional contexts

The issues highlighted in Section 2 indicate widespread concern that the current provision of education for the built environment may be inadequate. Recent press reports have referred to a shortage of crucial skills in the sector and an inability to recruit top graduates (*The Times*, 8/3/98; *Construction News*, 21/5/98). In both the education sector and the construction industry, there has been increasing pressure for change. In the Dearing Report, universities have been charged with creating new standards of excellence in postgraduate education (Dearing, 1997). In the construction industry, the Egan Report has highlighted the potential for large improvements in quality and productivity of construction. Dearing and Egan have set new goals for universities and industry to meet. To achieve each of these goals - excellence in education and in practice - it will be necessary to ensure that students are motivated and properly educated.

In the context of these government reports, there has been a secular shift in the general patterns of education and knowledge development in many Western societies. Gibbons et al. have referred to these changes as the shift in modes of knowledge production, from Mode 1 to Mode 2 (Gibbons et al, 1994).

Traditional knowledge production systems - Mode 1, were based on a clear demarcation between the public and private sector. Universities were independent, discipline-based and providers of basic education and skills to students. Quality was scrutinised and controlled within well-defined frameworks. Under Mode 2, the lines between public and private have become blurred. Universities are involved in more consultancy and industry has become a significant participant in scientific research and training (although sadly not in construction). Knowledge production has shifted towards interdisciplinarity, research in the context of application, problem-solving and greater collaboration - Table 3. At the same time, quality of outputs has become more varied and is difficult to measure.

Table 3: Modes of knowledge production

Mode 1	Mode 2
• discipline-based teaching	• interdisciplinary learning
• clear demarcation between universities and industry, academic and consultant	• blurring boundaries between universities and industry, academic and consultants
• universities educated, industry trained	• greater collaboration
• more students means a better education system	• knowledge production widespread in society
• peer review	• learning organisations
• high levels of trust in science – independence	• research in the context of application
	• declining trust in science and scientists

Source: Adapted from Gibbons et al, 1994.

The implication of this mode of knowledge production for the built environment is as yet hard to determine. It indicates that in the future, with an increasing need for interdisciplinary skills, research and teaching will need to be conducted in the context of application. New forms of collaboration between the education and industrial sectors will need to be fostered.

The line between education and training has also become blurred in the context of Mode 2. Under Mode 1, education was the responsibility of the university sector and training the responsibility of the individual and industry. Education involved knowledge for life and training provided skills for technical tasks. In the modern workplace, such a distinction makes little sense. Now, people are involved in research and knowledge creation in both universities and industry; and technical training is widespread at universities. Large firms are creating their own 'virtual' universities. For example, British Aerospace launched its corporate university in 1998 for its 40,000 employees, whilst Motorola caters for 100,000 employees in the USA. Early in 1999, BT announced that it too would establish a new virtual university to create a workforce with the types of business and technology skills it believes to be essential for the coming decades. This will provide education, training and bespoke degrees and vocational courses for the company's 125,000 employees.

Concepts, such as lifelong learning and portable skills, attempt to overcome the simplistic dichotomy between education and training (Watson and Taylor, 1998). Yet, little is known about the new production of knowledge in the built environment and further research may be required to assess the long-term implications. For example, what is the lifelong skills formation process for designers, engineers and managers working in the built environment, and how can their needs be met?

In the context of this new mode of production, the organisations providing education and training (eg universities and colleges) and bodies which exert influence over those organisations (eg professional institutions, accrediting authorities) in the built environment may remain extremely fragmented. A concerted effort will be necessary to bring together all institutions with a common vision of the direction along which the sector is developing, if future needs are to be addressed.

3.1 Innovation in the built environment and the structure of the industry

There are a number of major pressures for change in the production of the built environment. These can be summarised as follows:

- *pressures for improved performance from major customers*
- *changing markets and requirements for new types of built facilities*
- *new types of business process - partnering and supply-chain management*
- *new financial players and cost structures*
- *tougher regulations*
- *innovation by suppliers in terms of new component parts and delivery mechanisms*
- *new materials*
- *environmental technologies*
- *bio-engineered technologies*
- *IT in products and IT process tools*
- *issues concerning the location of design, engineering and production*
- *skills shortages.*

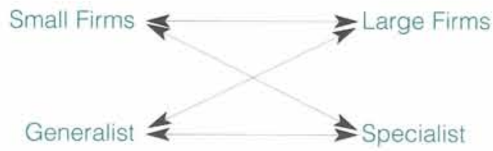
Whilst these forces for change are creating exciting new opportunities for developing and using new knowledge within built environment professions, there is a distinct gap between leading-edge and current practices.

In the construction sector, there are also great differences in needs. In some senses the sector is divided in two: one involving internationally operating, technologically advanced firms, and another involving small, craft-based systems of production.

In the interviews conducted for this research, we found a tension between the needs of large and small firms (Figure 3). Large firms were concerned with the general education of students. They felt it was necessary to win the top graduate students by offering an exciting and innovative work opportunity. For these firms, it was the creativity, variety and innovativeness of students that was of paramount importance. At the same time, these firms argued that they would continue to need specialised experts in particular areas of activities. The future would be about combining specialised expertise with universal skills.

Smaller firms have a more grounded set of skill requirements. Small firms wanted students with a proper basic education in fundamental skills in a particular discipline. They appear more sceptical about interdisciplinarity and felt that students lacked the necessary set of technical expertise to make their interdisciplinary skills useful. Small firms recognised the need for students to have some familiarity with management issues, but were critical of what they thought was a general trend toward the creation of generalist skills among students. These results were taken from a very small sample and more detailed and extensive study is required to verify them.

Figure 3: Tension between small and large firms in the built environment



The tension between the needs of large and small firms can only be resolved by providing variety in educational courses. In this respect, the UK system of education in the built environment fulfils this test, as we will discuss in the following section.

Students often tend to view construction firms as offering low wages, an unstable working environment and unchallenging work. This perspective is somewhat misleading because it does not take into account the activities of world-class firms operating in the UK - such as Foster and Associates, Ove Arup & Partners, or W.S. Atkins. However, it does indicate a general need for the construction industry to make efforts to improve its reputation in order to attract and retain the best students. Different institutional actors in the sector have tried to encourage students to enter the built environment, but in the future, these activities may need to be strengthened.

A recent study by the Institute of Employment Studies, commissioned by the EPSRC and the Institute of Materials, surveyed employers' views about the provision of newly qualified postgraduate engineers and material scientists (Jagger and Connor, 1998). The study involved 50 face-to-face interviews with engineering employers and a survey of 1,600 recent graduates from masters and doctoral engineering and materials science training programmes. It showed that employers look for particular 'soft skills' among graduates, these include:

- *interpersonal skills*
- *communication skills*
- *business awareness*
- *flexibility/versatility*
- *team working, and*
- *initiative/proactivity.*

In terms of technical skills, employers felt these skills were important but not of over-arching concern: current graduates in materials science were found to have adequate levels of technical competence. The ability of graduates to translate technical knowledge into non-technical language was considered a prize asset among employers. In terms of the construction sector, the employers interviewed stressed the importance of soft skills in combination with technical competence (Jagger and Connor, 1998).

This study also showed that the most important skills students gained in relation to their current activities were learnt whilst studying for Masters or Doctor of Philosophy degrees. The results are based on respondents assessing the contribution of a list of skill categories on a 1 to 7 point Likert scale. On the basis of the responses, the skills currently most important for graduates appear to be problem-solving, communication skills and business awareness. For PhD students, the most important skills learnt were in communication, IT skills and problem-solving (see Table 4). The patterns for both Masters and PhD graduates were similar.

What is interesting about this finding for our purposes, is that it shows the skills most important for graduates in engineering tend to be interdisciplinary, associated with activities outside narrow technical disciplines. (Jagger and Connor, 1998)

Table 4: Skills currently important for Masters and PhD graduates

Skills	Masters	PhD	All
Communication skills	6.0	6.1	6.0
Problem-solving	6.1	6.0	6.0
Planning and organisation skills	5.8	5.9	5.9
Oral communication	5.9	6.1	5.9
Problem identification	5.7	5.9	5.8
IT skills	5.6	6.0	5.7
Initiative/proactivity	5.7	5.8	5.7
Time management skills	5.7	5.8	5.7
Team-working skills	5.7	5.3	5.6
Flexibility	5.6	5.3	5.5
Writing skills	5.3	6.0	5.4
Project management skills	5.4	5.5	5.4
Business awareness	4.8	4.9	4.8
Creativity	4.6	5.0	4.7
Customer orientation	4.8	4.6	4.7
Leadership	4.5	4.7	4.6
Literature searching and review	4.0	4.6	4.1
Use of test/analytic equipment	3.9	3.6	3.8

Source: IES survey of recent engineering and materials science postgraduates.

Table 5: Skills gained from education on Masters and PhD programmes

Skills	Masters	PhD	All
Problem-solving	5.1	5.6	5.2
Problem identification	4.8	5.4	4.9
Initiative/proactivity	4.8	5.5	4.9
Literature searching and review	4.6	5.7	4.9
Communication skills	4.8	5.1	4.8
Planning and organisation skills	4.7	5.1	4.8
IT skills	4.6	5.5	4.8
Oral communication	4.7	4.9	4.7
Writing skills	4.4	5.6	4.6
Time management skills	4.4	4.5	4.4
Project management skills	4.3	4.2	4.3
Team-working skills	4.4	3.2	4.2
Creativity	4.0	4.8	4.2
Flexibility	4.0	4.6	4.1
Use of test/analytic equipment	3.9	4.2	4.0
Leadership	3.6	3.2	3.5
Business awareness	3.2	2.9	3.2
Customer orientation	2.6	2.6	2.6

Source: IES survey of recent engineering and materials science postgraduates.

As part of the IES study, respondents were asked to describe what skills they had gained as a result of their education. Overall, the fields that graduates felt were important in their current practices were those developed in their formal education. Graduates gained problem-solving skills, initiative, literature searching and communication skills from their education (see Table 5). The results show that, on the whole, the education system for engineering and materials science is meeting the needs of employers and recent graduates. But there are significant gaps. For Masters graduates, skills in customer orientation, leadership and business awareness seem to be not so well developed and yet important to their current work practices. For Doctoral graduates, customer orientation, business awareness, flexibility and leadership seem to be poorly developed and yet are important for their current employment practices (Jagger and Connor, 1998). This suggests areas for improvement within the education system.

Built environment education system 3.2

It is helpful to think of the courses offered by universities and institutional actors in the built environment as part of an education system. This system involves over 80 universities, teaching nearly 30,000 students and 1,500 research and teaching staff. A large number of professional bodies advise and regulate the sector, including the professional institutions and The Engineering Council. Within the system, there is considerable institutional variety, a wide range of practices and diverse outcomes.

Student enrolment 3.3

Partly as a result of its poor reputation, there has been a fall in numbers of students applying for degree courses in the built environment.

It is difficult to trace the trends in built environment student numbers because the datasets changed between 1993 and 1994. The data from polytechnics and universities in the pre-1992 period are not comparable to post-1992 data, when the binary divide was ended. However, the data suggests that enrolment for civil engineering rose between 1988 to 1993 and declined in the middle of the 1990s (Engineering Council, 1998). Enrolment in civil engineering reached a peak of 3,265 students in 1992. It has since declined by over 1000 students to 1,925 in 1997.

Recent data from UCAS entry applications shows a 21% decrease in applications in built environment courses from 1994 to 1997 (Table 6), while at the same time, applications in all subject areas have increased by 12% (UCAS Annual Report, 1997: 45, Tables 3 and 4). Despite the decline in applicants, the number of students in built environment courses has remained constant from 1994 to 1997. Yet, the percentage of successful applicants out of the total number of applications has grown considerably. In 1994, 63% of applicants applying to built environment courses were successful. In 1997, this number had increased to 82% (Table 7). The percentage of successful applicants in built environment courses has risen faster than the averages for all other subject groups.

Table 6: Applications to built environment courses, 1994 to 1997

Fields	1994	1995	1996	1997	% Change from 1994 to 1997
Civil engineering	5,104	4,538	4,207	3,766	-26%
Architecture	3,269	3,237	3,097	3,179	-3%
Building/construction	4,006	3,860	3,232	2,803	-30%
Total Applications	12,379	11,635	10,536	9,748	-21%

Source: UCAS Annual Report.

Table 7: Percentage of successful applicants out of total applications, built environment and all subject groups, 1994 to 1997

Fields	1994	1995	1996	1997
Civil engineering	68%	74%	76%	83%
Architecture	60%	67%	70%	74%
Building/construction	59%	70%	75%	89%
Total applications in built environment	63%	71%	74%	82%
Applications in all subject groups	61%	63%	65%	67%
Difference between built environment courses and all subject groups	2%	8%	9%	15%

Source: UCAS Annual Report.

Within these general patterns of student levels, the number of women studying built environment courses has remained stable at 12%. Yet, the number of foreign students has increased considerably. In 1994, foreign students comprised 17% of the total class. In 1997, foreign students accounted for 28%. In civil engineering courses, foreign students now account for close to 40% of total students (UCAS Annual Report, 1997: 47, Table 5). The increasing numbers of foreign students not only reflects the international reputation of British universities, but it also indicates the consequences of changing education policies. One of the most important of these is the EU Erasmus Programme which sponsors EU students to study in other EU countries. UK universities receive domestic fees for EU nationals. Nationals from outside the EU pay high levels of tuition fees and provide much needed resources to UK universities. As universities seek to expand in a period of limited financial resources, foreign students play a key role in generating extra funding. The implications of higher levels of foreign students for UK universities and the UK construction industry have not yet been explored, and further research is required.

Table 8: The percentage of women and foreign students in built environment courses, 1994 and 1997

	Women		Foreign Students	
Fields	1994	1997	1994	1997
Civil engineering	10%	9%	20%	39%
Architecture	19%	20%	19%	30%
Building/Construction management	8%	9%	10%	13%
Percentage of total student population	12%	12%	17%	28%

Source: UCAS Annual Report.

In response to falling numbers of students, South Bank University announced in August 1998 that 25 members of staff (one quarter of the total staff of the department) would be laid off. Westminster University closed its civil engineering degree course. The prospect for the rest of the university sector if present trends continue is equally grim. It has been suggested that the fall in the number of built environment students may be related to problems in sixth form teaching where teachers are not promoting industrial careers (Gann and Senker, 1998). The Engineering Council has suggested that misconceptions about the state of the industry may be responsible for a fall in student applications (Engineering Council, 1998). A survey of secondary school pupils (aged 7-11) conducted by the Engineering and Marine Training Authority found that dirty working conditions were associated with engineering. Another study of pupils in the West Midlands at the ages of 10, 15 and 17 found that engineering was viewed as manual and intellectually undemanding (Engineering Council, 1998). In both studies, women were less likely to be interested in a career in engineering due to its negative associations. The Royal Institute of British Architects sees declining numbers as partly a response to a withdrawal of government support combined with the high cost of materials.

Student choices

3.4

In the interviews carried out for this report, different actors commented on what they felt was a weak information provision in the built environment education and industrial system. Students, they felt, were not provided with the information necessary to make informed choices about which programmes were right for their needs. Interviewees argued that few 18 year olds have the information necessary to decide whether they want a career in surveying or building services. Moreover, one senior academic, with many years experience in recruiting new students, explained that there has been a decline in the number of new entrants who come to study construction degrees following a carefully chosen career path. The range and quality of new students differs from the past, but most are less interested in the industry and are not looking for a career in the built environment. In contrast, students choosing interdisciplinary postgraduate degrees usually do so having made a careful assessment of options.

Students rely on published sources, word of mouth and reputation to make the decisions about what courses to attend. Published sources, such as the UCAS handbook, provide useful information about a large number of courses and, if students wish to learn more about a particular programme, universities have prepared detailed prospectuses. However, the information contained in these prospectuses varies considerably. Few prospectuses inform students about the number of students enrolled in the programme and the kinds of employment opportunities available to them upon graduation. Typically, these prospectuses provide only detailed information about the course modules. There are notable exceptions, such as Oxford Brookes.

In response to this information overload, students often rely on 'word of mouth' to determine to which programmes to submit an application. Word of mouth is not the most efficient of information mechanisms. It depends on the student having access to people with knowledge of the sector. Reputation is also a fickle information source. Interviewees argued that students need a better information system from which to make decisions which will affect the future course of their lives. At least, it might be possible to have the universities agree to publish the number of students enrolled in a particular course. It might also be possible to have universities agree to provide common information in all prospectuses so that students have some basis for comparison. This information may include RAE scores, Teaching Quality Assessment (TQA) information and the like. Other more social activities, such as mentoring or gap years spent in firms, would also help to improve the information system.

4 Interview and database results

4.1 Interview results

As part of the research, 33 interviews with leading actors in the built environment education system and industry were conducted. The interviewing sample included 22 employers, six academic personnel, three representatives from professional institutions and two students.

Among employers, there was a general perception of shortages of graduates with appropriate combinations of skills. The main interdisciplinary competencies that employers sought from graduates were project management and communication. Project management skills were needed to enable the effective execution of multi-disciplinary projects and communication skills were necessary to work with clients to help them understand the nature of the construction process. The interviewees were also questioned about what skills they felt graduates were missing. Interviewees cited communications and an understanding about the industry as lacking. Several interviewees commented that many graduates leave the university sector without practical experience and little understanding of construction processes. Employers also complained about a lack of basic literary and numeracy skills on the part of graduates. *'They lack common sense'*, commented one interviewee. In general, employers were more concerned about the level of basic education or skills than about specific technical skills.

When asked why students entering the industry had declined in quality, interviewees argued that the poor reputation of the industry was largely responsible. There was little or no marketing at GCSE or A-level, they suggested. School teachers have a low view and poor understanding of the industry and this was passed on to school leavers, they continued. One interviewee commented that they had rejected six recent applicants to the firm because *'none of them was worth hiring'*.

Several interviewees suggested increasing the number of sponsored courses, such as those offered by Loughborough. Employers were quick, however, to stress that the costs to the firm of involvement in such programmes were very high and they suggested that small firms would not be able to afford this option. Interviewees also suggested that the current system of recruitment needs reform. The 'milkrounds' of prospective firms offering information to students is a poor one and needs to be replaced by stronger relationships between university career development officers, course convenors and firms.

One leading academic argued that having faculty members capable of teaching a subject from different points of view is the most important requirement for modern built environment education. This presupposes a department with a critical mass of staff and access to external industrial lecturers from different disciplines. Departments with few staff and weak industrial links are unlikely to succeed in teaching interdisciplinary courses.

Employers paid attention to the university from which the student had graduated, but few studied the details of the course the student graduated from. University reputation was the key factor in determining an interest in a student. Employers felt that course information was constantly changing and that they had no method or time to track these changes. Employers were also sceptical about postgraduate training. Many industrial interviewees felt that many forms of postgraduate training were unnecessary and that practical experience would be more worthwhile to the student than another degree. This viewpoint was recognised when discussed with a leading academic, who expressed an opinion that most firms have little idea about what postgraduate education is for, unless they have been on a course themselves, thus illustrating the gap in understanding between industry and universities.

A student studying for the postgraduate qualification in interdisciplinary design at Cambridge had specifically chosen this course because it provided *'a unique opportunity to broaden his knowledge of history of design, and contextualise design activities through an understanding of different processes'*. However, he found it difficult to convince his employer of the relevance of the interdisciplinary nature of the course, and his company oscillated between being 'curious' and 'confused' at his choice. Nevertheless, the organisation remained committed to training and continuing education and sponsored him through the course. This example illustrates potential difficulties experienced by individual professionals wishing to develop their own knowledge and skills – lifelong learning - within the context of a specific field of employment.

In some instances, interviewees argued that postgraduates were 'too specialised and academic' for industrial needs. On the other hand, industrial placements were welcomed by interviewees. Interviewees felt that these placements allowed the student to gain valuable hands-on experience and a knowledge of the internal workings of business.

The majority of the sample of employers felt that interdisciplinary skills were important and that the need for interdisciplinary skills would increase in the future. Employers felt that there was a willingness to change among the universities, but new pressures from SARTOR and other measures were limiting opportunities for interdisciplinarity. Several interviews also blamed professional bodies for limiting the development of interdisciplinarity in universities by focusing on discipline-based skills development. *'Many professional bodies simply wish to protect what they stand for and do not want to see greater interdisciplinarity in their field'*, suggested one interviewee.

Database

4.2

The main findings from the database concern the type and nature of courses offered in the built environment. 85 universities in the UK offer courses in areas related to the built environment at the undergraduate level. In many cases, a particular department may offer several courses in similar subject areas. Moreover, in a significant number of instances it is likely that similar courses are being taught by two or more institutions in the same town. This may result in a dilution of resources and in confusing choices for potential applicants. It almost certainly represents competition within the academic sector between 'old' and 'post-1992' universities. Much of this is likely to deflect attention away from the real issues of educating people for a career in the built environment.

Overall, there are 527 undergraduate courses in the UK. The largest number of courses are offered in civil engineering with 57 universities offering these courses. Surveying courses are offered in only 33 universities (Table 9).

Table 9: Number of undergraduate courses by subject, built environment

Subject	Number of courses	Number of universities
Civil engineering	203	57
Architecture	107	53
Building services/built environment	106	41
Construction management	59	34
Surveying	52	33
Total	527	85

Source: SPRU Built Environment Course Database.

At the postgraduate level, there are 457 courses offered in the UK at 63 different universities. Of these courses, civil engineering, including structural and other engineering disciplines, are the largest group, comprising 123 courses. Building services and architecture have the second and third largest number of courses offered respectively (see Table 10).

Attempts have been made by several universities to establish interdisciplinary postgraduate courses in building services related areas. One example is the Intelligent Building Integrated Graduate Development Scheme Masters degree, established at Reading University in 1997. Interviews in the building services sector suggest that courses that do well are those populated by mature students with work experience. Those which are doing poorly tend to be the ones that take students direct from school. This suggests that efforts to increase the number of high quality building services postgraduate courses may be beneficial. Unless this is done, given the size of industry and increasing levels of technical complexity in building services work, it is questionable as to whether student and industrial uptake and provision of such courses is sufficient to meet future needs.

The data show that postgraduate programmes are concentrated in a lower number of universities than undergraduate programmes. Yet, the number of courses offered at the postgraduate level is quite high, indicating a high degree of specialisation at this level. At the postgraduate level, surveying falls well down the list of main subject areas, while housing rises to prominence.

Table 10: Number of postgraduate courses by subject, built environment

Subject	Number of Courses	Number of Universities
Civil engineering	123	30
Architecture	102	30
Building services/built environment	113	34
Construction management	60	27
Housing	52	16
Surveying	7	5
Total	457	63

Source: SPRU Built Environment Course Database.

The data presented above indicate that there is great variety in the university system in the provision of education for the built environment. This variety is both a source of strength and a cause for concern. Given the variety of the construction sector, variety at the level of the education system provides the necessary support to the diverse sets of activities involved in the built environment. At the same time, the long list of universities involved in the provision of training for the built environment indicates that there is a wide range in quality, teaching methods, and types of programmes across the university system. This presents a tension between the need for variety and the desire of actors within the system to maintain quality, attract new students and to further the development of the sector.

As part of the study, each course offered in the built environment was assessed by the extent of interdisciplinarity using the UCAS handbook. The research team drew from a listing of classes offered in each course each year. Interdisciplinarity was defined as the number of classes offered each year to students outside their core disciplinary training. For each year of each course, a two point scale was developed for the extent of interdisciplinarity. The two point scale represented the extent of interdisciplinary course work students were asked to complete for that particular year. Each year was assessed and the total was taken for each year of the course. The total was then compared to the maximum possible score for each three, four or five year programme. This figure represents the interdisciplinary index for a particular course. For example, if a four-year civil engineering course offered two courses in construction management in the fourth year, it would receive a two point score the fourth year, and two point score out of eight for the total years of the course. Having developed an interdisciplinary index score for each course, it was possible to see what features characterise interdisciplinary courses.

It is necessary to raise a note of caution about the limitations of such a method of calculating interdisciplinarity. First, it says little about the actual content of each class offered in the course. Second, it misrepresents interdisciplinary courses, such as construction management and to some extent architecture, because it focuses on courses offered outside the discipline. If the course is itself interdisciplinary then it does not reflect this fact. Despite these limitations, it does offer a relatively comprehensive measure of interdisciplinarity in UK built environment courses because it is based on classes offered each year in each course. It also enables the comparison of interdisciplinarity with other factors of university behaviour.

The first finding when analysing courses using this interdisciplinary index is that interdisciplinarity is widespread in UK built environment courses. The average student receives at least one class outside his or her subject area per year on their course. As might be expected, construction management at undergraduate level has the highest level of interdisciplinarity among the five course groups (building services/built environment, construction management, surveying, architecture, and civil engineering) (see Table 11).

In general terms, interdisciplinary courses were associated with high entry requirements. Table 12 shows that courses with high entry requirements (defined using a three point scale of the point totals of A-levels students needed to have to qualify for the programme) have greater levels of interdisciplinarity. This finding held in different subject areas, such as civil engineering.

Table 11: Interdisciplinarity in built environment courses, undergraduates, 1997-98

Courses	Interdisciplinary Index	Number of Courses
Civil engineering	80%	145
Architecture	49%	78
Building services	77%	66
Surveying	76%	34
Construction management	85%	32
All courses	72%	355

Source: SPRU Built Environment Course Database.

Table 12: Entry requirements and interdisciplinarity

Entry requirements	Interdisciplinary Index	Number of Courses
High	79%	112
Medium	70%	200
Low	68%	44
All	72%	356

Source: SPRU Built Environment Course Database

Interdisciplinarity was also generally associated with high scores in the 1996 Research Assessment Exercise. Departments receiving 5 or 5* in the 1996 RAE had a higher level of interdisciplinarity than low-rated research departments (Table 13). This result varied among subject areas, however. Surveying, civil engineering and architecture all exhibited high levels of interdisciplinarity and high RAE scores. Yet, in construction management and building services, the opposite was true.

Table 13: Research assessment exercise scores, 1996, and interdisciplinarity

RAE scores	Interdisciplinary Index	Number
5 and 5*	74%	67
4	76%	58
3a and 3b	72%	189
1 and 2	66%	59
All departments	71%	373

Source: SPRU Built Environment Course Database.

Many recent initiatives to provide educational opportunities in new areas - in particular, the key and growing area of building services - have been undertaken by enterprising educational institutions with relatively low status and prestige, presumably perceiving new and growing interdisciplinary areas as opportunities. However, they have not generally been successful in attracting high calibre students. Conversely, 'high prestige' institutions which are able in any case to attract good students, may not have felt under the same pressure to innovate, by developing new types of courses, as some of their less well-established competitors.

Our analysis of the emerging field of building services at the undergraduate level shows 72 courses provided in 1997. The results indicate cause for concern. Courses scored in the mid-range when analysed for interdisciplinarity. However, entry requirements are low and many courses are taught in departments that have low RAE scores and that are sub-critical in terms of resources and student numbers – see Table 14. It is unlikely that many of these courses will satisfy the SARTOR requirements. Again entry requirements were derived by banding 'A' level points as 'low', 'medium', and 'high', scoring these 1, 2, and 3, and taking the average for each course.

Table 14. Building services entry requirements and interdisciplinarity

Courses	Interdisciplinary Index	Average Entry Requirement	Number
Construction management	85%	2.0	32
Civil engineering	80%	2.3	145
Building services	77%	2.0	66
Surveying	76%	2.2	34
Architecture	49%	2.2	78
All courses	72%	2.2	355

Source: SPRU Built Environment Course Database.

The relationship between interdisciplinarity and research is partly related to the fact that large departments have high RAE scores. The data show that large departments received considerably higher scores in the RAE than smaller departments (see Table 15).

This finding holds for the number of staff in the department considered research active by the RAE, the amount of research funding the department received, the amount of industrial income, and the level of research publication produced by the department in the RAE (for research income see Table 16). Within these different measures, there is a great deal of variety among subject areas, but the general trend shows interdisciplinarity associated with strong departments.

Table 15: Size of department and RAE scores

Size of Department	Average RAE score	Number of Courses
Very Large	4.8	62
Large	4.7	51
Medium	3.8	186
Medium Low	2.4	143
Small	1.9	57
Total	3.4	499

Source: SPRU Built Environment Course Database.

Table 16: Research income and interdisciplinarity

Research Income	Interdisciplinary Index %	RAE Score	Number of Staff	Average Funding from Council Per Staff	Number of Courses
Very High	79%	5.9	32	£14,125	59
High	79%	5.2	23	£8,324	67
Medium	71%	3.7	19	£4,900	85
Medium Low	62%	3.4	16	£2,018	67
Low	66%	3.1	16	£67	87
Total	71%	4.1	21	£5,314	365

Source: SPRU Built Environment Course Database.
Note: RAE score was recalibrated as a 7-point scale (representing 1, 2, 3a, 3b, 4, 5, 5).*

Correlation analysis

4.3

A correlation matrix among key variables in the built environment education system shows that the interdisciplinarity index is correlated to the RAE score of the department and to high entry requirements. Whilst this finding supports the results of the descriptive analysis discussed above, the correlation analysis shows that interdisciplinarity is not associated with the size of department in terms of number of students or staff. Interdisciplinarity is also not associated with industrial funding or number of publications. Entry requirements are correlated to RAE scores for the department, indicating strong research programmes are associated with high entry requirements.

The correlation matrix shows that the RAE score of a department is correlated to number of staff and students, industrial funding and publications. Large departments have a strong research background. They also have high levels of publications and industrial funding. There is a slight negative correlation between entry requirements and number of staff. This would indicate that large departments do not necessarily require high entry standards, although they may be research intensive. The number of students in a department is correlated to the RAE score, number of staff, industrial funding and level of publications. The level of industrial funding and number of publications are highly correlated to each other and to the number of staff and students. High correlations among industrial funding, RAE scores and publications are not surprising given that the RAE score is, in part, a reflection of excellence in these areas.

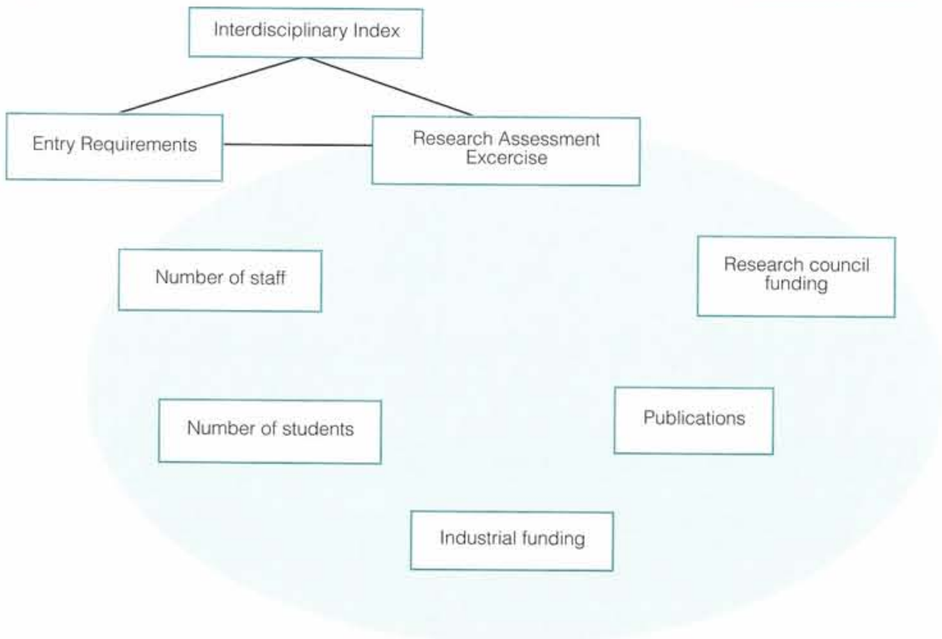
The results of the correlation matrix support the findings of the descriptive analysis and show that interdisciplinarity is associated with research intensive departments with high entry requirements. Interdisciplinarity is not necessarily associated with the size of the department, industrial funding or publications. This finding indicates that interdisciplinary education and training may be possible at smaller institutions, as long as they have high entry requirements and a strong research base.

Table 17: Correlation matrix for built environment education system

	Interdisciplinary index	Entry requirements	RAE	Number of staff	Number of students	Industrial funding	Research council funding	Total publications
Interdisciplinary index	1.000 (396)	.1586** (392) P=.002	.1073* (372) P=.039	.0210 (372) P=.686	-.0046 (372) P=.930	.0595 (354) P=.264	.0696 (306) P=.225	.0607 (393) P=.230
Entry requirements		1.000 (409)	.1602** (380) P=.002	-.1109* (380) P=.031	-.1279* (380) P=.013	-.0948 (362) P=.072	-.0788 (313) P=.164	-.0261 (405) P=.601
RAE			1.000 (498)	.5106** (498) P=.000	.5866** (498) P=.000	.4108** (453) P=.000	.5688** (364) P=.000	.5679** (498) P=.000
Number of staff				1.000 (498)	.8309** (498) P=.000	.7187** (453) P=.000	.7902** (364) P=.000	.9656** (498) P=.000
Number of students					1.000 (498)	.7189** (453) P=.000	.8417** (364) P=.000	.8425** (498) P=.000
Industrial funding						1.000 (453)	.6988** (364) P=.000	.7147** (453) P=.000
Research council funding							1.000 (364)	.8054** (364) P=.000
Total publications								1.000 (.547)

*Note: Number of observations is in parentheses and P-values are placed underneath number of observation. * denotes significance to >.05 and ** denotes significance to >.01.*

Figure 4: Correlation between different attributes of the built environment education system.



These findings are preliminary, much more detailed research and analysis is required to understand the dynamics between education provision and industrial needs. They indicate that research intensive departments allow students to draw from more disciplines in their course modules. Research intensive departments appear more sensitive to interdisciplinarity. In sum, they show that although interdisciplinarity is not a panacea for the needs of the construction sector, it does seem to be an important characteristic of the best courses and departments in the UK built environment education system.

Yet the opposite may not be true. In weak departments or courses, interdisciplinarity may be an unnecessary luxury. Several interviewees argued the quality of technical skills among many graduates has fallen in many departments. This deterioration, they felt, was due in part to an overemphasis on interdisciplinarity in some courses. Technical skills had been displaced by 'fashionable skills', argued one interviewee. Given the falling number of applicants and concerns over the skills of current students, there may be some validity to this argument. It would seem that in the 'tail-end' of the education system interdisciplinarity is not essential, or rather, it might interfere with necessary technical education. At the other end of the educational system, interdisciplinarity appears to be a welcome complement to a strong technical education.

5 Policy suggestions

It was not originally anticipated that the results from this scoping study would lead to firm recommendations for action. However, a number of issues arising from the work point to the need for immediate action to improve the supply of well-educated built environment professionals. These issues include improving employment conditions and making the industry more attractive to new entrants and graduates.

Improving employment conditions

With falling numbers of applicants entering built environment fields, more work needs to be done by government, universities and industry to promote the sector. This work should be industry-driven. In the first instance, large clients and employers should work together to create more attractive employment conditions. They also need to develop better linkages with universities. The sector must counteract the common view that it offers low pay and that it is a dirty and dangerous place to work. This view can only be seriously challenged by making tangible changes in industrial practice. In this respect, the industry needs to offer more resources to training and lifelong education. Firms must expect to take it upon themselves to commit significant funds to training, support universities, and to encourage students.

It may be necessary for the industry to launch a broad campaign, such as the one currently being conducted to recruit teachers, to bring new people into the sector. Given the high profile nature of much of the activity of the sector, it would be possible to build a coalition of actors to support such a campaign. At the very least, the target of the campaign should be to return the number of applications to universities to the average of the rest of university disciplines. Government could play a supporting role in the campaign, but to be successful, it would have to be industry-driven. This is only likely to be successful if industry demonstrates changes in industrial practice, shows a new willingness to train and a commitment to working with the university and secondary school systems. There will be no quick solutions and industrial efforts will need to concentrate on overcoming worrying long-term trends. In part, these activities will involve trying to reshape the culture of the sector to encourage greater participation by minorities and creating a more positive image of the construction process in society.

In particular it is more important to raise the general level of quality than to expand the numbers of people being educated for built environment professions. There are some positive signs of these changes taking place, however. Greater industry and university co-operation may be emerging through programmes such as the Innovative Manufacturing Initiative (IMI). The IMI Programme has given the opportunity to industrial firms to participate in university research. More efforts, such as IMI, would build greater links between the university sector and industry.

Improving the information system

In preparing this report, we had to rely upon information sources available to students. These sources have shown themselves to be uneven in quality and completeness. Universities, industry and professional institutions should take upon themselves to improve the information system for students. At first, this might involve ensuring improvements in university prospectuses and a common web page where students could access every course and prospectus in the built environment. More important, perhaps, would be to increase the social links between the sector and students. Mentoring, site visits, gap year placements and other social forums should be developed and integrated into the education system. These activities are currently too fragmented and sporadic to be effective. Industrial actors need to play a leading role in this, opening up their firms to students and catalysing interest in the production of the built environment. Participation in media shows would also help to stimulate interest.

Integrating interdisciplinarity

The third policy conclusion to be reached from this study concerns interdisciplinarity. With the future of construction activities heading towards total solutions and large and varied project teams, the need for interdisciplinary skills is likely to increase. Universities and industry should not fear this change. The findings suggest interdisciplinarity can be a strength not a weakness in the education system. This conclusion is tempered by the need for the university system to maintain high levels of core technical education. Interdisciplinary skills can complement narrow technical skills, but are in themselves no substitute for a high quality technical education. The results of the study indicate that where there is a lack of basic skills, interdisciplinarity may even be a hindrance to the education of students for working in the built environment area. It is likely that interdisciplinary skills are best taught on postgraduate courses to students who already have work experience.

Reforming the education system

The results also point to the need to re-energise the built environment education system. The process of SARTOR certification will help to remove many of the under-performing departments from certified civil engineering courses, but it will not, by itself, be able to transform the education sector. With the advent of performance measures, such as the RAE and TQA, universities are under great pressure to change and to improve their performance. Many departments and course convenors are suffering from the additional bureaucratic burden this has created.

There appear to be too many low quality courses in sub-critical departments, particularly in areas such as building services. Some courses have already been closed, others will need to be terminated. This is likely to add to the stress and fears of many academics working in the sector.

Given the inertia of the education sector, it will be necessary to give university departments the opportunity and the time to find new ways of conducting education for the built environment. Radical solutions, driven from the top-down, may only result in demoralisation of university staff. There is a trade-off between the need to improve standards and the need to work with the existing university sector. This relationship will have to be handled with great care and attention, and needs to win the support of the universities' departments themselves to the task of improving their performance. Industry can play a strong and supporting role in this by working with university departments to raise standards and recruit new students.

Finally, new centres of excellence are needed to champion the weaker areas such as building services. This will help in setting quality benchmarks, improving links between educators and industrialists and attracting high calibre students to fewer, better courses.

6 Future research

Educating and training built environment professionals is as much about developing the skills for lifelong learning as it is about imparting detailed technical knowledge. The capability for professionals to add to their knowledge through their work experiences is recognised as becoming more important as access to sources of information and knowledge increases. People progress at different rates. Some have an inclination towards leadership and management, others demonstrate strengths in the technical excellence of their work. There is not necessarily any relationship between these two areas, nevertheless both are equally important. It is not easy to develop an education system which provides the right mix of skills to meet employers' needs and sets people on the learning path.

This report does not present any answers to these issues. It touches on a wide range of questions, most of which received only cursory examination. Further research will be required to develop more robust conclusions for public policy. That being said, the research has demonstrated that there is considerable change taking place in the built environment education system, little of which is properly understood. In this section, several different research topics are identified. These need to be developed in future studies. Results from these studies could be used to improve feedback mechanisms and response times, and thereby increase flexibility and applicability of future built environment courses.

In the first instance, better information for planning and resource allocation is required. Data on the changing nature of demand and supply of professionals in the built environment are inconsistent and lack detail. One of the most pressing needs is to improve the quality, consistency and coverage of data on professional skills in the built environment.

Design and engineering knowledge for the built environment

To date, little is known about the nature of design and engineering knowledge for the built environment. The changing nature of knowledge and skill requirements is poorly understood.

Vincenti's study of the nature of engineering knowledge for the aircraft industry demonstrates what detailed analysis can provide and how it might be used to guide future education and training policies. It shows how engineers draw on tacit knowledge in order to develop new technologies. This tacit understanding is built over time based on their educational background, workplace experience and personal inspiration. Vincenti showed that engineering in aircraft depends on a wide body of practice from a variety of different disciplines and sub-disciplines (Vincenti, 1991).

Future research of a similar kind, probing the nature of design and engineering knowledge would help show what engineers (and architects) know and how they know it. It would further illuminate the nature of innovation in the built environment by characterising the way knowledge is developed and harnessed for innovation. The study could draw upon the work of The Engineering Council. It could also review international experiences, drawing upon previous benchmarking studies such as that carried out by the Royal Academy of Engineering (1996a). This study could be of great merit in helping to align longer-term vocational needs and expectations with an appropriate balance of specialist and interdisciplinary education in different skill areas.

Skills and career development: exemplar case studies

A second research project to be considered following the findings of this report should focus on what students learn from their education and how they apply this knowledge in their workplace activities. It would be helpful to produce a number of exemplar case studies which illustrate good practices in education, training and employment. These should not focus entirely on projects. They should include aspects of management, the operation of overseas offices and development of joint venture teams, etc.

An understanding of the nature of skills in the context of initial professional practice would help to show how students apply knowledge on leaving university education in their first workplace activities. This research could track students as they move from education to employment. Over a number of years, these students could be followed in their career development to determine what kinds of skills they learnt at university and how these skills were applied in practice. Such a study could also assess knowledge and experience of course convenors and employers. It would provide a better understanding of life-long learning processes in the built environment.

Interdisciplinary education

Not enough is known about the strengths and weaknesses of interdisciplinary education, particularly in the context of new courses developed in the built environment area. A third area for research would focus on interdisciplinary education and training in universities, in the context of the changing nature of knowledge production. It could explore the character of interdisciplinary courses, comparing these courses with more disciplinary courses. A review involving case studies of leading departments could draw general lessons for the development of course programmes, exploring the strengths and weaknesses of interdisciplinary courses, particularly at the postgraduate level.

Future demand for professional skills in the built environment

A fourth project would canvass firms about their future skills needs and about what types of education they would like to see provided in the universities. Better knowledge about future demand for professional skills in the built environment would help course convenors and assessors plan new courses and update existing provision. This research should include developing a much better understanding of professional skill requirements in large, medium and small firms working in a variety of markets and at different points in design and production processes. It should be carried out within the context of a thorough analysis of the changing nature of construction and built environment industries. In particular, new technologies, new working practices, environmental and regulatory changes and international requirements should be considered.

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David Gann has been academic adviser and member of six Department of Trade and Industry Expert Missions in Europe, Japan, and the US to assess innovation and technology transfer in different areas of construction. He has worked extensively with the Department of the Environment, Transport and the Regions and has provided practical advice to industry and government on policies for innovation and technical development.

He has previously worked as director of a construction firm and two consultancy companies, as well as for a local authority as a housing surveyor. He is a member of the EPSRC's Technical Opportunities Panel, and was recently Advisor to the Deputy Prime Minister's Construction Taskforce. He is a Board member of the newly established Housing Forum and Innovation Director for 2000 Homes. In addition he advises several companies on their innovation strategies.

David Gann has a BSc in Building Construction and Management (Reading), an MSc in Science, Technology and Industrialisation, and a DPhil in Science and Technology Policy Studies (both Sussex).

Dr Ammon Salter

Ammon Salter has a DPhil in Science and Technology Policy Studies, (Sussex). He has worked as a consultant and advisor on a number of innovation projects, including the Program on Globalisation and Regional Innovation Systems (University of Toronto) and research on Ontario's Innovation Systems. He was involved in a study of the Economic Benefits of Basic Research for the UK Treasury. He is currently working on the EPSRC/IMI-funded project contributing to a major initiative on mapping, measuring, and managing innovation in project-based organisations. He is working closely with six firms to develop better knowledge about the management of technology, offering them new approaches to help improve performance by focusing on how technical capabilities are developed and enhanced. He is also working on a case study of the construction of the Millennium Dome.

Interdisciplinary Skills for Built Environment Professionals

A Scoping Study

In March 1998, because of their concern about the state of education in the construction industry, the Trustees of The Ove Arup Foundation decided that it would be beneficial to try to map the scope of education for the built environment, both for undergraduate and taught post-graduate courses. Prof David Gann was invited to undertake the study and so this report was commissioned.

What began as a survey has, because of the significant nature of the findings, been extended. The report confirms that there are serious weaknesses in education for the built environment and identifies them. The action recommended is far-reaching and will not be easy to follow through. Nevertheless, the Trustees and their Advisory Committee urge that action be taken immediately to improve the quality of education and career opportunities for those entering the built environment.

If the action is not taken, the built environment professions will increasingly fall short of the standards to which they aspire and their clients expect.

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