Orange Series: Design Curriculum Matters 3

CURRICULUM CONVERGENCE AND DIVERGENCE IN 'INDUSTRIAL DESIGN' AND 'TECHNOLOGY' PROGRAMMES IN HIGHER EDUCATION

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Acknowledgments

The author is grateful to all those who willingly contributed their time and knowledge concerning the development of link courses between engineering design, industrial design and other curriculum areas, without whom this Orange Series publication would not have been possible. Such contributions were not only made to this report, but also to the earlier ones to which it refers. In particular to the colleagues indicated below who gave their time to enable the visits and interviews.

Visits made:

TUDelft University (September 2007) to meet Professor Cees de Bont and Norbert Roozenberg

Brunel University (September 2007) to meet Professsor Joseph Giacomin and his colleagues

Napier University (October 2007) to meet Dr Paul Rodgers and his colleagues

Interviews:

Matt Sinclair (August 2007) … former student at both Loughborough and RCA/ICST

Rob Woolston (March 2008) … Managing Director, DCA

The author is also grateful to the Engineering CETL at Loughborough University for funding the initial project and, in particular to Dr Andy Wilson, for encouraging the application for an Academic Practice Award, and to Professor Tony Hodgson, for his on-going support for the project as Dean of Loughborough's Design School.

I would also like to thank colleagues in the Loughborough Design School, and particularly in the Design Education Research Group, for their comments on drafts of this publication. However, the author is of course solely responsible for any errors made in its preparation and for the views expressed.

Foreword

Professor Tony Hodgson, Dean of Loughborough Design School (2011-2012)

This predominantly historical perspective of Industrial Design Curricula is based on a particularly strong background of experience in the field. It considers fundamental research into design education, together with a series of reports into practice and education from 1963 to 2005, all of which underpin an investigation into Industrial Design and Technology course programmes in key institutions. It is interesting to reflect on the key issues that were considered to be important then and now, together with the very significant changes in context surrounding IDE programmes. In particular, the Cox Review reminds us of two significant changes recently: the economic downturn, and the speed at which the world has caught up with the UK's leading position in design and innovation.

So, looking back is useful when it is undertaken in a framework of looking and moving forward. This report makes it clear that we have to think more widely than core design skills and IDE, and engage with a broader community and evolving agenda. This is the mission of the Loughborough Design School – inspiring design that matters.

0. Executive Summary

One of the major recommendations of the Cox Report (2005) was the establishment of centres of excellence combining creativity (art & design), technology (engineering) and business teaching, essentially related to teaching at masters level. The thinking behind this recommendation clearly stemmed from the very successful postgraduate link course in Industrial Design (Engineering) (IDE) run by the Royal College of Art (RCA) and the Imperial College of Science and Technology (ICST), although reference was also made to other emerging examples of successful masters programme innovations in other countries. Cox also mentioned selected link courses at undergraduate level eg the Product Design Engineering course run by the Glasgow School of Art and Glasgow University, however there was no mention of the integrated design degree programmes, which have been long-established (also since the 1980s) in order to tackle such agendas. Notably for the author, of course, Industrial and Product 'Design and Technology' programmes at Loughborough, but also the courses at Brunel, Napier and Delft Universities, which have equally long histories, and there are now similar courses at a number of other universities. Creativity was apparently being essentially identified with 'Art & Design' and one of the recommendations for the required national 'remedial' action as interdisciplinary co-operation (between Art & Design, engineering and business programmes).

This Orange Series publication has developed from an Academic Practice Award made in 2006, which set out to explore the curriculum design issues surrounding 'creativity, design and innovation' both to support and inform emerging policy decisions at Loughborough University and beyond. In particular, the initial study aimed:

- to highlight the significant issues concerning 'serial' and 'parallel' approaches to integrated design programmes in higher education;
- to explore the evidence concerning the established practices, successes and difficulties of such parallel programmes;
- to review the emergence of the Loughborough programmes and make related recommendations.

The study was motivated by the belief that established programmes related to IDE must embody important principles and practice relevant to overcoming the apparently significant barriers between 'design', 'technology' and 'business'.

The evidence collected in order to support the analysis and recommendations was:

- prior research relating to IDE;
- an analysis of the conceptual frameworks underpinning the emergence of the Loughborough 'Design and Technology' programmes;
- a review of the designing tasks incorporated into the curricula of the programmes at Loughborough, RCA/ICST and TUDelft;
- a small number of selected visits and interviews.

Visits were made to colleagues at Brunel, Napier and TUDelft in order to discuss emerging ideas. In order to develop the framework for this study, papers were prepared in two areas:

- research conference papers related to the analysis of designing tasks using Thistlewood's categories of designing (archetypal, evolutionary and historicist);

- a case study analysing the conceptual development of the Industrial Design and Technology programmes within the Department of Design and Technology at Loughborough University.

The papers relating to the first category were presented at the DHS conference at TUDelft University in September 2006 and the PATT18 conference at the University of Glasgow in June 2007. The case study was circulated to the Design Education Research Group within the Department of Design and Technology and their suggestions incorporated.

- Desk research was largely completed in March-April 2007
- Data collection was completed between July and September 2007.

Writing of this final report was delayed for two reasons. Firstly, in order to allow for the publication of research by the Design Council and other organisations to be completed and published, so that its outcomes could be considered. Secondly, to allow time for the formation of Loughborough Design School (LDS) to be completed so that the publication could play its role in supporting the policy discussions that would surround the formation of LDS. Design programmes do not have centrally agreed curricula agreed by accreditation bodies. They also evolve and, on occasions, are the subject of rapid change. In the case of LDS, some modules have remained in place over the years, such as 'The Injection Moulding Project', which was introduced in the 1980s by the late Mike Hall, then Course Leader, and has subsequently evolved over the decades under the leadership of several staff. Others, such as 'Technology for Design' have come and gone, and returned transformed, as perspectives concerning the technology considered to be appropriate for design undergraduates to study and the associated pedagogies have altered.   Design programmes exist within a sea of technological change, and the timing of the publication of this report has been chosen to support the emergence of the Curriculum Development and Educational Research (CDER) Group that is being established to play its part in ensuring that LDS' design programmes remain world-leading as the tides ebb and flow.

The following conclusions and recommendations are made.

- The project model for design education that embraces learning by doing is well-established for IDE programmes.

- The pedagogy associated with the engagement with technologies within IDE programmes must deal with elements that are either hierarchical or progressive and should not be generalised. This could also apply to aspects of other disciplines that might be introduced in the future.

- There are evident signs of convergence in the pedagogy of IDE programmes in using comparable designing tasks to integrate and update inputs from mono-disciplines.

- There are growing pressures on undergraduate IDE programmes as a result of the increasing requirement to incorporate learning related to the fuzzy front end of designing, such as design thinking. This has led to some divergence in programmes.

- Such divergence leads to the possibility of meeting the expectations of a greater range of stakeholders, both students and future employers, providing the institution is sufficiently large to support the diversity.

- Responses to change should be founded on a general course philosophy, such 'evidence-based designing' as suggested by Rob Woolston, rather than piecemeal responses to particular issues.

- It would be useful to reconsider the undergraduate programmes in the light of the 'major – minor' structures being adopted in Europe in order to forward the provision for diversity

- It is essential to identify those human capabilities that make designing possible and which enable designers to resolve conflicting constraints and develop appropriate products, services, systems and strategies in determining preferred human futures.

- Modelling, including cognitive modelling, and its role in designing needs to be thoroughly researched in a X-disciplinary context.

- Prototyping plays a key role in facilitating X-disciplinary, and particularly group designing tasks. LDS should develop resources that show its power in order to support undergraduate and postgraduate students eg a permanent exhibition or library, physical or virtual, illustrating prototyping techniques.

- The role of graphicacy, as well as those of literacy, numeracy and articulacy in determining the human modelling capability, and its relationship to designing, needs to be researched and defined.

- Design innovation essentially results from the survival of the most valued, and hence understanding the roles that values play in design decision-making is crucial.

- Innovation in the context of designing must be seen as embracing the re-presentation of artefactual and historicist designs in response to different value positions, as well as evolutionary steps. This is reflected in the final year projects from IDE programmes and the curriculum design implications of this reality need to be fully recognised.

- Strategic Product Design, or business considerations, is an appropriate further step for masters programmes that follow-on from an IDE undergraduate course, although some aspects are developed within the undergraduate programmes.

- A new masters programme should be developed for Loughborough Design School that audits and develops the core human designing capabilities, and then exploits these through both interdisciplinary group projects and individual projects linked to a client companies and organisations. This should take advantage of LDS' strong human factors capability.

- The design and development of such a masters programme would be appropriately pursued as a participatory action research project, engaging with postgraduate students, prospective employers and academic staff in defining its goals, and evaluating progress towards achieving them.

- A 'X-disciplinary' project centre should be established to initiate, support and assess interdisciplinary group projects for undergraduates and postgraduates across Loughborough University.

- An effective way forward would be the formation of a Curriculum Development and Education Research (CDER) Group within the newly formed Loughborough Design School in order to take responsibility for curriculum renewal.

Possible Terms of Reference for a CDER group

- To provide an organisational structure through which LDS' academic staff can focus some (or all) of their research efforts on LDS curricula, whilst remaining members of other research groups as they choose.

- To act as a research group for those members of LDS' academic staff that choose to commit all of their efforts to education research, whether within LDS or beyond it eg in general education.

- To develop two-way partnerships with other LU organisations, such as the Centre for Engineering and Design Education, the Mathematics Support Unit etc

- To be the focus for active responses to current design education research agendas eg as evident from E&PDE (Antwerp, 2012), or the DRS/Cumulus (Oslo, 2013) conferences

- To monitor (and research) curriculum development initiatives stemming from internal or external sources

- To manage curriculum development where there is a need to engage with external agencies and internal research groups and particularly where there is no existing LDS staff expertise within the teaching teams.

- To act as a focus for external funding bids relating to design education.

- To attract, supervise and support research students in the area of design education and particularly international research students.

1. Introduction

This Orange Series publication is being written during a period of major reviews of design and design education in the UK. The Cox report (2005:3) was 'triggered by concerns about how UK businesses can face up to the challenge of a world that is becoming vastly more competitive'. Following the Cox Report a major study was undertaken by the Design Skills Advisory Panel, which was brought together through a partnership between the Design Council and Creative & Cultural Skills, which is the Sector Skills Council for advertising, crafts, cultural heritage, design, literature, music, performing, and visual arts. The Skills Council seeks to bridge the gap between industry, education and the government and was founded in May 2004. The Advisory Panel included representatives from across the UK design industry. This Panel published a consultation document in May 2006, with consultation ending in November 2006 and an agreed action plan entitled *High-level skills for higher value* in June 2007. Some extracts from the Executive Summary of this report are shown below.

> **'A new design industry for a competitive economy**
> *This is an important moment for the UK design sector and its profile has never been higher. Our design education system is respected worldwide and the industry has grown rapidly over the past decade to become the largest in Europe, with an annual turnover in excess of £11.6bn …*
>
> **Opportunities and challenges**
> *There is significant potential for growth of the design industry and there are real opportunities for design to have even greater impact on the UK's prosperity and quality of life. In the new global economy, businesses are no longer competing solely on cost but also on added value, and design is a key component in the creation of desirable products and services.*
>
> *Demand for design is growing but it is also changing. Up to now, the perception of design has been connected mainly to delivering products, packaging, graphics and logos. Increasingly, however, companies are now looking to designers to deliver innovation, establish brands and improve systems. They are using designers more strategically across their businesses to help them grow and compete more successfully in global markets.'*   *(4-5)*

The evidence presented here draws on these recent major studies and includes summaries of some key aspects. It extends the discussion in these reports in relation to two key areas.

- The relationship of technology and designing within design curricula in higher education (eg Industrial Design (Engineering) and Industrial Design and Technology)
- Pedagogy that supports the development of creativity and innovation within such curricula.

Many of these integrated design courses had their origins in the 1980s, and, like Loughborough University's Industrial Design and Technology undergraduate programmes, had reached a state of maturity in the 1990s. They have already established a fine legacy of achievement, which this publication celebrates, but where do their futures lie in the 21st century?

The definitions given of design, innovation and creativity in the Cox Report were as stated below.

> *"**Design'** is what links creativity and innovation. It shapes ideas to become practical and attractive propositions for users or customers. Design may be described as creativity deployed to a specific end.*
>
> *'**Innovation'** is the successful exploitation of new ideas. It is the process that carries them through to new products, new services, new ways of running a business or even new ways of doing business.*
>
> *'**Creativity'** is the generation of new ideas – either new ways of looking at existing problems, or of seeing new opportunities, perhaps by exploiting emerging technologies or changes in markets.'*   *(Cox, 2005:2)*

These are useful starting positions, and their interpretation in the context of design education is explored in detail in Section 6.

The report begins by discussing the current context provided by the Cox and Design Skills Advisory Panel Reports in more depth. The findings of some recent Design Council investigations in Europe, America and Asia, and the world-wide growth and development of design schools are noted. The background and development of industrial design (engineering) programmes based on previous reports is then summarised and particularly the development of the Royal College of Art/Imperial College MDes course.

The nature of innovation in a design education context is then explored and the associated conceptual history of the Department of Design and Technology at Loughborough University is reviewed. Designing tasks within the integrated programmes at Loughborough University and TU Delft are presented and the possibility of there having been some curriculum convergence discussed.

Some general recommendations are made, but this publication is essentially concerned with the presentation of evidence relating to the emergence of design programmes that are situated at the interface of 'designing' and 'technology'. It could be taken as well established that good design concerns creative responses to the balancing of a number of competing constraints. This was well represented by Stuart Pugh's 'circus plate' analogy for product design specifications (1971), or by Tim Brown's representation of design thinking as relating to desirability, viability and feasibility (2009). This publication is essentially discussing viability (technology) rather more than desirability (people) or feasibility (business), and must start with an acknowledgement that it is essential for design programmes to engage fully with issues surrounding desirability, viability and feasibility. However, saying that does not get close to the heart of the matter. The key issues are related to questions such as these.

- What are the aspects of designing that facilitate such balancing of competing constraints?
- What capabilities of humans make such designing possible?
- How are these agendas introduced most effectively through design curricula?

This Orange Series publication is addressing some aspects of the third of these complex questions. The Orange Series publications prepared for Ken Baynes' 2009/2010 Modelling Seminar Series address some aspects of the first and second

questions. However, there is much work to be done before we can be said to be making significant inroads on these complex, interdisciplinary research agendas. It would be hoped that the work of the CDER Group within Loughborough Design School could move the frontiers of our understanding forward.

Of course, in the meantime, there are immediate curriculum development issues to address. The Final Report of the Design Skills Advisory Panel (2007) discusses the issue of expanding student numbers and suggests the most appropriate strategies with which to approach it.

> ### 'Colleges and Universities
> *At further (FE) and higher(HE) education levels, design education in the UK has solid foundations, growing from the pioneering 19th century schools of design and the strong influence of the arts and craft movement right through to the present day, with some UK design schools rated amongst the best in the world.*
>
> *Design educators are leading curriculum development all over the world and large numbers of international students come to the UK to study design. In 2005-06 there were a total of 60,000 design students of whom nearly 8000 were from outside the UK. Colleges and universities have responded to market demand and there is a wide range of courses and qualifications available with anecdotal evidence suggesting many design courses are over-subscribed. This popularity has, however, led to a number of inter-related problems.*
>
> ### Student numbers
> *The number of undergraduates and postgraduates taking design related degrees has grown steadily, with a 40 per cent increase in the number of design graduates between 1996 and 2004 and a 71 per cent increase in the number of postgraduates. This large rise in student numbers means that many graduates need to consider their employment options more widely as they will inevitably have to apply their design skills and capabilities to jobs in different industry sectors. This could be viewed very positively, in that increasing the number of design graduates working in related fields will help bridge the gap in understanding between designers and design buyers or users, whilst also helping to ensure that design thinking and approaches are applied in a range of areas that could benefit. The sheer number of students means, however, that there is an over-supply of designers in the UK market, with almost half as many students of design as there are designers in industry.*
>
> ### Blurred career pathways
> *A key difficulty here is the lack of differentiation made by the colleges and universities between their courses and the possible career pathways for students. (24) (… and later …) Students' expectations should be aligned with the broad range of career options, enabling greater flexibility in design education to develop excellent skills, not just as designers, but as managers, researchers, strategists and communicators' (44)*

This is an area where change could be very rapid as a result of globalisation and increasing worldwide competition. Cross-disciplinary programmes and collaborative multi-disciplinary projects may well have roles in meeting student demand to study design-related areas and retain good employment prospects relating to other disciplines.

The Cox Report raised the prospect of masters courses targeted at supporting creativity and innovation through link courses between engineering, business and design, but how best such courses could be structured remains unclear. Is it a matter of increasing individual capability or team activity? There is a natural temptation to consider copying the successful RCA/ICST link course model, but internationally, other innovative course structures exist and are emerging.

The undergraduate programmes within Loughborough Design School also need on-going development in order to remain competitive. The evaluation of these programmes is a continuous activity and, as international competition increases, the need for responsiveness and flexibility will grow. Just 'staying ahead' or 'keeping afloat' will require the development of new programme structures that facilitate change.   It is hoped that this publication can provide a supportive background to the discussions from which curriculum renewal will derive.

2. Context provided by the Cox Report (2005) and the Design Skills Advisory Panel (2007)

2.1 The Cox Report

The Cox Report was concerned with retaining international competitiveness and focused on SMEs (small and medium-sized companies) and one of its major recommendations was the establishment of centres of excellence combining creativity, technology and business teaching. The report is essentially referring to teaching at masters level eg

> *'I accept that it is not always easy to establish links between different faculties and institutions, but we already have highly successful models of joint courses such as the Imperial College and the Royal College of Art (RCA) offering an MA in Industrial Design Engineering. These courses prove that effective collaboration between institutions can be achieved and I believe the prize to be worth the effort.'* (ibid: 33)

Cox also mentions link courses at undergraduate level eg the Product Design Engineering course run by the Glasgow School of Art and Glasgow University. However, perhaps understandably, there is no mention of the research conducted concerning the development of such courses or the difficulties (eg Myerson, 1992). And most disappointingly there is also no mention of the integrated undergraduate courses, which have been long-established (since at least the 1980s) in order to tackle such agendas. Notably, of course, for Loughborough University, the omission of its Industrial Design and Technology programmes, but there is also no mention of the courses at Brunel University, which have a similarly long history and there are now similar courses at a number of other universities. Creativity was apparently being essentially identified with Art & Design and one of the solutions to the implementation issues as cross-curricular co-operation, particularly with Engineering.

Recommendations from the Cox Report

Five recommendations are made in the Cox Report, but only the 3rd and 5th are particularly relevant to this report.
- *3rd recommendation … 'Tackle the issue, in higher education, of broadening the understanding and skills of tomorrow's business leaders, creative specialists, engineers and technologists.'*
  - *Closer links should be established between universities and SMEs*
  - *Higher education courses should better prepare students to work with, and understand, other specialists*
  - *Centres of excellence should be established for multi-disciplinary courses combining management studies, engineering and technology and the creative arts*
  - *Five such centres would move the UK into a leading position in this field*
  - *Given the urgency of the requirement, Cox recommended that HEFCE take responsibility for carrying the proposal forward*
- *5th recommendation … 'A network of 'Creativity and Innovation' centres should be established throughout the UK, with a central hub in London*
  - *To be developed with RDAs*
  - *Expected annual cost £4.6 million, with £2.8 million coming from letting, retail activities and workspace*
  - *… the balance from grants and other funding*
  - *Design Council could co-ordinate*

The view of Sir Christopher Frayling (Rector of the Royal College of Art) as stated in the Cox Report was as follows.

> *'We need to equip all students with an understanding of business and technology –*
> *in addition to the creativity at which they already excel – if they are to use their skills*
> *to the full'.*   (*ibid*, insert: 31)

It's hard to disagree with this, but it tends towards begging some of the important questions eg Does a knowledge of technology enhance or inhibit creativity? What is the relationship between understanding business and innovation? How much space is there within the curricula in order for additional areas to be addressed? Do successful design curricula have fragilities within their structures? And could the creativity they are renowned for developing be undermined through efforts to develop and exploit it?

Cox did begin to recognise these issues as can be seen from the comments made concerning placements.

> *'An effective way of exposing students to this wider business context is through*
> *industrial and business placements. The main barriers to setting up more of these*
> *seem to be the time and effort required by the university, particularly if the*
> *placements are to be with SMEs, as already discussed. I believe the effort is well*
> *worthwhile, however.*
>
> *One interesting example of a scheme to foster placements and facilitate knowledge*
> *transfer has been the Inside Track scheme piloted by the Design Council in*
> *conjunction with the Shell Technology Enterprise Programme (STEP). Under this*
> *scheme, a final-year undergraduate business student is paired to work with a design*
> *student on a joint placement for eight weeks. Together, they assess how the*
> *business uses design before progressing to a project chosen in conjunction with the*
> *company, both to deliver an immediate commercial benefit and raise awareness of*
> *the potential that exists for innovation. It is intended to help design schools to*
> *produce graduates who can go beyond executing a brief and add real value to the*
> *decision-making process. More of these opportunities should be available for*
> *business students.*
>
> *Placements alone do not change the need for the courses themselves to give*
> *students that wider grounding, outside their area of specialisation. I recommend that*
> *all universities and colleges – working with the employers and skills bodies – review*
> *their courses to make sure that they all give an essential insight into how their skills*
> *fit with those of others.*   (Cox, 2005:32)

The report gives four examples of good university-SME interaction: Nottingham University Business School, London Metropolitan University – Furniture Works, University of the Arts London (UAL) – Creative Learning in Practice (CLIP) and One North East. More significant for this report are the examples given of 'a number of UK institutions pioneering approaches to more rounded specialism …' and higher education institutions becoming 'more multi-disciplinary around the world …' . These are shown in Table 2.1.

Apart from mention of the 1987 Glasgow course as 'new', and the ICST/RCA course there is no acknowledgment of the rich 'IDE tradition' which has been developing in the UK since the 1980s. There is also no mention of the conclusions of the Ewing Report

Institution	Notes
UK	
London Business School (LBS) – New Creative Ventures	*A new combined course which brings together 35 students from the University of the Arts London and 35 from the LBS MA programme. The elective unit sets students a practical project where they must work collaboratively to develop a business plan*
University of Strathclyde – Design, Manufacture and Engineering Management	*Strathclyde addresses industry's needs for engineering graduates with analytical skills, management skills and leadership potential Students from all years work closely together, simulating real-life business conditions. After initial grounding in a range of engineering disciplines, students study modules in Marketing, e-Business, operations Management, Finance, Product Development and Entrepreneurship, with many opting to spend time studying abroad.*
Formula Student	*Formula Student has been running since 1997 and sees students competing to build and race the best car in a number of categories. Mechanical and automotive engineering students assume a manufacturing firm has engaged them to produce a prototype car for evaluation. Cars are judged on performance (braking, accelerating and handling qualities), cost, reliability and ease of maintenance. The car's marketability (aesthetics, comfort and usage of common parts) is also taken into consideration. Through the competition, engineers develop skills in marketing, design, business and project management.*
Glasgow School of Art and Glasgow University – Product Design Engineering	*A new Glasgow course is split between the two institutions, with students initially coming through the engineering faculty. During the first year students spend four days per week on engineering theory and one day on design. The division gradually reverses through the course to produce graduates equally comfortable speaking the languages of engineering and design. Since its inception in 1987 there has been a shift away from traditional manufacturing towards product design, new media and electronics.*
International	
International Design Business Management programme (IDBM), Finland	*IDBM is a joint teaching and research programme of the Helsinki School of Economics, the University of Art and Design Helsinki and Helsinki University of Technology. Students are drawn from each institution to take part in courses and form a mixed discipline team which tackles a project commissioned by industry. The programme teaches students to make full use of their own skills and potential, as members of an interdisciplinary team.*
Zollverein School of Management and Design, Germany – MBA in Management and Design	*The Zollverein School brings together managers and designers, to teach the former how to understand and use design to improve a company's productivity and competitiveness and to give the latter a grounding in business and economics and how to link these activities to company strategy.*
Stanford D-School, USA	*The D-School teaches design to business, engineering and humanities students so that they come to see design as a fundamental discipline. The School merges disciplines, encouraging students to collaborate, innovate and push the limits of their creativity. David Kelly, from the school, sums up the importance of this – "Great innovators and leaders need to be great design thinkers".*
INSEAD, France and Art Centre College of Design, Pasadena, California	*MBA students from INSEAD work with design students from Pasadena to develop a new product and present their concepts to investors, who could potentially take the ideas to market. The programme gives MBAs an insight into the role of creativity in business decisions, how innovation really works and why design is important to corporate management.*

Table 2.1 UK and international programmes specifically mentioned for their innovation in the Cox Report

(1987) or Carter Report (1993), which both investigated them. Cox's UK choices are an interesting, but a selective group. However, one matter they do highlight effectively is how much more exciting and innovative the four international initiatives are.

In December 2006, Competitiveness Summit 06 was held in Central London to follow up the Cox Report. It was advertised as follows.

> *'Design and innovation need to be at the forefront of the British economy. The threat posed to UK competitiveness by rapidly emerging economies requires a response*

*from government, and for all parts of the economy to rise to this challenge and ensure that Britain becomes a world leader in **innovation** and **design**.*

*One year on from the Cox Review of Creativity in Business, this major one day summit will bring together industry and government, along with representatives from education, creative industries, business and enterprise support, and regional, local and devolved bodies. It will discuss progress towards creating a value-added and **knowledge-based economy** and will ask what more can be done to link innovation with economic growth.'*

In the end, the issues were apparently again expounded, but very little progress was reported. (The author was not present at this summit). Alistair Darling, then Secretary of State for Trade and Industry, stated that the locations of the HEFCE funded Higher Education Innovation Centres recommended in the Cox Review were soon to be announced. He is also reported as saying that the Cox Review was being seen by the Design Council as a 'road map', and that links in higher education between design, engineering science, business etc were being seen as a key deliverable.

The plans for the London hub were reported in *The Times Higher Educational Supplement* 1 June 2007.

'Design-London will be a £5.8 million multidisciplinary centre bringing together the design skills of the RCA, the engineering expertise of Imperial and the business know-how of Imperial's Tanaka Business School to form an "innovation triangle"…

Imperial and the RCA have run a joint masters degree in industrial design engineering since the 1980s. The new centre will enhance the existing course, and the future will see new modules for MA, MEng, and MBA students at Imperial and the RCA and new courses on design and innovation management …

A facility called the Incubator, which is funded by £900,000 from the National Endowment for Science, Technology and the Arts will give entrepreneurial graduates from the RCA and Imperial the opportunity to develop new ideas commercially. Meanwhile the Simulator will allow businesses to refine the business case for their designs. …

The Higher Education Funding Council for England has provided funding for £3.8 million over three years, with additional funds provided by Imperial and the RCA' (5)

In November 2007 an announcement was made of an MA in Creative Design to be developed jointly by the University of the Arts (London) and Cranfield University with a further injection of £3.8 million of HEFCE funding. This was the first of the 'regional hubs' to be announced and a further 3 were expected in due course.

2.2 The Design Skills Advisory Panel

During 2006 a major study was undertaken by the Design Skills Advisory Panel, which was brought together through a partnership between the Design Council and the Creative & Cultural Skills Working Group and includes representatives from across the UK design industry. This Panel published a consultation document in May 2006, with consultation ending in November 2006 and an agreed action plan to be published early in 2007. The summary of the consultation proposals is shown below.

'Summary of proposals
The Design Skills Advisory Panel's consultation proposals are aimed at the long-term development of the UK design industry and its skills base. The key issues the Panel's proposals seek to address are:
- *The weak links between design education and current design practice, and the near absence of structured Continuous Professional Development for designers at work*
- *The cottage industry approach to management and leadership apparent in many businesses*
- *The lack of a cohesiveness within the industry, which means that clients and the public do not see design as a valuable profession*

The Panel's vision is that:
By 2020 the UK design industry will be viewed as the global epicentre of high-value creative design and innovation.

To achieve this, the Panel believes that the imperative must be to create more of a professional and cohesive design industry; one that learns and adapts systematically from and with its clients, other design businesses, other disciplines and design educators. The Panel sees the proposals below as the building blocks for a new system. Not the solution to every issue in every area. Therefore, over the course of the consultation the Panel is keen to hear how it can build on these ideas and address unresolved issues.

In summary, the key proposals are:

Work
- *Benchmark and celebrate the creative and professional performance of UK designers and design businesses through an internationally recognised, widely-owned professional accreditation system*

College and University
- *Develop enhanced partnerships between design education and industry, linked to professional accreditation for graduates*
- *Collate and share impartial information on courses and career pathways for prospective students*

School
- *Create an up-to-date baseline design curriculum for all*
- *Increase the involvement of practising designers in schools' design teaching and enhance the professional development of design teachers'* (2006:2)

Such proposals would attract widespread support, but it is also worth observing two matters.
- The categorisation of design disciplines used in the report are the same as those used in the Design Council and Design Business Association's Design Industry Research 2005[1]
  - Communications design
  - Product and industrial design
  - Interior and exhibition design

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[1] Annex 1 of the report explains that 'Product and industrial design' includes automotive design, engineering design and medical products and that the Design Council and Design Business Association's 6th category was 'Other' which included aerospace design, building design, mechanical design etc

- o Fashion and textiles design
- o Digital and multimedia design
- o Service design
- No 'engineering organisations/initiatives' are listed amongst the extensive list provided in Annex 3 of the report.

Annex 3 provides short summaries of the main organisations and initiatives that support design in schools, colleges and universities and in the workplace.

> *The broad criteria for inclusion are that the organisation/initiative is on-going or recently completed; that it operates at a significant scale and that it supports:*
> - *Professional development of design educators*
> - *Design learning of design students*
> - *Development of innovative approaches to delivering design education and/or the design curriculum*
> - *Advancement of design research*
> - *Design education and/or policy infrastructure*
> - *Professional development of practising designers and/or design businesses*
> - *Design learning for design buyers/clients*   *(ibid:95)*

It is clear that it is an impressive list of people representing many design areas, who came together to reflect on and advocate the reform of the UK's design industry. It is less apparent that the kind of 'joined-up thinking' that underpinned the development of the industrial design (engineering) and integrated design programmes in the later part of the 20th century is embodied in the thinking. Similar divisions are evident in the general school curriculum from design appearing in two subjects, design & technology and art & design, and from the exclusion of design & technology from early discussions of the STEM (Science, Technology, Engineering and Mathematics) initiative in 2007, although this policy has been later reversed to some degree. It is perhaps surprising that the UK appears to be undertaking a major review of the design industry with at least a suspicion that it is carrying forward the same conceptual divisions, which have proved quite problematic to overcome towards the end of the 20th century, into the revision of the design industry for the 21st century. Perhaps this suggests that the conceptual divisions between the 'arts' and the 'sciences' are so engrained into UK culture that they will remain permanently, either as a hindrance or a support. Or, perhaps again, these apparent barriers are founded on something more permanent than tradition.

The Final Report was published on the 1 June 2007 and provides a strong agenda focussing on high level skills needed to develop design-led innovation, international markets, sustainability, strategic design and the public sector, around which the design community can unite to drive reform forward. Nevertheless the relationship between design and engineering remains largely unexplored within the report, although there are passages where the agenda is being developed eg

> **'The innovation gap**
> *One of the main threats we face is the possibility of a weakened innovation performance compared to other nations. Currently we are among the world leaders in scientific research, with more citations than many other countries. However, we are less good at developing the intellectual property, filing the patents and creating the new products and business ventures which contribute significantly to economic growth. The use of design in the innovation process needs to be fully understood and exploited by both technologists and designers.'*   *(19)*

However, the phrasing seems to suggest an 'applied science' perspective on innovation and the importance of design approaches in developing technology, as well as its exploitation needs further emphasis (eg Vincenti, 1990; Norman, 2006),

The Panel's final recommendations concerning colleges and universities were as follows.

> *'To strengthen partnerships between education and industry and ensure that design students in colleges and universities have the right skills, develop:*
> *- A network of visiting design professors to better connect further and higher education with professional practice*
> *- Joined-up promotion of multi-disciplinary programmes*
> *- A web-based career and course information service'* (6)

The report makes important recommendations concerning the employability of graduates, which are discussed in section 3, and the focus here is on the second recommendation concerning multi-disciplinary programmes.

> '***Joined-up promotion of multi-disciplinary programmes***
> *This recommendation is aimed at both supporting curriculum development and disseminating the results of multi-disciplinary programmes of study that equip design graduates with a broader set of professional skills.*
>
> *These professional, complementary skills prepare students for work in professional, commercial environments and include business management, understanding industry and markets, operating in global contexts and working in multi-disciplinary teams. These skills need to be developed in addition to the core specialist design areas skills that students learn. As design expands into new areas, designers are increasingly expected to work alongside engineers, technologists, marketers and management consultants. These multi-disciplinary teams will arguably be in the best position to respond to the needs of future businesses and public sector organisations.*
>
> *A network of colleges and universities involved in the development of multi-disciplinary activities across the UK will be developed, building on work already underway as a result of the Cox Review. This initiative is being led by the Higher Education Funding Council for England (HEFCE) and a number of higher education institutions, in collaboration with the Design Council. These multi-disciplinary activities will be publicised through web-based information about the network, featuring different courses, modules, projects and centres that link design, business, technology, teaching, learning and research. This web resource will also provide information about relevant schemes, competitions and initiatives that could help students' professional skills and multi-disciplinary experience, such as the RSA's Design Directions award scheme, the Fulbright exchange programme and the 1851 Commission's academic bursaries.'* (43)

The Panel makes their view of the required complementary skills and multi-disciplinary teams clearer in one or two earlier passages.

> *'Most FE and HE programmes for creative subjects do have elements of occupational learning that imitate real-world practice but in many there is still significant distance between the educational and commercial settings. The main gaps in skills development are the professional skills that complement the specialist*

subjects. Addressing this issue means creating designers with very deep expertise in one discipline but some knowledge and skills in a wide range of other domains. One way to develop these complementary skills is to work in multi-disciplinary teams.

Links across education
Multi-disciplinary teams are now a feature of many professional design projects and a merging of conventional design disciplines is increasingly occurring. In multi-disciplinary teams, each person learns to take a more holistic and professional approach, with some understanding of different specialisms enabling them to work effectively with their colleagues. Although multi-disciplinary teams occur frequently in design practice, they are much rarer in education where the subject 'silos' make collaboration more difficult. There are some examples of programmes and projects that connect different subjects, and recent progress has been made through initiatives such as the multi-disciplinary centres of excellence which the Cox Review recommended. The additional benefit of working in this way with other disciplines and subjects is the mutual learning – non-designers learn more about design while design students learn about science, technology, business and the wider context of design.'   *(27-28)*

The integrated, undergraduate Industrial Design (Engineering) (or Industrial Design and Technology) programmes, and the development of 'Design & Technology' in secondary education in the 1980s and 1990s were at least partly about creating programmes that did not respect rigid subject boundaries ie that were not subject 'silos'. Perhaps these are what the Panel are referring to by 'some examples of programmes', but this is not likely from the context. The view being advocated seems rather more to suggest that the more traditional subject disciplines remain the only strong elements within education. This is by no means the case, and it might well be argued that the more progressive programmes that respect fewer discipline boundaries attract criticism for risking educating students as 'jacks of all trades and masters of none', rather than 'jacks of all trades and masters of one', which seems to be the perspective taken by these recent reports. Of course the risk of 'insufficient depth in a discipline' is there, but there are some fine balancing acts to perform here, and such criticisms depend on particular views concerning disciplines as the current 'status quo'. They also disregard the long, successful track records which the more progressive integrated design programmes have established since the 1980s.

3 Recent Design Council reports and other evidence

Following the publication of the Cox Review, the Design Council in conjunction with the Higher Education Funding Council for England, supported a network of academics in developing a response. Delegations including members of this group and policy makers visited companies, universities and studios in America, Europe and Asia in order to explore emerging practice and inform new initiatives in the UK (Design Council 2006, 2007 and 2010). In 2010 the Design Council also published a report on multi-disciplinary design education in the UK and an analysis of 8 associated case studies.

3.1 Lessons from America (2006)

The following were the key findings of the delegation's visit to America.

> *To prepare future generations of creative specialists and business leaders we need:*
>
> - *To develop different types of creative professionals – specialist designers and design managers, as well as design thinkers, who come from design and other subject areas, and can operate across disciplines*
> - *Stronger collaboration with, and involvement of, industry and public sector organisations in education*
> - *Development of cross-disciplinary opportunities in universities, especially at postgraduate level, and simplification of credit systems to encourage greater levels of collaboration*
> - *Innovative education models that integrate research, teaching and live project work*
> - *To promote multi-disciplinary teamwork, involving business, design, science and engineering students, and to include new disciplines within design teams working in the area of innovation, especially the social and life sciences, and humanities (eg, anthropology, psychology and the creative arts)*
> - *More creative spaces - physical environments and resources for prototyping, brainstorming, project development and creative teamwork.* (2006:1)

The evidence supporting these findings had been gathered through visits to universities and design firms in California, Illinois and Massachusetts. Some of the more detailed statements are shown in Table 3.1

Report section	Sub-section	Evidence
2. Design thinking, skills and methods of innovation	2.1 Design thinking	*The recurring use of the term 'design thinking' was a subject of some debate about the extent to which it signalled an extension of traditional design skills or a departure into a new discipline. The term was generally used to describe the use of design processes and methods which included the questioning of briefs, making early speculative proposals and developing iterative prototypes to foster innovation and contribute to business growth (2)*
	2.2 Specialists and hybrids	*Design thinking was associated with the ability to integrate specialist knowledge of one or two areas with a broad understanding and curiosity about other areas. This skill is embodied in IDEO's T-shaped model, in which 'vertical specialist depth, developed mainly through undergraduate qualifications is complemented by the 'horizontal' appreciation and understanding of other disciplines and professional contexts, often developed in postgraduate degrees and early career experience (3)*
	2.3 Innovation methods and creative processes	*New emphasis is being placed on ethnographic methods for conducting user and market research. While some of these methods are transferable and can be taught to senior business managers, concerns were raised about the danger of trivialising specialist design skills and methods.(4)*

3.Developing innovative practice	3.1 Multi-disciplinary and inter-disciplinary teamwork	*Faculty (Stanford d-school) emphasised the way discourse and dialogue between different disciplinary specialists are balanced by practical experience of doing…. a lot of the most interesting challenges don't fall neatly into existing disciplines (MIT's MediaLab). (5)*
		The sizes of teams varied: the d-school regarded 3-4 as the ideal number of team members and supported this with research conducted at Microsoft; In MIT's joint masters programme, with students from engineering, management and design (from the Rhode Island School of Design), team sizes were as large as 6-7. The common perception was that three-person teams are best. (5)
		In some cases, the low disciplinary boundaries in some of the multi-disciplinary centres visited were said to have an alienating effect on links with the rest of the university, where disciplinary boundaries were more rigid. (6)
	3.2 Collaboration across subjects	*An obvious example was Northwestern's MPD and MMM programmes which are delivered by faculty from the McCormick School of Engineering and the Kellogg Business School. These programmes cover more than 23 subjects over 2 years, with intensive classes geared to students' needs, such as 'Turbo finance' – a five week class on finance in business. (7)*
	3.3 Culture of prototyping	*All the academic programmes we visited championed a project-based teaching approach and highlighted the importance of complementing theoretical studies with real-world solution seeking embedded in a culture of prototyping. …*
		MIT MediaLab projects begin by generating solutions with no prior data, prototyping concepts right at the start of the project, followed by user testing. Project teams at Stanford d-school commonly produce 8-10 prototypes for each concept. (8)
	3.4 Physical spaces	*In the universities the existence of a physical 'place' that is non-territorial in terms of faculty affiliation was seen as important in getting students and tutors from different faculties to collaborate on an equal footing. (9)*
4 Links with industry	4.1 Live projects, real world situations and internships	*There was an acknowledgement of the importance of 'constraints' as agents of creativity, and exposing students to real-life situations and real financial and time constraints was generally seen as a key part of the structuring of projects. (10)*
	4.2 Corporate culture and education sponsorships	*Programme leaders are naturally attentive to the needs of industry sponsors and in some instances referred to them as their 'client', with their students referred to as their 'product'. This attitude, which may be common in many business schools, is increasingly found in design schools. (11)*
	4.3 Regional dimensions	*The strong industrial connections were reflected in the different 'flavours' of design and innovation that have evolved in each of the cities visited. (12)*

Table 3.1 Extracts from Lessons from America (Design Council, 2006)

3.2 Lessons from Europe (2007)

The following year a delegation was sent to visit leading companies, universities and design studios in The Netherlands, Denmark and Finland and build on the findings from the American visits. The findings confirmed the growing importance of this area and the extracts from the key findings and evidence presented here, focus on the educational insights that were gained. Hence, some of the key findings from this report were as follows.

- The practice of multi-disciplinary education varies greatly across the European universities visited – and those different interpretations have been shaped by a number of contextual factors: organisational aims and structures, existing courses, government funding, location, heritage, national/local government agendas and links with industry
- There is strong evidence to show that leading European universities are responding to the changing needs of industry by developing postgraduate courses that bring together different elements of creativity, technology and business – such as the International Business Management course in Finland

- Both the well-established and newer universities are nurturing a willingness to co-operate and develop new organisational structures that support cross-disciplinary teaching and learning
- There was an emphasis on products rather than services or media content, and most of the models of innovation were based on interaction between product design, engineering and business – few other disciplines were mentioned
- Broad consensus exists that multi-disciplinary education should take place at Masters level but there is debate over the need to entirely restructure existing courses or add short courses to existing programmes
- European universities have developed highly sophisticated structures for developing and managing their engagement with industry
- Industry professionals are becoming increasingly involved in the delivery and assessment of student projects
- Giving students the opportunity to work on industry briefs in multi-disciplinary teams helps them gain crucial work experience, appreciate the value of co-creation and improve their employability   (2007:4)

Report section	Sub-section	Evidence
Multi-disciplinary Learning in Higher Education	Evidence of multi-disciplinary education in Europe	*There was a trend for the lead partner in these collaborative models to be the design department/university and for variations of 'design thinking' to lie at the heart of the programmes. It was striking that the concept of multi-disciplinary education varied greatly in both form and meaning across the HEIs we visited – and how these different interpretations have been shaped by a range of contextual factors (9)*
	Willingness to collaborate across departments and institutions	*Central to the success of all the multi-disciplinary programmes we visited was willingness on the part of faculty members to collaborate across the disciplines and forge working relationships between departments …* *The IBDM has been running for 12 years and is the most integrated programme we saw. It is highly regarded within industry with Nokia, Kone and Desigence sponsoring student projects and recruiting graduates into management positions. (9)*
	Organisational structures that enable multi-disciplinary teaching	*For the newer institutions, like the Design Academy in Eindhoven and Kaospilots in Denmark, they have avoided the issue of silos between academic disciplines by developing flexible structures that support the way they want to work. The Design Academy has developed a model based around 125 part-time 'coaches' who work a maximum of 1.5 days a week, the vast majority of which are practising professionals …* *Clearly this is not a route open to most HEIs in the UK where legacy, existing structures and academic silos are significant barriers to change. (10)*
	When should multi-disciplinary teaching be introduced?	*The general consensus of opinion from the European examples was that students at undergraduate level should continue to focus on the development of 'core' skills and multi-disciplinary activities should be introduced at post-graduate level. This view was endorsed by faculty at TU Delft who feared standards would drop if students didn't develop their technical abilities before moving on to team-based activities. However, their situation is somewhat different to others in that almost all their students stay on and take a Masters degree…* *This was not a view shared by everyone - with some arguing skills such as teamwork and co-creation should be introduced earlier in the curriculum. (11)*
	Restructure existing courses or add electives in innovation?	*WorkCamp07 is a course in 'dramatic innovation' developed and run in partnership between Zentropa Workz agency and the University of Copenhagen. Based on the 'Hero's Journey' concept used in the film industry it forms multi-disciplinary teams and over a 5 week period students work through a highly structured process to solve real life problems sponsored by companies. According to Michael Thomsen*

		"companies pay for access to talent and a process to tackle their problem". He strongly believes that innovation within a university setting is not possible because "you need a neutral space where everyone is equal, as soon as people arrive at WorkCamp they know the rules inside the space are different" (11)
Teaching and Learning Strategies	Learning through workshops, teamwork and projects	*All of the student projects we saw were based on multi-disciplinary teams, ranging in size from three people to a maximum of 10. The majority of student projects were in response to industry briefs, but some were students developing their own ideas in response to market needs. (12)*
	Emphasis on industry briefs	*Working on company briefs was seen as an ideal way for students to gain industry experience and enhance employability. However, an over-emphasis on industry briefs can be seen to have an adverse impact on efforts to support student entrepreneurship. (12)*
	Benefits of multi-disciplinary teaching for students	*Across all the programmes the notion of rapid prototyping was a constant theme and all the institutions had modern and well equipped facilities and work spaces. Prototyping was also being outsourced to industry partners.(12)*
	New terminology for students and lecturers	*Building on the need to create working environments similar to those found in industry many of the HEIs visited have dropped traditional terms such as 'students' and 'lecturers'. For example, at the TU in Eindhoven project teams are made up of competency coaches (academics), project coaches (industry representatives) clients (industry sponsors) and junior employees (students). (13)*
	New approaches to assessment	*In terms of assessment there was a general shift away from exams to projects and assignments …* *All the institutions mentioned the increasing role industry professionals are playing in the delivery and assessment of student work in terms of presentations and feedback at the end of projects. (13)*
Links with Industry	Models for engaging with companies	*All of the programmes visited have developed structured ways of engaging with industry. (14)*
	Incentives for companies	*In terms of incentives a common response was that companies use student projects as a way to test new ideas and to recruit the brightest students.* *Location and regional dimensions have also played a key role in the types of relationships HEIs have been able to develop and this has shaped the direction of their teaching. For example, TU Delft has developed expertise in the healthcare sector given that so many healthcare companies and hospitals are based in the region. (14)*
	Alumni networks	*All of the institutions visited have mature and well developed alumni networks that they use to engage with past students who are now practicing professionals. This was cited on numerous occasions as one of the best routes into companies. (14)*

Table 9.2 Extracts from Lessons from Europe concerning educational perspectives (Design Council, 2007)

3.3 Lessons from Asia (2010)

In 2010 a report was published summarising key findings from visits to leading companies, universities and design srtudios in Beijing, China and in Seoup and Daejeon, South Korea. Some of the key findings relating to design education are shown below.

> *- Design is understood to be an essential part of innovation and is used extensively by industry in parts of Asia*
>
> *- Technology is the key driver of innovation and technical design expertise is highly valued*
>
> *- The rich heritage of craft and culture has a strong influence on contemporary design, and emotional human needs are also recognised*

- 'Convergence' is the term used most often in industry and education to describe the collaboration and connection between design and science, technology and enterprise subjects. Several universities promote this approach and provide multi-disciplinary experiences for students

- Design courses in South Korean universities are over-subscribed and very selective, while in China design is the third most popular university subject

-Staff – student ratios are generally better than in the UK, contact hours are higher and required study time is longer

- Emerging issues such as sustainability and social innovation are starting to be included in some student projects, particularly at postgraduate level

- Collaboration between industry and academia is well established and provides mutual benefits in the form, for example, of funding and live projects for universities and new talent for businesses (2010:4)

Report section	Sub-section	Evidence
Context		*Both South Korea and China are rapidly developing their design capability, learning from the 'best of the West' as well as building on their own significantcreative and cultural backgrounds.Technology is a huge driver of innovation in Asia and design is clearly perceived as a key translator of science and technology, and increasingly too as a means of meeting social needs . (5)*
	South Korea	*Korean design is well established and achieving significant results. 'The Design Declaration of the 21st Century Korea' (2008) states that the role of design is in creating industrial and economic value 'by merging humanities, science and the arts'. (6)*
	China	*Price and manufacturing capability have been key factors in China's rapid economic growth. While this competitive advantage shows no signs of abating, China is now looking to go one step further, and move from 'made in China' to 'designed in China'. (8)*
Education perspectives	Policy and funding	*Government support for university-level multi-disciplinary design education in South Korea and China is significant. In the universities we visited there was evidence of government actively encouraging the development of multi-disciplinary teaching, learning and research with funding. …* *Generally, in both policy and education, design is understood as a key element of innovation and closely aligned with the STEM subjects (science, technology, engineering and maths). (10)*
	Multi-disciplinary approaches in HE	*There was a general acceptance that design needs to be taught and learnt in the context of innovation and that specialists from a number of disciplines should be involved in the design process. This approach reflects professional design practice and builds on examples of design education in Europe and the US. …* *One key issue is whether education should aim to create specialists rather than generalists, with most of the academics agreeing that designers should be specialists first. This is in line with the quite well developed concept of 'T' shaped designers who have deep knowledge of their own specific area but also broad knowledge of several others. ..* *We saw a range of courses potentially developing a number of different types of graduates - from the very specialist, technical designer to the broader generalist and 'hybrid' design manager. (11)*
	Collaboration	*A distinctive feature of the university visits was the collaboration both within the institutions (HEIs) and with external businesses and other organisations. Both in South Korea and China, programmes have been set up and developed with collaboration as a core element. …* *Many collaborations were in place with universities outside Asia – particularly with American universities such as Stanford, Carnegie Mellon and MIT. German, Dutch and Japanese universities also have links with the Korean and Chinese HEIs we visited though there was less evidence of similar links with UK universities…* *Within the universities, there was evidence of collaboration across faculties, departments and schools. This usually involved design,*

		engineering and management which enabled the multi-disciplinary activities to be developed and delivered. There was also a strong move towards working across art and design disciplines – sometimes with an inter-disciplinary approach (media art, interactive design and digital technology, for example, at Tsinghua) and sometimes to provide multi-disciplinary experiences (collaboration between film, media, advertising and photography courses at Hongik) *… The collaboration with industry was probably the strongest element we saw. This ranged from universities that were set up by business (Samsung Art and Design Institute, SADI) to those that had set up funding, research projects and internship arrangements. …This focus in the curriculum on professional skills is in contrast to teaching and learning strategies that foster student enterprise and a start-up culture, as is the case in the UK. (12)*
	Skills	*In most of the student work we saw, there was a strong understanding of technology and a focus on the technical aspects of design, as well as its business context. The business links and real world contacts also help develop practical and applied skills. … The focus here is on working in industry, not on entrepreneurship. Some of the universities are also developing a stronger focus on concept development and the wider use of design in society with, for example, some interesting projects at Masters level that addressed major current social challenges. (13)*
Industry perspectives	Skills	*There is an expectation in the design companies and teams we met that the graduates they recruit will have a good understanding of business, if not real experience, although creativity is still considered to be the most important attribute. (15)* *' A "learn when needed" approach is most important' (15)*
	Collaboration	*The links between the design industry and higher education and between large companies and consultancies are accepted much more as the norm in Asia than in the UK. There is a strong, symbiotic relationship between industry and academia, with industry playing a vital role in financially supporting university courses for mutual benefit. The businesses involved typically have direct links with universities and influence the skills and knowledge that students develop. (16)*
	Design approach	*The focus of design work was almost all on branding, styling and incremental product development rather than radical innovation, largely reflecting the types of client projects available. There was a strong sense in both countries of the link between design and human needs, acknowledging the spiritual and emotional responses to products and services. …* *The use of structured design processes was evident in the projects designers were working on. In one instance, this was described as design research, covering four stages that included user research, strategy and market research, service and experience development and future trends analysis. In another example, 'research, thinking, development, delivery and connection' were described as the project stages. The design research mostly uses analytical methods and generates quantitative data, although observational and ethnographic methods were also applied. (17)*

Table 9.3 Extracts from Lessons from Asia concerning Educational Perspectives (Design Council, 2010)

3.4 Multi-disciplinary design education in the UK (2010)

The report on multi-disciplinary design education in the UK restates the case for this approach as seen the Multi-Disciplinary Design Network. It makes some recommendations and notes methods which have been adopted for embedding design and multi-disciplinary team working in HEIs.

Report section	Sub-section	Evidence
Developing tomorrow's designers	1. By developing the business skills of tomorrow's designers	*While UK designers are generally well qualified and their skills and creativity are valued by clients in the UK and across the world, Design Council's research has found specific areas where designers' professional skills needed to be improved.12 Designers need to be able to understand their clients' businesses and the markets in which those businesses operate. They also need to be able to understand, and articulate, the wider global context in which the products, services and systems they design will exist. Design employers have described that designers often need better communication skills to explain their work and the value of design to new and existing design buyers. And designers are often business owners and managers too, so designers also need entrepreneurial business skills to help them set up, develop and manage their own enterprises, and leadership skills to grow them.* *Enabling design students to undertake taught modules on business and management, and to learn about business processes and systems helps to close these skills gaps. Having design students work in multi-disciplinary teams, especially if they are on 'live' briefs for established companies, helps them to develop a deeper understanding of real-life business contexts. (15)*
	2. Broadening designers' knowledge of science and technology	*Today's practising designers, particularly those in the fields of product and industrial design and in the digital sector, already have to understand a great deal about current and emerging technologies and this demand will only increase.* *Giving design students the opportunity to work with scientists and technologists, and to learn more about these subjects, equips them for a future, which will see the increasing convergence of, for example, internet-enabled technologies with designed products and services. And if new areas, such as nanotechnology, are to result in economically successful products, they will need designers who understand the technology and can work with the subject's experts. Similarly, complex global issues, such as climate change, are already demanding new solutions that can only be developed by teams whose members understand issues outside of their individual specialism.*
	3. Helping designers to understand manufacturing and engineering	*As well as understanding new technologies, it is important that designers of manufactured goods understand materials and production methods. Both tooling and volume manufacturing is increasingly undertaken overseas, and ensuring consistent quality from offshore manufacturing demands a higher level of understanding on the part of the designer. Similarly, production methods are developing and will continue to change. Designers will need to understand where it is appropriate to shift away from traditional tooling and towards rapid manufacturing, small batch production and mass customisation. And ensuring that tomorrow's products are environmentally sustainable demands that tomorrow's designers know more about design for disassembly, remanufacturing and recycling.* *Giving product and industrial design students the opportunity to work with engineering students, materials scientists and computing specialists will help to ensure that this understanding is embedded in product development teams. (18)*

Table 9.4 Some recommendations from 'multi-disciplinary design education in the UK' (2010)

The report noted that there was no one way to introduce multi-disciplinary design education and noted the following possibilities:

- Collaboration between institutions (Design London and C4D, see section 2.1)
- Design-led modules and projects within MBA programmes Design London and Saïd Business School, University of Oxford)

- Multi-disciplinary Masters courses (Northumbria University School of Design linked to Newcastle Business School, Kingston University, C4D, Nottingham Trent University, Teeside University, Manchester Business School, University of Nottingham, Lancaster University)
- Multi-disciplinary research, PhDs and Doctoral Training Centres (HighWire at Lancaster University. Horizon Research Institute at Nottingham University and the Design Innovation Research Centre at the University of Reading).
- Multi-disciplinary design education working with business (Design London, C4D, Northumbria University and Nottingham Trent University)
- Researching multi-disciplinary teaching and learning (the Innoversity project at Kingston University, Northumbria University and the University of Nottingham)
- New course and centres in development (Ravensbourne, University College Falmouth, Teeside University and De Montfort University)

Report section	Evidence
Design London: building on a history of co-operation between institutions	*Design London is a collaboration between Imperial College Business School, Imperial College Faculty of Engineering and the Royal College of Art. It was created in 2007 with £5.8million funding for three years (£3.8 million from HEFCE, £900,000 funding from NESTA for an incubation centre and the remainder from within the Royal College of Art and Imperial College), its HEFCE funding has now been extended until 2011. Design London offers teaching, research, a business incubation unit, an Innovation Technology Centre and a programme of industry services and executive education called 'Design Connection'. (8)*
C4D: developing relationships across institutions	*A partnership between Cranfield University and the London College of Communication, University of Arts London, the Centre for Competitive Creative Design (C4D) was launched in 2007 using an investment of £3.5m over three years from HEFCE's Strategic Development Fund. C4D offers taught Masters courses and runs a research programme as well as services to industry. (14)*
University of Nottingham: embedding creative problem solving and design thinking in entrepreneurship education	*The University of Nottingham Institute for Enterprise and Innovation (UNIEI) was established in 2000 and is based at Nottingham University Business School. It offers undergraduate and postgraduate teaching, research and practical support for staff and student enterprise as well as local business engagement under the banner of the EMDA-sponsored Ingenuity Programme. (18)*
Northumbria University: multi-disciplinary curriculum and assessment design	*Northumbria University offers a Masters in Multi-disciplinary Design Innovation, run by the School of Design in collaboration with Newcastle Business School and the School of Computing, Engineering and Information Sciences. Launched in September 2008, the degree can be awarded as an MA or an MSc depending on the focus of the final semester's work. (22)*
Kingston University: researching multi-disciplinary teams in action	*In 2008, Kingston was awarded £250,000 from HEFCE for a two-year initiative to develop 'Innoversity', a cross-faculty project to investigate how multi-disciplinary teams from design, business and technology backgrounds collaborate to solve problems. Postgraduate students from Kingston University's multi-disciplinary 'creative economies' Masters courses are at the heart of the project, which is a longitudinal study on multi-disciplinary team-working and aims to transfer research knowledge into the teaching of Kingston's multi-disciplinary courses. (26)*
Nottingham Trent University: studying innovation processes through real life projects	*Originally a pathway open to students on the MA in Product Design, the Multi-disciplinary Masters programme at Nottingham Trent University (NTU) has developed into a scheme open to students from five NTU schools: Art and Design; Architecture, Design and the Built Environment; Business, Science and Technology; and Animal, Rural and Environmental Sciences. The programme draws together staff and students from these colleges to address a new set of product innovation challenges posed each year by four to six collaborating companies. (30)*
Lancaster University: embedding design research and teaching in amulti-disciplinary	*ImaginationLancaster is a creative research lab at Lancaster University, which offers multi-disciplinary MA and MRes design courses, design-led PhD research and a combined undergraduate degree in Marketing and Design in conjunction with Lancaster University's Management School. ImaginationLancaster sits within the multi-disciplinary Lancaster Institute for the Contemporary Arts (LICA), which brings together Lancaster's teaching and research activities in Art, Design, Film Studies,*

contemporary arts institute	*Music and Theatre Studies. (34)*
University College Falmouth: prototyping a multi-disciplinary team project in advance ofcreating a new academic research and development centre	*University College Falmouth will formally launch its Academy of Innovation and Research (AIR) in 2011, a £9million investment which will operate as a multi-disciplinary research and development laboratory and as a creative facilitation space. In advance of this, University College Falmouth has been testing approaches to multi-disciplinary team-working on a service design project for Dott Cornwall, funded by the Cornwall Council, the Design Council, and the Technology Strategy Board. (40)*

Table 9.5 The headlines from 'multi-disciplinary design education in the UK: eight case studies' (2010)

3.5 World's best design schools?

Further evidence of the increasing importance of this agenda is shown by the recent investigation published by *Business Week* (Blomberg, 2010). They presented a 'snapshot of the nascent movement to teach design thinking and innovation to a new generation of global corporate leaders'. The 30 programmes selected as the 'world's best' were presented in a slide show[2], and extracts are shown in Table 9.6. They were listed in alphabetical order and all 30 have been shown in order to demonstrate how rapidly the issue of teaching design thinking is coming to the fore.

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[2] *The slide show can be found at*
http://www.businessweek.com/innovate/di_special/20090930design_thinking.htm

Design School	Description
Art Center College of Design/INSEAD Pasadena, California/Fontainebleau, France or Singapore	**Programs:** *Masters in Industrial Design (Art Center College of Design)/MBA (INSEAD)* **Business Partnerships:** *Disney, Hewlett-Packard, Motorola* **Why it's on the list:** *As part of an exchange program hosted at INSEAD, Art Center students can apply to take MBA courses for four months. INSEAD students can study with the design students in the eight-week Strategies for Product and Service Development elective, offered through the 10-month MBA program*
California College of the Arts San Francisco, California	**Program:** *MBA in Design Strategy* **Business Partnerships:** *Continuum, IDEO, Jump Associates* **Why it's on the list:** *The Design MBA program, as it's known, launched in 2008. The two-year program has so far enrolled 48 students, all required to take courses in finance, management and leadership as well as more practical design-related skills. Both studio and academic classes emphasize hands-on learning.*
Carnegie Mellon University Pittsburgh, Pennsylvania	**Program:** *Masters in Product Development* **Business Partnerships:** *Ford, Navistar International Truck, New Balance* **Why it's on the list:** *The program is a collaboration between Carnegie Mellon's School of Design, Department of Mechanical Engineering, and the Tepper School of Business. During the one-year program, engineers, industrial designers, and marketers refine their areas of expertise, are given insight into each others' disciplines—and learn how to work together.*
Case Western Reserve University Cleveland, Ohio	**Program:** *MBA* **Business Partnerships:** *Fed Ex Custom Critical, PNC Bank, Sherwin-Williams* **Why it's on the list:** *As part of the Weatherhead School of Management's "Manage by Designing" initiative, launched in 2002, the MBA curriculum now requires all students to take a two-semester course in either "Managing Design Opportunities" or in "Sustainable Value." They must also study week-long courses on topics such as systems thinking, and are taught hands-on skills such as sketching and prototyping.*
Chiba University Chiba, Japan	**Program:** *Masters in Service & Product Design* **Business Partnerships:** *Denso, Fujitsu, Hitachi* **Why it's on the list:** *Students in this "practice-based" program, started in 2007, take four studio-work programs and do two design projects with partner companies such as those listed above. The courses, taught in Japanese and English, focus on project management, product development and design engineering.*
China Central Academy of Fine Arts Beijing, China	**Program:** *Masters in Design Management* **Business Partnerships:** *Adobe , Chinese government institutions, Gehua Cultural Development Group* **Why it's on the list:** *The Chinese-language program, started in 2004, aims to cultivate professionals who understand design's role as both art and business builder. Students can opt for a variety of courses such as the one educating them on how to develop appropriate, design-centric strategies for China's own market.*
Cranfield University/University of the Arts London Cranfield, U.K., London, U.K.	**Program:** *Masters in Design in Innovation and Creativity in Industry* **Business Partnerships:** *Ford, Procter & Gamble, Xerox* **Why it's on the list:** *In 2008, this program began to integrate design, management, and engineering. Students learn managing at the Cranfield School of Management, technology at the Cranfield School of Applied Sciences and study consumer behavior at the Centre for Competitive Creative Design (a joint venture between the two schools).*
Delft University of Technology Delft, the Netherlands	**Program:** *Masters in Strategic Product Design* **Business Partnerships:** *BMW, Procter & Gamble, Unilever* **Why it's on the list:** *This masters degree trains students to use market analysis, consumer and behavior research, trends, government policy and new technologies to help companies define a strategic direction when developing new products.*

Domus Academy Milan, Italy	**Program:** *Masters in Business Design* **Business Partnerships:** *3M, BTicino* **Why it's on the list:** *The English-language program is structured to be a laboratory for designers, managers, and entrepreneurs. The curriculum aims to create a new managerial class for design-oriented companies and new businesses, with graduates trained to combine design thinking, management skills, and a self-starter attitude.*
Helsinki School of Economics/University of Art and Design Helsinki/Helsinki University of Technology Helsinki, Finland	**Program:** *International Design Business Management* **Business Partnerships:** *Kone, Nokia, Panasonic* **Why it's on the list:** *The IDBM minor studies program, started in 1995, represents 20 to 40 credits and allows students to take courses at the other participating schools. (120 credits are required for a masters degree.) In addition, business, engineering, and design students work in multidisciplinary teams to learn how to manage international design-intensive businesses, operations, and product development. They also work on a year-long project with a sponsor company.*
Hong Kong Polytechnic University Hong Kong, China	**Program:** *Masters in Design (Design Strategies)* **Business Partnerships:** *Philips, Microsoft, Reebok China* **Why it's on the list:** *The program, started in 2004, hones strategic thinking skills and methods. There are about 20 full-time and 30 part-time students, who are mostly professional designers, entrepreneurs, and those interested in using design to develop business and to translate technology into compelling experiences.*
Illinois Institute of Technology Chicago, Illinois	**Program:** *Dual degree Master of Design and MBA* **Business Partnerships:** *McDonald's, Target, Toyota* **Why it's on the list:** *IIT launched the two-year program in 2006 to offer two distinct degrees that tackle innovation. The design masters is overseen by the Institute of Design, and focuses on the link between strategy and human-centered innovation. The MBA, administered by IIT's Stuart School of Business, teaches a traditional AACSB-accredited business curriculum.*
Imperial College/Design London London, U.K.	**Program:** *MBA, Executive MBA, Weekend Executive MBA* **Business Partnerships:** *BAE Systems, Hewlett-Packard, Procter & Gamble* *All MBA students at Imperial College Business School are required to take the Innovation, Entrepreneurship and Design (IED) course at Design London, a joint venture between Imperial College and the Royal College of Art. Teams work on real-world business and design problems. The course results in the final presentation of a business case or feasibility study developed for a new technology, idea, or business need.*
Korea Advanced Institute of Science and Technology Daejeon, Korea	**Program:** *Masters in Industrial Design* **Business Partnerships:** *LG, Nokia, Johnson & Johnson* **Why it's on the list:** *The masters program, set up in 1991, focuses on human-centered design, technology convergence, and business innovation. Students take courses in design marketing and design management to understand wider corporate issues and also learn how to use design as a strategic tool.*
National Institute of Design Ahmedabad, India	**Program:** *Strategic Design Management post-graduate degree* **Business Partnerships:** *Autodesk, Hewlett-Packard, Sun Microsystems (* **Why it's on the list:** *The two-year program, taught in English, trains graduates to help companies understand consumer needs. The first semester focuses on teaching practical design skills, the second on business and management, the third on creating a business design proposal, and the final semester on working with sponsors on a specific project.*
Northwestern University Evanston, Illinois	**Program:** *Masters in Product Development* **Business Partnerships:** *Harley Davidson, Northrop Grumman, Motorola* **Why it's on the list:** *The part-time, two-year program at the McCormick School of Engineering & Applied Science is targeted at working professionals. They meet one day per week to take 21 classes looking at product development. Class themes include the management of creativity and design, design strategy, customer-focused innovation, and financial issues.*

Pontifícia Universidade Católica do Paraná Paraná, Brazil	**Program:** *MBA* Emotional Design* **Business Partnerships:** *Electrolux Brazil, Volvo Brazil, Whirlpool do Brazil* **Why it's on the list:** *This Portuguese-language MBA started in 2008 in partnership with Electrolux. The program is offered mainly to employees of partner companies and includes 365 hours of classes. It aims to teach executives about another, softer side of business. Course titles include "Cognition and Emotion in Design."* *This MBA is a postgraduate degree, not a masters. The two are distinguished in Brazil.
Pratt Institute New York, N.Y.	**Program:** *Masters of Professional Studies in Design Management* **Business Partnerships:** *Anna Sova Luxury Organics, Grameen Bank, Korea Institute of Design Promotion* **Why it's on the list:** *The two-year program, launched in 1995, develops skills such as leadership, team building, strategy, finance, marketing, and operations for graduates looking to manage design firms or design teams. Courses focus on the role design can play to build a well-grounded, sustainable business.*
Royal College of Art/Imperial College London London, U.K.	**Program:** *Dual degree Innovation Design Engineering* **Business Partnerships:** *Bank of America , Sony, Unilever* **Why it's on the list:** *In two years, students receive two masters degrees in industrial design engineering: an MA from RCA as well as an MSc and diploma from Imperial College London. The program features a concentration called "Design Enterprise," covering issues such as raising finance, marketing, designing service and support infrastructures, project management, and production/supplier relationships.*
Savannah College of Art and Design Savannah, Georgia	**Program:** *Masters in Design Management* **Business Partnerships:** *Coca-Cola, Dell, Newell Rubbermaid* **Why it's on the list:** *Started in 2007, this program builds design thinking into strategy, planning, and management. Coursework and projects include topics such as visualization, design development, and how to build collaborative corporate cultures. Students learn to work across business functions to integrate design thinking into strategy, planning and management.*
School of Visual Arts New York, N.Y.	**Program:** *MFA Designer As Author* **Business Partnerships:** *Adobe, Illy Cafe, Target* **Why it's on the list:** *The program, also called MFA Design, started in 1998 and focuses on entrepreneurship and visual art. Students, who generally already have creative backgrounds, learn contract law, intellectual property, business planning, pitch, and presentation. Their thesis requires them to come up with a concept that addresses a real need, and then to produce and market it.*
Shih Chien University Taipei, Taiwan	**Program:** *Masters in Industrial Design* **Business Partnerships:** *Acer, HTC, Lenovo Mobile Communications* **Why it's on the list:** *The masters, launched in 1998, has about 80 students and uses a studio-based curriculum that integrates humanities, social sciences, technology, and engineering. Students assess case studies of design management in action and learn about leadership and how to market design within business through workshops and seminars.*
Stanford University Stanford, California	**Program:** *Joint Program in Design and the Hasso Plattner Institute of Design (d.school)* **Business Partnerships:** *Electronic Arts, Visa, Wal-Mart* **Why it's on the list:** *Graduate students in the Joint Program in Design, which integrates technology and human-centered design, can join students from across Stanford University at the Hasso Plattner Institute of Design. The d.school, as it's known, is a multidisciplinary program that was founded in 2003. About 350 students enroll each year and learn to use design methods to collaborate and solve problems. Every class is taught by at least two instructors and many also have coaches from industry to offer a range of perspectives.*
Suffolk University Boston, Massachusetts	**Program:** *Executive MBA with concentration in Innovation & Design Management* **Business Partnerships:** *Design Management Institute*

	Why it's on the list: *Sawyer Business School launched this 21-month, Saturday-only program in 2006. The courses aim to give professionals from many different fields the skills needed to manage design and innovation at the project and strategic level. The innovation and design management concentration represents six of 20 total classes. Regular EMBA classes cover organizational skills, decision-making, and understanding the marketplace.*
Umeå University Umeå, Sweden	**Programs:** *Masters in Industrial Design* **Business Partnerships:** *Ericsson, Nokia, and Electrolux* **Why it's on the list:** *The two-year program at the Institute of Design, taught in English, offers concentrations in Interaction Design, Advanced Product Design, or Transportation Design. Students also work together to learn different approaches to problem solving. Business classes are not mandatory but the school does run projects with supporting corporate partners to offer hands-on, real world experience.*
University of California Berkeley Berkeley, California	**Program:** *MBA* **Business Partnerships:** *Cheskin Research, Fitch, Smart Design* **Why it's on the list:** *MBA courses bring together students from Haas School of Business with those from Berkeley's College of Engineering and the California College of the Arts' Industrial Design program. Haas, which enrolls about 240 full-time students every fall, regularly offers courses that use design theory and methods as a tool for building a better business.*
University of Cincinnati Cincinnati, Ohio	**Program:** *Masters in Design* **Business Partnerships:** *Citi, General Mills, Procter & Gamble* **Why it's on the list:** *With mandatory classes in strategy and research methods, students can also take electives in science, engineering, business, and anthropology. They also participate in the Live Well Collaborative, which operates in the university's Center for Design Research & Innovation, to do research and corporate projects that focus on the needs of America's aging population.*
University of Gothenburg Gothenburg, Sweden	**Program:** *Masters in Business & Design* **Business Partnerships:** *Puma, Volvo* **Why it's on the list:** *The two-year masters is a partnership between HDK School of Design and Crafts and the School of Business, Economics and Law at Gothenburg University. The program, started in 2008, is targeted at professionals interested in using the design process to build smarter businesses. About half of the courses integrate the two disciplines of design and business, covering topics such as strategy and legal issues.*
University of Toronto Toronto, Ontario, Canada	**Program:** *MBA* **Business Partnerships:** *Medtronic, Nestle, Pfizer* **Why it's on the list:** *The 260-plus MBA students at the Rotman School of Management can elect to take courses at DesignWorks, the school's academic and commercial learning lab for design-based innovation and education. In addition to core MBA classes such as finance and leadership, students can take classes on building an innovation culture and strategic business design.*

Table 9.6 The World's best design schools according to Business Week (2010)

4. Background and development of Industrial Design (Engineering) programmes

Design courses seeking to merge the arts and the sciences began in earnest in the 1980s, and most notably with the postgraduate link course between Imperial College of Science and Technology (ICST) and the Royal College of Art (RCA). These courses became generically known as 'Industrial Design Engineering' (IDE), and a report on their development was completed by Ewing for the UK's Design Council in 1987. Ewing's report summarised the recommendations of previous reports concerning design as follows.

> *'During the period from 1963 to 1984 five major enquiries have been undertaken by the Department of Scientific and Industrial Research, the Design Council, the National Economic Development Office and the Engineering Board of the Science and Engineering Research Council, into Design (from product design and industrial design education, to engineering design and education). The reports are as follows:*
>
> *1. 1963 - Engineering Design …   ('Feilden Report')*
> *2. 1976 - Engineering Design Education …   ('Moulton   "   ')*
> *3. 1977 - Industrial Design Education in the UK … ('Carter   "   ')*
> *4. 1979 – Product Design …   ('Corfield   "   ')*
> *5. 1984 – Engineering Design Working Party …   ('Lickley   "   ')'   (ibid:5)*

… and later …

> *'… The unanimous findings of the five reports, which span 15 years, say design is important to our survival as a manufacturing nation, so the time for a change in our educational system is overdue. If we follow the broad outlines of the recommendations of these reports together with the finding of other parties involved in design education … and continue to combine and fully integrate the arts and science education of our future designers, we will have set in train a process leading to industrial recovery'.   (ibid:9)*

These reports were founded on the ideas culture of their eras and these are perhaps best represented by the 'variations on the design spectrum' shown in Figure 4.1, which clearly indicates a relationship between the knowledge, skills and values required and the product area in which a design task resides. The 'design spectrum' originated in the Carter Report in 1977, and was highly influential in characterising the thinking of the time (including my own, see Section 7: 64). Ewing commented on the key conclusions of the Carter Report as follows.

> *The views of the Carter report … were that the two disciplines, industrial design and engineering design, should not be amalgamated. However the report went on to state: 'There is a large area of common ground in the practice of the two disciplines, including information assembly and analysis, creative identification of problems and the production of solutions, conservation of resources, economy of expression and a desire to produce a solution that is correct, satisfying and elegant. A vital requirement for practitioners in both disciplines is that they should be able to work as part of a design team; and the ability of a particular designer, whether an industrial designer or an engineering designer, may lead him to undertake duties and responsibilities in industry beyond the scope of his immediate discipline'. The recommendations for undergraduate and postgraduate courses include the following:*
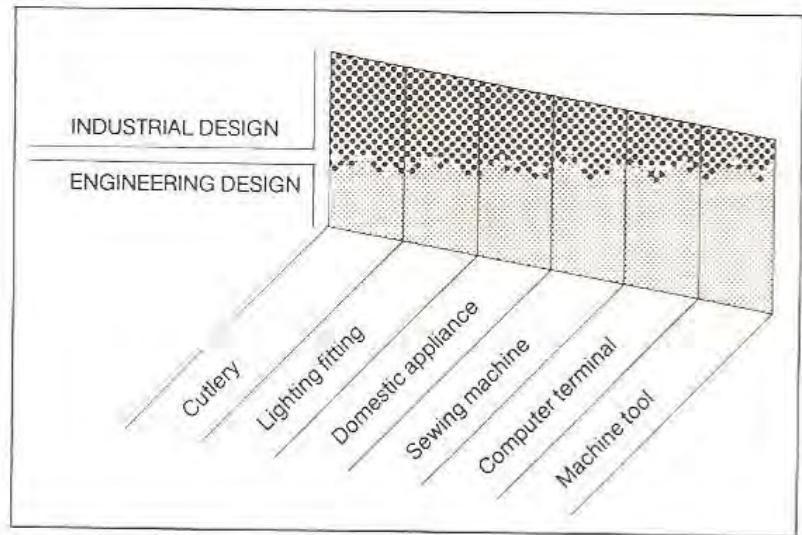
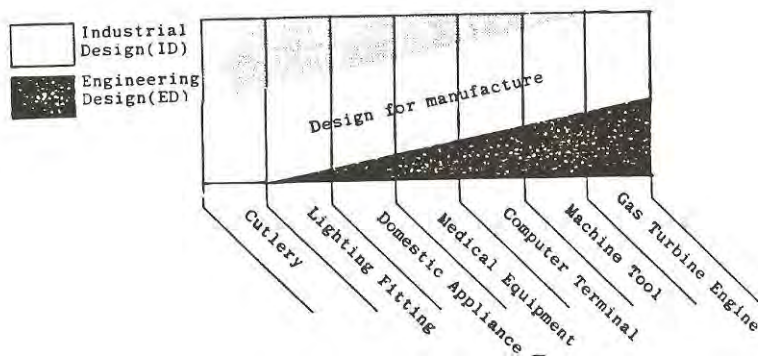**Figure 4.1A The Design Spectrum (Carter, 1977:13)**

Figure 4.1B The Design Spectrum (Laming, 1981:88)
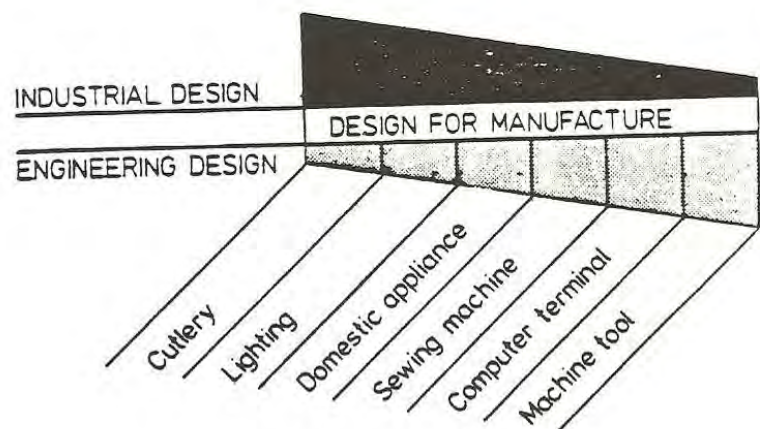

Figure 4.1C The Design Spectrum (Ewing, 1985:52)

Figure 4.1 Variations on the design spectrum from the 1970s and 1980s: Laming's and Ewing's variations are shown in articles included in Ewing's 1987 IDE report

'Industrial design degree courses should provide a broad education, but there should be an awareness in students and teachers of the requirements of industry; and postgraduate courses geared to familiarisation studies in industrial design should be offered to graduates other than design'.   *(ibid:7)*

So Ewing was observing that in this 21 year period (1963-1984), there was both a recognition that Snow's 'two cultures' model of human knowledge was potentially damaging to the development of design education, and a hesitation to fully grasp the implications of that realisation. By the time that Ewing was writing his report on IDE in 1987, David Carter was interviewed (as the founder of DCA Design Consultants Ltd) and his comments reflect the shifting ground.

'The process by which a product is designed and created must reflect the most effective use of technology and encompass the sometimes conflicting requirements of the client and the consumer who buys the product. Innovation, the use of new technologies, market trends, styling and colour and the almost forgotten and ignored ergonomic factors are all important in product design.

We have also felt for a number of years that industrial design could be practised far more efficiently if it had closer links with the technology of production. So I now look for designers with an understanding in industrial design, and both mechanical and electronic engineering. As Chairman of the Design Council's Committee on Industrial Design Education (reference to the Carter Report), we reported that the two disciplines of engineering design and industrial design should at that stage be not amalgamated. However, since 1977 I have changed my thinking, and I hope others have to, and I now think there is a case for amalgamation.

At DCA we are concerned with structures and materials technology, light metal work fabrications, metal forming, casting, plastics moulding, assembly techniques, micro-processor systems, software design, printed circuit design and audio and video telecommunications, so I expect my designers to be conversant with these techniques.

The students should have some experience already from their first degree course in engineering, therefore I would expect the joint course curriculum to cover all these topics thoroughly, and to educate them in all the techniques of industrial design.'
                    (ibid:56)

These comments were made in response to a review of the ICST/RCA joint postgraduate IDE course and were made in the context of the 1980s, which was the period when debates about the merging of these disciplines were getting underway. This was the decade in which integrated undergraduate programmes combining engineering and industrial design emerged at Brunel University, Loughborough University and Napier University. This was also the decade in which CDT (craft, design and technology) developed in the UK's general education curriculum following major projects completed in the 1970s relating to the place of 'craft' (Keele University, 1971), 'design' (RCA,1979) and 'technology' (Loughborough University, 1971) in children's education, and the analysis by the APU (Assessment of Performance Unit) in 1982. The 1980s was the decade in which the 'two cultures' model was challenged in practice, as well as in theory.

However, these developments remained controversial. An investigation of undergraduate provision of course lying at the interface of engineering and industrial

design was undertaken for the Royal Commission for the Exhibition of 1851 by Mitchell and Loch in 1986. Following a survey of 44 Departments of Mechanical Engineering at Universities (35 completed the questionnaire) and 18 Faculties of Art and Design at Colleges/polytechnics (all completed the questionnaire), 9 follow-up visits and 4 industry visits, they concluded as follows.

> *'5. Recommenations*
>
> *5.1 Since design activities in many industries are essentially of a multi-disciplinary nature involving team effort, there appears little need for academic institutions to attempt to produce the 'hybrid' designer, that is one who is expert in Engineering and Industrial Design methods and techniques. Obviously, such 'hybrid' designers already exist in industry through the possession of innate artistic and technical skills, and no doubt make a valuable contribution to design. However, these designers are the exception rather than the rule and there appears little need to structure more higher educational courses to produce such hybrids. DCA's experience of product design at team level suggests that industry is not clamouring for such a designer and Teeside Polytechnic's difficulty in placing their output of such students tends to confirm the view.*
>
> *5.2 As an adjunct to (1) there is little doubt that an Engineering Designer whose education and training have equipped him with a strong awareness and appreciation of Industrial Design would enhance, by virtue of better communication, the effectiveness and performance of a product design team.*
>
> *5.3 There is a genuine need for Engineering students to receive instruction in Industrial design. This may be best achieved by enhancing existing courses in Engineering Design with an option or module possibly even taken in a Faculty of Art and Design.*
>
> *5.4 Industrial Design activities should have a strong content of engineering product design as this would appear the most effective vehicle for teaching Engineering students.*
>
> *5.5 Close collaboration with industry is recommended to provide the necessary material together with practical constraints. Where time, cost and materials permit, students should be introduced to model-making as an invaluable aid to design activities. It is possible that this aspect of model-making could form an integral part of the Engineering Appreciation modules (EA1 and EA2), these being a component of university Engineering courses accredited on behalf of the Engineering Council by an Engineering Institution'.*   (ibid, 1986, 18-19)

In the Foreword it was noted that this report was 'not, and does not claim to be, exhaustive in its coverage. Rather it illuminates a spectrum of options and examples' (ibid, 1986). Loughborough's 'design and technology' programmes were not reviewed, or visited, neither were Brunel's, and Napier College's course was said to appear 'unique in regard to the content of Science and Technology and the blend with Art and Science' (ibid, 1986:17). This report certainly represented the view of many at the time, but rests rather on being able to draw a clear boundary between engineering design and industrial design, whilst starting the report by noting Archer's view that 'there is basically no difference between engineering and industrial design'. This is difficult territory and the 'design spectrum' has already indicated the 'greyness' of such a boundary. It was

inevitable that a wide range of undergraduate programmes would be offered and that debate would continue.

By the 1990s, it might have been hoped that these discussions would have reached maturity, with the establishment of 'design and technology' in the UK's National Curriculum, and through the strengthening and growth of the undergraduate and postgraduate courses in higher education. Whist there is evidence of such a new post-modernist perspective on design education gaining momentum, it has not gained any ascendancy, as evidenced by the Cox Report. For example, Archer wrote as follows in the mid-1990s.

> *In 1989, there were fewer than ten university courses on engineering product design, By 1994, there were more than 200, some of them producing graduates with aesthetic sensibilities and communication skills comparable with those seen in graduates of schools in art and design. In an important sense, tertiary education is catching up with the revolution in design and technology that has been fought for in primary and secondary education.* (Archer,1995, published in 2004:7-8)

One of the key questions for this report is whether such integrated perspectives on design education have begun to achieve greater recognition and acceptance and represent one of the directions towards which design curricula might have converged. Equally, it is appropriate to recognise that there are delicate balances to resolve within the design of design education programmes in higher education that can lead to other valid perspectives, and a lack of convergence should not necessarily be interpreted as intransigence. And for any such changes there is likely to be associated inertia.

Table 4.1 shows some notes concerning 4 of the courses combining engineering and industrial design which feature in this publication, and had developed sufficiently in 1987 in order to be included in Ewing's report. The report also considered other courses in the UK (University of Bath, Central School of Art and Design, Huddersfield Polytechnic, Polytechnic of the South Bank, Teeside Polytechnic, Cranfield University, Manchester Polytechnic, Leicester Polytechnic) and outside the UK (Illinois Institute[3] of Technology and Stanford University in the USA, Chiba University in Japan and the Academy of Industrial Design, Eindhoven in The Netherlands). All the comments in the 1987 column are taken from Ewing's Report on IDE.

Courses	1987	2007	Other notes
UK			
Brunel University	*'Brunel University's BTech four year 'sandwich' course in industrial design started in 1985, is the first university undergraduate course combining engineering and industrial design. The collaborating college is the West Surrey College of Art. The Course aims to produce students who will have had training in both engineering design and industrial design and who will pursue a career in industry as designers.* *The course approach to design teaching is the opposite to that of the traditional art/design school methods and works from the sound bass of technology towards styling. The activities of engineering, technology and artwork through project activity run concurrently towards design of the product for the marketplace so that a*	In April 2007 there were 5 undergraduate design pathways: 4 BScs, Industrial Design, Product Design, Product Design Engineering and Virtual Product Design and a BA programme in Industrial Design and Technology. The most relevant aspect of the undergraduate programmes for this	One of the early integrated design programmes, which was the reason for the visit being arranged.

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[3] Ewing's initial research identified two other American programmes of interest at Carnegie-Mellon University, Department of Design and Massachusetts College of Art, but information was only received from Illinois and Stanford

	compromise is reached by the designer between the extremes of functional and artistic design … *Students graduating per year: BTech – 45 …'*	report, is the distinction between the BA in ID&T and the BSc programmes eg "Throughout the programme you will share many core design modules, including materials, graphic media and workshop practice with students on the BSc programmes, but the study of mechanics and electronics will be via workshop-based learning rather than pure subject based lectures."	
Imperial College/RCA	*'… the two year postgraduate Joint Course in Industrial Design Engineering, run by the Imperial College of Science and Technology and the Royal College of Art which started in October 1980 …* *From the early '70's the School of Industrial Design at the RCA had welcomed graduate engineers onto its courses. The number of students, 5 in that decade, taking this unusual path in educational direction was too insignificant to have any effect nationally on design, but the seeds of a new and unique course were being sown.* *Research into the course structure and the direction of desirable curriculum change started at the beginning of the Spring Term 1984 and was initially based on an in-depth study of the course as experienced by its students. The author being the researcher became, in effect, a first year student and with the agreement of all concerned attended most lectures, tutorials, project briefings, presentations and assessments. A weekly tutorial was held with the students to listen to their views and aspirations for the course, as well as to discuss their projects with them. At the author's request the first year students collectively wrote a course report …* *During this period of research a number of companies and design consultancies in the UK and Europe were visited together with a number of interested individuals involved in design education and the employment of designers…* *The initial research was completed in September 1984 and an interim report was submitted to the Design Council and the Colleges… As an addition to this, a paper was written at the invitation of the Design Council discussing the need for joint courses and suggesting a model for industrial design engineering education …* *A revised curriculum for teaching industrial design engineering through a structured lecture programme and project based design work has now been established …* *Recommendations for the formulation, teaching, assessment and running of joint courses in*	See Section 5	As a pilot study concerning curriculum convergence for this report, it was decided to make a comparison of the end point of Ewing's 1987 research towards an ideal IDE curriculum, and its current interpretation, with the positions reached by TUDelft and Loughborough's Department of Design and Technology. These programmes can be broadly considered to have travelled along independent pathways and any apparent convergence would be correspondingly interesting.

	industrial and engineering design, for other universities and colleges who are proposing or planning such courses, are given …'		
Loughborough University of Technology	*'The university offers three courses in design at undergraduate and postgraduate level in the Departments of Design and Technology and Materials Engineering Design respectively. They are a BA (Hons) three-year course in design and technology and a four-year BA (Hons) Cert Ed in design and technology with education. The postgraduate course is a one-year MTech in engineering design…* *The BA three-year course develops the students in three-dimensional designing and making. The practical designing is supported by the study of design related subjects. They include knowledge of materials and processes, the development and communication of ideas, the techniques of planning and costing and the practical experience necessary for the production of prototypes and finished artefacts.* *The MTech one-year course of four terms (total 46 weeks) is based in the Design Centre (which) emerged as a result of the Fielden Report (1963) with the dual objectives of educating and training young engineers in the arts and skills of engineering design… The course gives the students a professional training in design, enabling the student to compete with the designs of others and to prepare them to assume responsible positions in industry as designers of engineering equipment and systems,* *The course teaches by group projects and divides into one term of lectures and then three terms of projects. The mode of teaching in the course is through a design core procedure, the essential features of which are market (user), specification, conceptual design, detail design, manufacturing and selling. In sympathy with the design core they also teach techniques which are related to the design core, which are costing, ergonomics, genesis, methods of selection, decision making, competition analysis and market analysis …* *Students graduating per year – BA 15; MTech 10'*	See Section 7 and 8	Whilst not entirely inaccurate this is a misleading description of the BA/BSc course in 1987 (see Section 7). Despite the impression given in Ewing's Report it is experience gained concerning the BA rather than the MTech, which is relevant to the evolution of integrated product design programmes. The 1987 MTech programme was essentially focused towards the engineering design end of the spectrum.
Napier College, Edinburgh	*'The College offers one course in Industrial Design (Technology) – the ID (Tech) is a four year sandwich undergraduate BSc degree course …* *The course is unique at degree level and is suitable for students whose abilities and aptitudes in science and technology as well as in art and design. A broad education is offered in fields of design and technology and industrial design is taught through principles and practice. Emphasis is given to individual development of creativity through the relationships of aesthetics, scientific technology and organisational disciplines. Graduates of the course have normally found employment as industrial designers with manufacturing companies and major consultancies serving industry in the*		One of the early integrated design programmes, and much favoured by Ewing's Report . Hence, the reason for arranging the visit.

	following areas: mechanical and electronic product design, automotive industry, medical and hospital equipment design and general domestic product design. *Students graduating per year – 16'*		
Outside UK			
Delft University of Technology, The Netherlands	*'The Department of Industrial Design offers one, four year undergraduate course in industrial design engineering. The course has the largest input of students, 200 in 1985, of any of the joint courses throughout the world. This large intake is a direct result of the Dutch educational system where entry to a university is by right granted to all applicants… It is expected that the number of students who will graduate each year from the course in future will be approximately 100.* *In 1970 the Department of Industrial Design started to model a course for a new type of engineer, and a new profession, industrial design engineering. The design research staff found that industry within The Netherlands required a different type of designer, a designer who could combine the skills, techniques and the conceptual thinking of the industrial designer and the theoretical knowledge and practical skills of the engineer.* *The curriculum embodies a substantial lecture programme …* *Visual design projects: colour, form, styling and aesthetics – the effect of the product on the consumer; freehand drawing and graphic design.* *Design projects: in each of the four years the student undertakes a number of projects covering all aspects of industrial design.* *Final Year project: this part of the course is spent in industry, the project is usually specific to the sponsoring company.* *During this final year the students have to spend six months in industry working on their Masters project. The project brief is given to the student by the sponsoring company, and the student is expected to work on all aspects of the design during this period. The student then returns to Delft to finalise the finished design in the form of a per(sic) production prototype and write the Masters thesis.* *Delft University has an educational research department within the School and is continually researching into design teaching methods in close collaboration with industry following the Government's directives on design education. The Dutch Government has seen the need to produce and educate designers who can design, in totality, consumer and industrial products for the mass and professional markets.'*	See Section 8.1	One of the early integrated product design programmes

Table 4.2 Industrial Design Engineering courses included in the Ewing report (1987)

Ewing commented as follows on the UK programmes.

'The above courses have all gone some way in combining the two areas of design in their respective curricula, but none with the possible exception of Napier College, have achieved an ideal balance between the traditional methods of teaching design. However all courses use a similar structure in having a compulsory lecture programme and project based modules.

The courses at Bath, Huddersfield, Loughborough and to some extent Brunel, see their role as educating engineering designers who are given some understanding of industrial design, its skills and methods, and why this area is important to the overall product. …

The Central School, and Manchester and Teeside Polytechnics are really traditional industrial design schools who realised long ago that the industrial design can no longer experiment with design in terms of ideal concepts only and have no understanding of technology, and this is reflected in the title of their respective courses. …

All courses see the need to have a good grounding and understanding of the business end of design and all have comparable management, economic and marketing modules in their courses.

Communication skills are seen by all in education as a necessity for students of today, and this is taught to some degree in all courses, but only Bath, Brunel and Manchester see fit to have language modules in their courses.

It is interesting to note that the 'engineering based' courses have all adopted methods of teaching design long used in art schools, ie, the use of freehand sketching to get ideas on paper quickly, the use of sketch books to record and develop design ideas, the art of presentation drawing to visualise finished designs, and modelling techniques using foam and wood to get an understanding of form. All these methods are still frowned upon and never used in engineering degree courses. Ergonomics and human engineering as subjects, now taught on the above courses, do not appear on traditional engineering course curricula, as this is seen as the prerogative of the industrial designer.

The courses cited are moving towards each other, but are not achieving a common standard as they all require different entry standards from students with different levels of academic ability. What they have achieved is courses in design that give the student an education in his or her chosen field, but with a good understanding of the whole spectrum of the overlapping activities of engineering and industrial design.'

(ibid:26-28)

A further study of developments in UK postgraduate courses in Industrial Design Engineering was prepared by Carter in 1993, for which the six courses shown in Table 4.2 provided the basis. The comments relating to 1993 are taken from pages 7-8 of the Carter Report.

Course	1993
De Montfort University, *MA*	*'A course with a 20 year history in industrial design, one of the longest-running masters programmes of its type in the UK. Focus redefined and curriculum reshaped in the mid-1980s with the appointment of a new course director to develop a multidisciplinary*

Industrial Design	*strategy. Intake includes graduate engineers, technologists, graphic designers and ergonomists. Currently 24 students on a two-year full-time course, of which six are graduate engineers.'*
RCA/Imperial College *MDes Industrial Design Engineering (also DIC – Diploma of Imperial College)*	*'Started in 1980. after discussions arising from concern among staff of both institutions to end the long-standing, but arbitrary division between the practice of engineering design and industrial design. Currently has 42 students on two-year full-time joint course.'*
Teeside University, *MA Industrial Design for Engineers*	*'Started in 1989. Closely modelled on the RA-Imperial course. Makes considerable use of strengths in teaching and facilities of undergraduate industrial design programme. Currently eight students on a four-term full-time course.'*
Loughborough University, *MSc Engineering Design*	*'Started in October 1990. Course runs in two modes: as either a full-time one-year course or as a flexible part-time model enabling engineering designers in industry to study on a modular basis over a period of three or four years to suit the needs of their employers. Currently 28 full-time and 68 part-time students'*
South Bank University, *MSc Engineering Design*	*'Started in 1990. Offers a full-time route of one calendar year and part-time route of two calendar years. Specific emphasis on developing engineering products rather then broader consumer artefacts. Currently has 30 students on the course.'*
Brunel University, *MSc Industrial Design*	*'Starts October 1993. One-year full-time or three-year part-time cross-cultural course aimed both at graduate engineers with little design experience and design graduates with little technological experience. Based on opportunities afforded by modularisation of Brunel's BSc Design programme. Planned student intake: 15. Also at Brunel: up to 40 postgraduate engineers and computer scientists are being introduced to industrial design principles via courses and research activities in the Centre for Geometric Modelling and Design, which was founded in spring 1992.'*

Table 4.2 Industrial Design Engineering postgraduate courses analysed in the Carter report (1993)

In his 1993 report, Carter described the courses shown in Table 4.2 as follows.

'Generally speaking courses fall into two camps.

- *The MA and MDes courses state categorically that they are taking engineers and giving them the ability to apply knowledge and skills in industrial design in order to work in design practice in industry …*
- *The MSc courses remain more rooted in the engineering camp. They offer students an introduction to the principles of industrial design but suggest that they will remain engineers, albeit in a role involving design.*

… Students generally have a clear understanding of course aims and objectives and their own aspirations are broadly in line with those expressed in course documents.'
(Carter, 1993:10)

Introducing some degree of awareness concerning industrial design is highly unlikely to generate any significant curriculum design issues, and consequently the experiences of developing the MSc courses are correspondingly unlikely to reveal a great deal about delicate curriculum balances. The 1993 Brunel MSc was interesting in that it was planned to take design students with little technological experience. However, the MA/MDes and the MSc programmes are essentially two different traditions as the Carter report indicated.

'The MA and MDes courses tend to emphasise within the core curriculum such issues as aesthetic theory and design practice methodology to work as a consultant. The MSc courses, on the other hand, stress an engineering methodology within the structure of a large industrial company. As a result the MSc course put more emphasis on issues such as quality engineering and optimisation analysis in their curricula.' *(ibid: 15)*

The 1993 Carter report does also indicate the emergence of further programmes combining ID and ED.

'Undergraduate courses which combine the disciplines of industrial design and engineering design, and involve an alliance between two separate departments or institutions, are on the increase. New courses at Glasgow (a four-year BEng joint course by Glasgow University and Glasgow School of Art), Coventry University and the University of Central Lancashire at Preston demonstrate the scope for cross-cultural collaboration of this kind. *(ibid:6)*

A new one-year MSc in Product Design proposed by the Faculty of Electronic Engineering at Swansea Institute of Higher Education will take design graduates and give them the 'technical knowledge necessary to allow the design of electronic and electrically based products' *(ibid:30)*

In India, the Indian Institute of Technology (plans to start a new MDes course in September 1993.' *(ibid:3)*

Conclusions of the 1993 Carter report

The Carter report was based on research into the course intake and aspirations, course organisation and content, teaching methods and assessment, employment perspectives and future developments of IDE masters programmes. The evidence base was essentially the analysis of course documentation and interviews with graduates and employers. The full report is, of course, publicly available, but enough of the conclusions are reproduced here to indicate some of the issues that had been resolved.

From the Foreword …

'For a long time the RCA-Imperial course stood alone, the only bridge-builder of this kind at postgraduate level. But today the picture is different. As this report demonstrates, there are at least half-a dozen postgraduate courses in the UK, which aim to introduce graduate engineers to the principles of industrial design and encourage a more holistic view of designing.

This is all to the good given the complexity of the challenges which now face manufacturing industry. I believe there is now in place an educational resource geographically dispersed throughout the UK which has the capacity to make a significant contribution to the products of industry. I say this not just as an educationalist but also as an employer of industrial design engineering graduates, whose special mix of expertise has proved highly influential in the work of my own consultancy business over a long period.

These courses are seeking to break new ground. They and the graduates they produce justify the highest level of support and encouragement to enable a new generation of specially trained designers to contribute to national economic

objectives. I hope this report will assist in making the work of these courses familiar to a wider audience'. *(ibid: v)*

Some details from the Summary …

'15 *All the courses observed had the following core curriculum: human factors, computer applications, marketing, production processes/management, polymer-based materials, design process/methodology, and communications.*

16 *Course leaders commented that graduate engineers initially encounter 'culture shock' when introduced to the emphasis on synthesis and subjective values which are integral to industrial design.*

17 *However, graduate engineers generally respond well. They swiftly develop drawing, presentation and communication skills and an understanding of design culture and history. They are also strong on the practical applications for new technologies.*

18 *Postgraduate IDE courses are largely centred on a design studio environment and based on a series of design projects. This delivery method is supplemented by other teaching strategies, including lectures, seminars, factory visits, workshop demonstrations and collaborative projects with industry.*

19 *All the courses visited have strong collaborative links with manufacturing companies, although recession has had an impact on the scale of involvement by industry.*

20 *All the courses visited organise a degree show of major student projects for public display. This is widely regarded as enabling engineers to communicate their ideas more effectively.*

21 *Assessment techniques vary, from those which include open-book examinations (more common in engineering education) to those which put the main focus on the major design project (more common in industrial design).*

22 *Graduates of these IDE courses have been employed in a wide range of positions in consultancy and industry, spanning the full gamut of design, engineering, development and management skills. The RCA-Imperial course, with more than 100 graduates, offers the fullest graduate employment profile.*

23 *In interviews, graduates commended their IDE courses for giving them a number of key attributes, including a grounding in practical design methodology and an insight into users and markets, encouraging lateral thinking and improving communication*

24 *In interviews, existing and potential employers of IDE graduates supported the integrative principles behind IDE postgraduate education. Comments centred on the belief that professionals who have a broader vision of product development, who can speak the cultural language of engineering*

and industrial design, and who can take key project management roles in fast-track multi-disciplinary developments will be highly employable in the future.

25   Future developments in IDE postgraduate education are likely to focus on more scope for research, a greater emphasis on conceptual innovation, and closer international links with manufacturers and colleges and universities elsewhere in the world. More courses are likely to come into existence in this area, a prospect which makes the need for a national publicity and promotion campaign more acute. The report ends on this pressing note.   *(ibid: viii)*

There are already evident clues here to the question of what kind of design capabilities facilitate the balancing of different design attributes. The 'core curriculum' that was evident in all the courses (see '15' above) was highly unlikely to have evolved identically and independently in these programmes as a matter of chance or coincidence.

So in 1993, all might have been thought to be set for either a successful consolidation or expansion of IDE programmes at postgraduate level, and, although there has been some, the outcome has not perhaps been as expected. The Cox Report has to some extent rekindled the embers, but there already appears to be lack of urgency in this renewal.

5. The RCA/ICST postgraduate programme

The RCA/ICST postgraduate MDes programme is long-established and well-respected and this section summarises prior research relating to the development of the programme.

5.1 Ewing's recommendations towards the 'ideal' IDE curriculum

The findings of Ewing's 1987 report are summarised below. Ewing began his study by researching the experience of the first two RCA/ICST cohorts and establishing the views of companies.

> *Following the digestion of both the Companies' views and those of the first and second intake of students, the main recommendations for change and reorganisation of the course were as follows:*
>
> ***Student Tuition** – Individual tuition at the drawing board within the studio environment (as opposed to group tutorials) is a very important part of the art of teaching design. Engineering students in this new design teaching area need 'drawing board' instruction on a one-to-one basis with their tutors to discuss ideas, to explore and develop thought processes, techniques and generally discuss industrial design. During these personal tutorial sessions the tutor can assess the individual needs of the students. Areas of weakness can be discovered and help and extra tuition given. This is not really possible in group tutorials run on the grounds of traditional teaching methods for graduate industrial design students. Engineering students are from another cultural background and need to build a platform of confidence prior to being exposed to the criticism of the more experienced design student and tutor who might not understand the difficulties of the engineer in coming to terms with industrial design. Above all else engineers need guidance, help and understanding of their individual weaknesses and the needs of these students will always vary greatly. They need to be informed by their tutors why one design is 'better' than another when comparing similar products, in short they need to know the bases of non-technical judgement. Only then can we as tutors expect them to formulate their own views, thoughts and ideas and put this into practice in their design projects. This method of teaching requires a special level of tutoring that can be carried out during the first weeks of the course and will benefit all greatly.*
>
> ***Drawing** – The use of drawing as a method of communication has in general not been understood by engineering students coming onto the course. Their training in drawing skills at university is in engineering drawing to BS308 level, and, on investigation, these skills were found to be at a low level… The drawings of all second-year students studied up to 1984 showed that they were incapable of drawing to BS308 requirements. This unforeseen lack of skills together with the known deficiencies in freehand, and presentation drawing and rendering, caused the course to be restructured to give the students the necessary instruction and practice to bring them to an acceptable level in all departments of drawing. It is worth noting that teaching highly intelligent students to draw well is not a problem once the need has been perceived.*
>
> ***Lecture Programme** – The lecture programme, though found to be relevant in general, has omissions that leave the student uneducated in areas of knowledge necessary for the designer to be useful to industry and consultancies.*

Projects – *A major shortcoming of the original course is the absence of any engineering based projects in the first year; this had to be rectified immediately as the engineer would lose the overall unifying thread of the course, and its connection with his first degree work.*

Additional courses – *The first year students need to learn quickly the techniques of the designer and a series of short specialised courses should be offered to overcome the lack of skills most engineering graduate students have at entry. They are as follows:*

> a) *Modelmaking*
> b) *Workshop Practice*
> c) *Principles and Applications of Colour*
> d) *Photography*
> e) *Electronics*
> f) *Microprocessor* (Ewing, 1987: 65-66)

Ewing's report then indicates that this initial study allowed a much improved curriculum to be put forward, but before doing so, it is made clear that Ewing believed that breaking down the 'two cultures' model of design education was going to be a 'serial', rather than a 'parallel' matter. This is plainly at odds with the unitary concept of 'design and technology', which has developed in secondary education during the 1990s and early 21st century, both in the UK and in other countries around the world. The RCA/ICST model therefore provides a potentially interesting comparison with the TU Delft and Loughborough programmes, which are essentially 'parallel' in nature. So, before looking at the proposed model for Ewing's RCA/ICST curriculum, the following quotation indicates the theoretical position on which it is based.

The small number of courses in the world which undertake the joint education of engineering and industrial design have, with one exception, one basic denominator in common, which is that the initial ingredient must be engineering and only students with such knowledge can be accepted and educated in this way. It is generally understood that the industrial design element can be taught or 'added on' successfully whereas the reverse, ie. a course which teaches trained industrial designers the engineering element, cannot. There is no evidence or research data that 'proves' that this method cannot or does not work successfully. At Stanford University in the USA, the Masters course in Product Design accepts art-based design graduates on the course and the students have to make up the engineering which adds an extra year to the course. It is difficult to ascertain the level or standard of engineering these students have at this stage. A number of undergraduate and postgraduate industrial design courses have an engineering module in their curricula, but do not teach engineering to the level required of the normal standard expected by the universities and the CNAA for awards of engineering degrees. If this were the case and the length of course was the accepted three or four years at undergraduate level, and two or three years at postgraduate level, these courses, if they existed, would not be successful in educating the student in engineering or industrial design to the now agreed level and depth of knowledge in each area. It is then established that courses of this nature must enrol students with one or other element already completed. In the present educational structure of this country this element is engineering.

(Ewing, 1987: 68)

This passage does not really establish anything. It admits that a course exists at Stanford University in the USA which took art-based students, but this was not apparently researched, and no evidence was presented. Ewing's 1987 report itself had already acknowledged the existence of other courses in the UK, which adopted an integrated approach, but again these were not apparently researched, and no evidence was presented. Their success or failure is a matter of assertion.   Perhaps most tellingly, it assumes that all the engineering taught in a three year programme is always relevant, whereas the product design spectrum would clearly suggest otherwise (see Fig.4.1). The need for particular levels of engineering knowledge will relate to particular product areas, and there might therefore be expected to be a relationship between the structure of design curricula and the product areas that they address.   As is well-known the traditional engineering disciplines focussed around particular problem classes (eg civil engineering/canals) and there is no reason why everything from a particular discipline should be transferable to other areas, although much of the knowledge, skills and values embodied may well be.

5.2 The 'serial' RCA/ICST IDE programme

The following information is taken from Ewing's 1987 report concerning IDE.

### 5.2.1 Overview of the 1987 RCA/ICST IDE programme

Year 1	
Lecture course *(1.5 days per week, including project weeks)*	Introduction *(I lecture – What is Design? What is an Industrial Designer? What is as an Industrial Design Engineer? What is Marketing and Product Planning?)*
	Design and marketing activities *(2 lectures)*
	Communication *(2 lectures)*
	Management *(6 lectures)*
	Cultural history *(22 lectures – The history of design …)*
	Design for manufacture *(12 lectures)*
	Ergonomics *(2 lectures)*
	Plastics product design *(3 lectures, industrial visit)*
	Plastics engineering *(6 lectures plus …2 lab(s))*
	Engineering materials *(6 lectures)*
	Advanced manufacturing technology *(6 lectures)*
	Electronics *(6 lectures and 3 practicals …)*
	Special lectures *(6 lectures … guests on design)*
	Languages *(encouraged … Language Laboratories)*
Studio skills	Freehand drawing *(2 weeks)*
	Drawing and presentation techniques *(1 week)*
	Engineering drawing *(1 week, (plus personal tutorials)*
	Visual awareness *(1 week)*
	Graphics *(1 week)*
	Ergonomics *(2 weeks)*
	Computer aided design *(1 week)*
Industrial design	Project 1 – *2 weeks. A simple project taking the students step by-step through the various stages of the industrial design process.*
	Project 2 – *2 weeks. A conceptual design project concentrating on the generation of ideas and sources of inspiration from nature, the man-made, artists and designers. The development of ideas and the communication of the students' ideas to others.*
	Project 3 – *2 weeks. Visual awareness through the design of a simple domestic product concentrating on the form and area relationships, with the*

	introduction of symmetry and the golden section, colour, texture and detailing.
	Project 4 – *3 weeks. The British Steel Project – design to a brief set by BS, a product to be manufactured from stainless steel. The project finishes with a visit to British Steel where the finished designs are presented.*
	Project 5 – *11 weeks. Student-selected in conjunction with the project tutor, emphasising the direction the student is taking in the industrial design spectrum. The student has to write the brief and prepare a programme and complete and present the project by the last week of term*
	Design for social need – *3 weeks. An optional project. Introduction; realities of life and death in 3rd world; design for the severely disabled and retarded (special needs of disabled hospital patients) intermediate technology, design and technology in social need – mandatory seminar presentation*
	Cultural history – *Summer Vacation Project. The students have to research and write an essay (5000 words minimum on one aspect of the taught material from the lecture course and submit a thesis at the start of the final year.*
Engineering design	Project 1 – *1 week (group project) – The engineering redesign of domestic appliances with industrial design input.*
	Project 2 – *3 weeks (group project) – The Vickers Hardness Machine – total redesign of the hardness machine using current technology and the skills learnt in industrial design.*
	Project 3 – *1 week (engineering practice) How to get new ideas supported, designed and successfully sold. 'Process economics: an introduction, 'Money for engineers' and 'Success and failure in product innovation'. The students are required to read the lecture-supporting material prior to the project week.*
Exhibitions and industrial visits	*Various industrial and exhibition visits relevant to the course are organised throughout the year.*
	(Year 1 assessment … 8 examinations, 1 essay and project work)
Year 2	
Lectures	*Any relevant ICST lectures, Visiting or Outside lectures, or repeat first year lectures*
Management project	*1 week. Small business presentation, requesting a bank loan, cash flow, profit and loss and securities.*
Design, make and test project	*30 weeks. The final year is devoted almost entirely, apart from the management project, to the major project, which the student has chosen with the agreement of the tutors at the end of the first year and researched during the vacation. The brief is discussed at the start of the new session and the students are also then informed of their project budget allowance (£500 in 1985). The students are monitored on a weekly basis, through personal and group tutorials by both RCA and IC tutors. The student has to present the project work in its finished form at the end of the final year either as a fully working design in every aspect of the design process, in the industrial and engineering sense, or in the form of a prototype displaying the technological and engineering working capabilities, and a block model showing the concept in terms of industrial design*

Examples of early design projects

The yacht rigging cutter
… Andrew Douglas (1982)
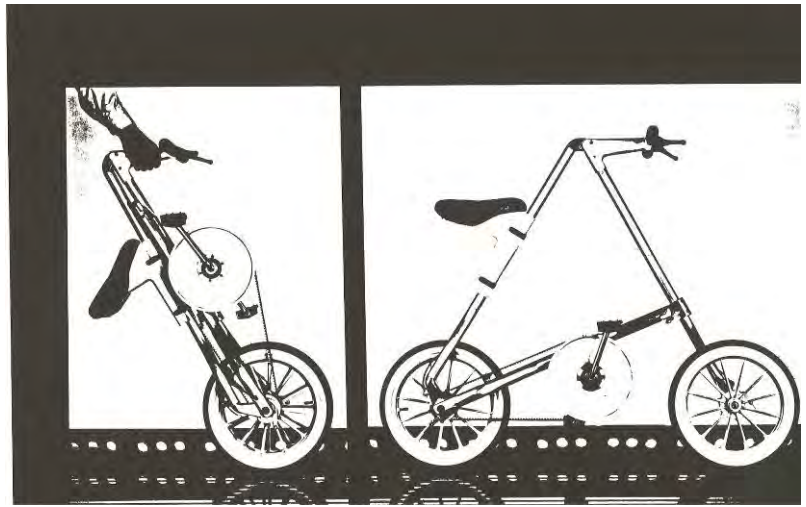
A new folding bicycle … Mark A Sanders (1985)

5.2.2 Overview of the RCA/ICST MA IDE in 2007

The following information was taken from the RCA website in February 2007. It indicates some of the ways that the thinking at the RCA has moved on in the previous 20 years.

- **'Introduction**

The 21st Century has been about change. Change that has been dramatic and swift. Such as: corporations falling from grace, the dotcom bubble bursting, globalisation and antiglobalisation somehow marching forward in tandem, the evaporation of job security, decimation of pensions, collapsing trust in politicians. Where does all this leave the designer? The designer is at the heart of all this: riding the tiger of change, reflecting the values of the moment, and influencing the future. Product design now has the pace, the immediacy and the quality that's previously been just a dream. Complex product designs increasingly go from concept ideas to the shops in just a few months. Ideas migrate from sketches to form models, CAD files, rapid prototypes, production tools, circuits and moulding.

IDE was born out of the need for leaders in contemporary design to have skills that extend beyond design, materials and technology, to also encompass creative business, marketing and the role of the entrepreneur. Our design work is rich and diverse. Our philosophy is that of the Enlightenment: creativity, design and science in harmony. In contemporary terms, we see Industrial Design Engineering (IDE) as a cutting-edge discipline in which our graduates work at the centre of complex, demanding projects, juggling creatively in teams, to achieve great ideas, designs and successful products.

In essence, IDE is a unique 'hub' discipline, from which creative multidisciplinary projects are inspired, led or joined and then executed. The combination of technical and creative design skills is vital for this. Hub requirements also include teamworking, innovation management, entrepreneurial skills and the ability to manage and communicate effectively with other disciplines: industrial design, architecture, finance, marketing and research.

The department believes in the benefits to society of design. Successful design

improves our quality of life and facilitates wealth creation. In this context, an IDE graduate must be equipped to undertake and manage the most challenging and innovative design projects.

- **Joint Course with Imperial College**

IDE is a joint two-year MA with Imperial College London. The course is delivered by a staff team from the RCA and Imperial College in the department studios within the multidisciplinary environment of the RCA.

Students already have a technical degree, relevant experience or excellent aptitude when they arrive and the course provides a springboard into a creative world. They embark on a very intense educational programme in which the first year is skills-based plus project-based and the second year is project-based only. The resulting qualification is an MA in IDE from the RCA and a diploma from Imperial College.

Although many of our graduates work in consumer or industrial product design, others can be found in design management, architecture/building design and the digital industries. Some are entrepreneurs and have company start-ups. It is a very competitive market and we make sure that IDE graduates are self-sufficient, highly employable and ready for the future.'   (RCA, 2007)

The website goes on to describe the development of global connections (eg with Thailand and China) for visits and project work, group working with students in other RCA Departments, (eg Vehicle Design and Textiles), and commercial project partners (eg Sony, Unilever and B&Q). The following description of the current Learning Strands indicates the key changes that have occurred.

- **'Learning Strands**

There are three core learning strands taught in the IDE studio programme that run though the first year of the course and are summarised as follows:-

Design (70% of the students' studio time):
• Innovation
• Drawing and model-making
• Form-finding: harmony, balance, proportion
• Socio-cultural research
• Materials technology and manufacturing

Digital methods (20% of the students' studio time):
• CAD/CAM, rapid prototyping, computer
animation and rendering
• Electronics, interface and communications
• Web and internet working
• Presentation skills
• Research online

Creative business (10% of the students' studio time):
• Teamworking
• Commercialisation skills
• Marketing
• Project management
• Business planning

The second year comprise two large self-managed projects: a group project and a solo project. These can be based around "Design for Manufacture" or may be "Experimental".'   (RCA, 2007)

The students still also complete a dissertation relating to the Critical & Historical Studies lecture series at the end of the first year. One the major apparent changes relates to the student intake. It is clearly no longer intended solely as a conversion course for engineers as indicated below.

QUALIFICATIONS

- The course is open to graduates with an engineering or other technical degree, along with creatives/designers with an excellent technical aptitude. Exceptional students may also have art or architecture backgrounds. Applicants with business or marketing backgrounds are considered if they can demonstrate a real creative potential.
- Applicants with technical degrees must have a degree at 2:2 level or higher.
- If you have a design background you must also have good professional practice experience or be able to demonstrate an excellent level of technical aptitude in your work.
- Applicants with work experience (vacation, sandwich or full-time) are encouraged. The course is extremely demanding and work experience can be a great help in terms of self-management, working with others, deadlines and planning.

(RCA, 2007)

The RCA/ICST course clearly remains very successful as indicated by the Facts and Figures reported on the RCA website and shown below..

- **Facts and Figures**

Graduate Destinations:
In a 2002 survey, 98% of Industrial Design Engineering graduates who studied here from 1997–2002 were found to be in directly related employment/activity

(RCA, 2007)

Examples of Projects from the RCA/ICST Masters programme

Some examples of major projects by the RCA/ICST 2005 students are shown below. The were downloaded from www.designcreate.info. Other examples from this source were used in the pilot comparative study shown in Section 8.2 concerning the possibility of curriculum convergence.

- ***Edamami Airline Food Pod… (Katie Goodwin)***

Solo Graduating Project … this was the project used to illustrate the RCA website

An induction heated steamed meal pod which provides two steam heated dishes and two chilled dishes. The pod represents a more sustainable meal system for flying - eliminating disposable wrappers and cutting weight on board.

- ***Warm Feeling … (Frank Wright)***

'My major project provides warmth when you need it. It is intelligent heating; a new approach to a key human requirement.

The appliance senses the infrared heat signature of people in the room and directs heat in their direction. Heat is focused via a parabolic reflector. This reflector has a unique translucent appearance, which lets light through but reflects heat.

Providing directional heat when it is needed leads to clear gains in efficiency when compared to traditional western space heating methods.'
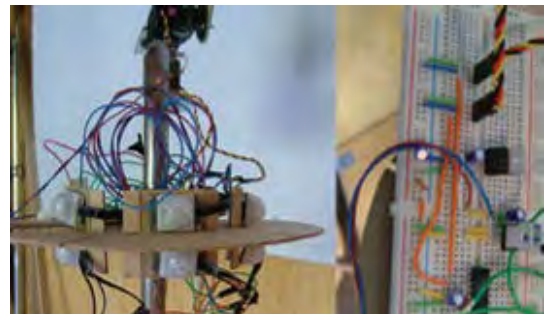
6. Disciplines and innovation within an integrated design curriculum context

In order to begin to explore the issue of 'delicate balances' in curriculum design, there are two fundamental matters to address. Firstly, the concept of a discipline in the context of integrated design programmes, and secondly, the interpretation of innovation in this context. What could the concept of a 'hub' discipline mean (see p51)? Does a 'hub' discipline support innovation in particular ways?

6.1 Disciplines in the context of integrated design programmes

The predominant model of University degree programmes throughout the world is currently that of mono-disciplines. In order to graduate, students must demonstrate mastery of particular areas of knowledge, skills and values that define a programme boundary. The risk is that such a conception of an undergraduate programme is transferred uncritically to the analysis of design programmes, and potentially that these are also seen as mono-disciplines.

The first published use of the term 'integrated product development' may well have been by Andreasen and Hein (1987) of The Technical University of Denmark, and, although it is a different story, TUDelft's IDE programme had even earlier origins, having started from an architecture programme in the early 1960s (Roozenberg, 2007). Roozenberg describes the key to TU Delft's success in terms of a matrix structure of mono-discipline courses and intersecting design tasks, which is a model also adopted by UK programmes. Two projects were set each year and the projects were updated every few years, which provided a useful mechanism for reflecting significant social and economic changes. However, despite the success of the programmes at TUDelft. Brunel, Loughborough and Napier, the view seems to be holding at least in terms of national policy-making that such integrated design programmes risk educating students to be 'jacks of all trades and masters of none', which is a perspective rooted in the traditional analysis of the expectations of undergraduate programmes as mono-disciplines.
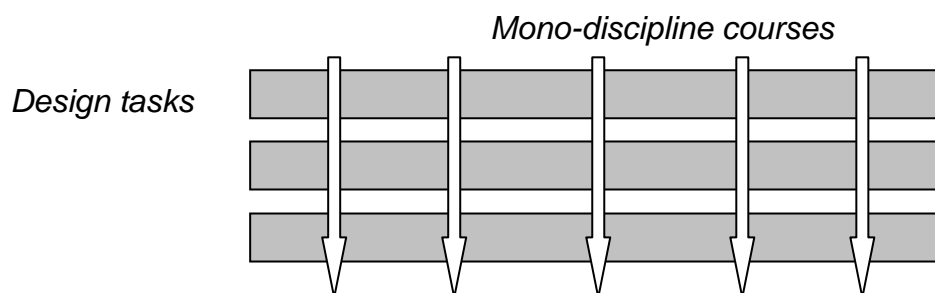
Fig. 6.1 IDE undergraduate programmes as the intersection of design tasks and mono-discipline courses (Roozenberg, 2007)

It has already been noted that the design spectrum suggests that designing in different product areas requires different proportions of 'industrial design' and 'engineering design', perhaps more easily conceived as different sets of knowledge, skills and values, and consequently the ways in which such designing tasks engage with the mono-disciplines will result in some delicate curriculum balances. In order to give some detail to this discussion, a particular case study, the polymer acoustic guitar, is

described below based closely on the original presentation at the Engineering & Product Design Education Conference in Barcelona in 2008.

Innovation in acoustic guitar design

Consider the development of a polymer acoustic guitar as a designing task. Innovation in acoustic guitar design requires a range of knowledge, skills and values that are not embodied in any current mono-discipline. People are educated to be luthiers, musicians, physicists and materials scientists, manufacturing, mechanical and structural engineers, industrial designers, ergonomists and as business experts, all potentially useful, but separately insufficient. The most advocated approach to attempting innovation in such product areas is that of 'inter-, cross- or multi-' or 'X-'disciplinary teams. Whatever their success elsewhere, the limited innovation in acoustic guitar design since Christian Friedrich Martin in the 1930s is a reality. Loughborough's polymer guitar project has demonstrated one of the possibilities for successful innovation and it might therefore be reasonably expected to have been more widespread. The guitar market is conservative, dominated by a belief in the primacy of tonewoods, and the Far East's effect on manufacturing costs could also explain the stagnation in design, but neither seem sufficient.

It is not that there has been no innovation in acoustic guitar design since the 1930s. There have been significant efforts and some successes, notably Maccaferri in the 1950s, who developed successful polymer ukeleles, and rather less successful guitars and violins, and in the 1970s, Gibson's Mark Series project (Bacon, 1991). More recently the Ovation and Rainsong guitars have achieved some success. The evolution of the guitar as a product species was discussed by Norman (2006b), and further explored as a case study demonstrating the human need and capacity to strive for change at product boundaries (Norman, 2007, see section 6.2). However, any brief visit to a guitar show or retailer would demonstrate that the acoustic guitar market is dominated by wooden, flat-top guitars as developed by C F Martin in the 1930s. The following is a brief discussion of some of the issues surrounding this agenda, particularly in relation to the potential contributions of mono-disciplines.

Recognising possibilities

It is well-known that acoustic guitar construction has a long history, but less well appreciated that wood was not so much 'selected' for the construction of guitars, but adopted as the only credible option. Clearly, the better woods were identified e.g. spruce or cedar for the soundboards, and the apparently obvious conclusion was reached that the grain would need to lie parallel to the strings in order for the wood to withstand the forces on it, but that is a long way from defining this as an 'optimal' choice. With a soundboard expanding 6-7mm transverse to the grain with differences in humidity, and, perhaps 0.15mm in the direction parallel to the grain[4], there are major construction problems to overcome. The rigid neck joint imposes great strain on the soundboard in the region close to it and transverse braces need to be fitted to keep it from splitting. Instruments constructed from wood in the traditional manner are masterpieces of structural engineering, designed to withstand these forces whilst using the minimum possible material in order to ensure good acoustic response to the small energy inputs. Luthiers need years of training and experience in order to master the required craft techniques, and, although this means that they have an excellent understanding of the solutions to the inherent problems of constructing wooden

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[4] Information from Alan Marshall, luthier at Northworthy guitars, Derbyshire, UK

instruments, it is not an ideal background from which to recognise alternative possibilities.

Applying science

The science of the acoustic guitar is also not sufficiently advanced for either physicists or material scientists to engage in innovation with any confidence. Bernard Richardson, of Cardiff University, is a foremost authority on guitar physics and a guitar maker. This quotation indicates the difficulties associated with current levels of understanding.

> *Because no two pieces of wood are alike, even … from the same tree, the maker has to fashion each piece of wood in an individual way to exploit its maximum advantage … there is no substitute for the sensibilities of the skilled craftsman who has learned through long experience how to extract the required vibrations from carefully chosen and carefully fashioned pieces of wood. It is these makers who are the key to the future prosperity of the instrument.* (1994: 10)

Again, it is not that no progress has been made in understanding guitar physics, but that the non-homogenous structure of woods makes analysis difficult and prediction impossible, given that the material properties will effectively be unknowns.

And then there is the human sound perception problem. Even if humans' ears receive identical sound waves, the way those sound waves are interpreted is a function of the way the resulting signals are interpreted by people's brains. Frequencies can be filtered out (e.g. the hissing of old transistor radios) or added in from memory (e.g. the bass lines of recordings when played through small speakers). So, it is not possible to conduct reliable listening tests, as the results will be culturally determined and as much a sociological outcome as a scientific measure of an instrument's performance. For the engineer, the major difficulty is in having a goal that is difficult, if not impossible, to define. There is no 'ideal voiceprint' for a guitar. Most customers buying guitars do not realise that each example of a particular model sounds different even when geometrically identical, because often they only hear the one, and their ears are not trained to hear the differences.

A branded market

The modern guitar market is controlled by the major guitar brands. They sign-up promising musicians to play on their brand, and images of 'guitar heroes' are published in the media. If you are purchasing your first guitar, then clearly you will not be able to play the instrument to test its quality, and will have no experience on which to base a judgment, even if someone else plays it. Most initial purchasers will wish to play safe, particularly in the eyes of their peers, and choosing the guitar being played by the current 'guitar hero' is a reliable option. If the reality that most current wooden acoustic guitars are made in the Far East at low cost and to a high quality is added in to this equation, then it becomes even clearer why there is currently stagnation. Changing production technology would be a major undertaking for any of the brands and what would be their incentive?

Sustainability

From an economic perspective, it is not possible to compete with the Far East manufacture of wooden instruments. There may well be ethical concerns associated with the distribution of wealth, as such instruments would cost an importer around 20GBP, or 30€, and sell for much more, but they are providing employment in the Far East. There may well also be environmental concerns because supplies of tonewoods are declining and manufacturers are expected to run into supply problems in around 5 years. Far East manufacture is rapidly consuming the remaining stocks and, even if planted, replacement trees with narrow grains must grow slowly. Spruce for

soundboards is not a renewable resource in the short term, and trade in some tropical hardwoods is banned under CITES agreements. There are also inevitably rising costs and environmental concerns from the energy requirements for transportation, as well as social concerns about lost jobs in traditional manufacturing nations.

A design – X-disciplinary - perspective
Designers are trained to be goal directed and 'find a way'. Quantity manufacture in an engineering material and the consolidation of parts to reduce assembly costs would be fundamental requirements of competitive manufacture in a European economy. Knowledge to help realize such a goal could be sought from the 'know how' of luthiers and the 'know that' of scientists. New styling opportunities could be pursued and modern polymer technology exploited. With these realizations, Loughborough University's polymer guitar project was initiated in an integrated product design department. The project has demonstrated the possibilities for successful innovation in acoustic guitar design (Norman et al, 1999; Norman and Pedgley, 2005). However the point of this discussion is not to promote those possibilities, but to ask the question of whether such a project could have been started within a mono-discipline? An expert in traditional guitar-making, physics, management or sustainability would need to see significantly beyond the boundaries of their discipline towards the wider picture. Of course a X-disciplinary team remains a possibility, but individual designers who take an integrated approach are another, which leads to the question … Are guitars so different?

An alternative perspective on integrated design programmes

The essential possibility is the recognition that designing in particular product areas requires associated knowledge, skills and values. For some product areas these will correspond with existing mono-disciplines, which is the reason they exist, but for others they may not. Clearly, being an expert in a mono-discipline does not make it any easier to address a task for which it is a poor match. Being able to address innovation in areas such as acoustic guitar design either requires individuals to develop the necessary 'fit-for-purpose' capability, for which the development of expertise in a particular mono-discipline might only be a partial starting point, or the development of special teams embodying the required expertise and relationships. There seems no reason to

	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Year 1	PD1-Introduction IDE	Products in Action	PD2-Concept Design	Mech. Engineering Design
	People and Products	Design and Experience	Business, Culture and Technology	Research and Design
Year 2	Dynamic Systems	PD3-Fuzzy Front End	Interaction and Electronics	PD4 Embodiment and Detail Design
	Strategic Product Innovation	Industrial Manufacturing	Technical product Optimization	Modelling and Simulation
Year 3	Minor		Optional Course 1	Bachelor Final Project
			Optional Course 2	

Fig.6.2 The remodelled Bachelor curriculum for IDE at TUDelft (Roozenberg *et al*, 2008:424)

conclude that the latter is always the more effective approach, and the potential of integrated design programmes needs more careful consideration. It is perhaps a post-disciplinary perspective that is really needed. TUDelft have now remodeled all their Bachelor programmes from 2007/8 as shown in Fig.6.2 in order to reduce the 'compartmentalized disciplinary structure of the former IDE curriculum' (Roozenburg *et al*, 2008). This remodeling was timely because it was necessary to introduce a Bachelor-Master system, as well as responding to the new requirements from practice and the need to try to stay ahead of competitors. It was also a response to developments in education, such as the new 'major – minor' system, as well as the belief that the teaching of design students should be different. Under the new major – minor system students spend 5 semesters on their major programme and the minor semester could be spent within the same or a different faculty of the same University, in studying at a different university or abroad, or on a work placement. It was important for TUDelft to be able to offer minors which were attractive to both their own students and those from other universities. Those offered within the IDE Faculty could relate to sustainable product design, research groups, such as human-centered or fuzzy-front-end design research, or multidisciplinary design organised between faculties.

The designing tasks have now been incorporated within this new structure, but founded on the principles established by the Institute of Design Education, for which there is no longer a need. Table 6.1 shows the distribution of effort in the new programme. The content has remained essentially similar to previous curricula, but the nomenclature of the mono-disciplines is no longer as visible, which could prove to be a major step towards the IDE programme being seen for what it is, and not what those external to it perceive it to be.

Area	ECTS[5]	%
Industrial design projects	40	22
Formgiving and ergonomics	31	17
Maths, mechanics, engineering drawing	46	26
Marketing and Management (including statistics)	18	10
Electronics	15	8
Manufacturing	30	7

Table 6.1 Distribution of effort in the TUDelft's new IDE programme

The other matter that this remodeling highlights is the critical nature of the presentation of mono-disciplines in IDE programmes. These were investigated by Myerson in 1992 and the difficulties associated with service teaching of such inputs were highlighted as indicated in the following passage.

> *'There is strong evidence to suggest that the best results in the teaching of technological subjects by engineering and science staff are achieved when:*
> - *engineering specialists reorganise their material and rethink their delivery in response to a course team ' brief' to suit the particular needs of ID (industrial design) students;*
> - *harmonious long-term relationships are established with course teams over several years, so getting away from the damaging effects of anonymous, ad hoc, ill-defined service teaching;*

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[5] ECTS refers to the European Credit Transfer System. In The Netherlands there are 60 credits per year and each credit represents 28 hours work.

- *industrial design courses are of sufficient size that engineering specialists can become full-time staff members of the course team, subscribing to its aims and sharing in its organisation and delivery. This has occurred in some cases through historical accident but is now a policy being consciously pursued by course teams: 'It is important for course tutors to instruct in technology - not make it the province of outsiders.'* (ibid., p44)

The investigation of the pedagogical issues associated with materials and mechanics was the subject of Norman's PhD (2002). Most significant for this report was the finding that these two technologies needed to be approached differently. Aspects of materials technology could be taught and learnt through designing, but this did not appear to be the case for the mechanics that was needed by the Industrial Design and Technology students at that time. Mechanical principles were only being effectively applied when designing by students who had acquired adequate prior competence. Roozenburg (2007) commented that within the new structure for the IDE programmes at TUDelft, the students only progressed to embodiment design by the fourth project, because the engineering strands have the longest lead times.

The apparent insignificance placed on the importance and track records of integrated design programmes is both surprising, and disturbing, given the importance of successful innovation for economic, environmental and social sustainability. However, the benefits from the contribution that integrated design programmes can make will not be fully realised without appropriate recognition and support of the alternative strategy that they represent.

6.2 Innovation in the context of integrated design programmes

It should be evident that whilst integrated design programmes are in no sense distancing themselves from science, or any other discipline, that exploring a model of innovation founded on the application of science is not appropriate in this context. The curriculum for IDE programmes is driven by the designing tasks, which also facilitate curriculum change and renewal. As the designing tasks and their related inputs are updated in response to either internal or external pressures, and the students respond to those tasks whilst engaging with new technologies, there is a process of almost continuous realignment in progress. In such a situation of Darwinian change, exploring innovation as an evolutionary process is perhaps an inevitable step. What follows in this section is an abridged version of a paper concerning a neo-Darwinian perspective on these matters that was presented at the PATT conference in Glasgow in 2007.

A neo-Darwinian perspective of innovation

In a 2004 paper, Langrish discussed the ideas associated with a Darwinian interpretation of product evolution and at the *2006 Design History Society Conference* concerning *Design and Evolution* presented the five basic requirements shown in Table 6.1. At the same conference, Norman (2006b) discussed the strength of the product evolution analogy in the context of the development of the guitar and concluded that Doyle's (2004) concept of technicity might provide an explanation for the associated human behaviour. These concepts, as well as Thistlewood's (1990) observed

1. The existence of variety – different kinds of things having mixtures of differing properties held in varying amounts

2. A competitive selection system which picks 'winners' from the different things, properties, amounts of properties or combinations of these

3. A system which replicates the 'winners' or some proxy for the winners. (e.g. male animals may compete but real competition is between the properties of the animals and only those properties which are linked to replicators get passed on). Preferential replication gradually replaces the 'losers'.

4. There has to be a system for the generation of new varieties because the above three on their own lead simply to a steady state (including oblivion as an extreme steady state). New varieties take us back to 1 and the continuation of the process.

To which it is necessary to add a fifth:

5. Even with the addition of 4, the system of change would slow down through diminishing returns, unless we have a fifth feature viz. changing the rules of the competitive selection system. Without changes in the environment or some other form of rule change, evolution would stop.

Table 6.1 Towards a general theory of Darwinian change: five basic requirements (Langrish, 2006:9)

categories of designing, are explored here in order to provide a neo-Darwinian[6] perspective on some of the key issues concerning design education. As in the discussion of innovation the guitar is the product used to illustrate the discussion

Thistlewood's classification of products

When discussing the classification of products, Thistlewood (1990) identified three types: archetypal, evolutionary and historicist. Archetypes are products which have developed through the generations and where 'significant departure from these characteristics leads at best to less-fit artefacts and at worst … to retrograde mutations' (*ibid*: 14-15). Musical instruments are one of Thistlewood's examples of archetypes in daily use and the others he lists are bowls, jars, tables, chairs, traditional water-craft and age-old instruments, like spades, hammers and cutting blades. In discussing the possibilities that designing archetypes presents, he comments as follows.

> *They represent a phase of human design enterprise before authorship was celebrated. The contemporary designer's contribution to their re-presentation consists in attending to secondary features such as materials, colours and decorative treatments: essential forms have ceased or virtually ceased evolving and are correspondingly non-negotiable. (ibid: 14)*

Archetypal forms of guitars have undoubtedly developed and many examples of current makers addressing such secondary features can be found (eg early classical (parlour) guitars, and steel-strung acoustic guitars based on the Martin designs).

Torres and the Spanish guitar: an 'evolutionary' step?

Thistlewood's second category of designing refers to evolutionary steps, which …

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[6] The term neo-Darwinism follows Langrish's use ie 'to mean Darwin's natural selection plus genes (which were discovered later). It is not suggested that design is somehow genetic. Design evolution is the evolution of ideas, and the Darwinian evolution of ideas is called "memetics" from the concept of self-replicating ideas called memes by Richard Dawkins (1976)' (Langrish:2004:4-5)

… obliges the designer to invent new forms that invalidate all their predecessors. Electronic typesetting has invalidated hot metal. …

…
'Evolutionary' designing compresses (and in this sense emulates) the centuries-long processes of development that have produced 'archetypal' artefacts. Much of this emulation is affected by means of 'accelerated use' – by subjecting artefacts to harsh regimes of durability-testing and programmes of mechanical wear-and-tear. This is pragmatic research and development. Much else, however, is achieved by imagining desirable but currently impossible outcomes - the opposite of pragmatism.
(ibid:15-16)

Such a remarkable step took place in guitar making in Spain in the nineteenth century.

The instruments played by Sor and his famous contempories – Dionisio Aguado (1784-1849) and Matteo Carcassi (1792-1853), for instance – were, however, far inferior to the guitars at the disposal of today's players. All that changed – with a quantum jump in the development of classical guitar construction – at the hands of a carpenter from San Sebastian de Almeria, Antonio de Torres Jurado (1817-1892). Better known simply as Torres, he was without a doubt the most important figure in the history of guitar design and construction. Musicians who played his guitars immediately discarded those of other makers. Throughout Spain luthiers adopted Torres' designs. In fact, to this day, classical guitar makers still construct their instruments in the manner of Torres   *(Denyer, 1982:42)*

The Torres construction guitars came to dominate the design of the Spanish guitar because of their superior musicality, but also because they were initially played by Francisco Tarrega – "the Chopin of the guitar" (Bonds, 2001:66); then by Andrés Segovia, who recorded their sound, thereby introducing the cultural power of exposure via mass media (Huber, 1994:12) and because they offer luthiers security for their reputation, established know-how and some flexibility (ibid:40-41).

The cultural influence is evident from the development in the USA of the only real alternative to the Torres construction guitars. C F Martin (1796-1873) brought his knowledge of European practice to America when he arrived in 1831, having been a foreman in Johann Staufer's shop in Vienna. The early guitars he made in America maintained their European influences, but over a period of 15-20 years his own designs emerged, most notably the cross- or X-braced top. 'The great majority of Martins from 1850 onwards have some form of X-bracing' (Gruhn and Carter,1993:18).

The search for volume: historicist designing

The third category of designing which Thistlewood identified was historicist, in which …

… the designer is conscious of working within an historical continuum. Buildings are the most obvious manifestations of this tendency … They are compared with antecedents that are still evident in the world around them, which in effect constitute a museum of architecture and building. Although houses have a familiar symbolism and of course an archetypal function – shelter – they have no essential form …
(op cit:15)

The emergence of the electric guitar is a long and fascinating story, but it is noted here as an example of Thistlewood's historicist designing. The sound of the electric guitar is

largely determined by the pick-ups used, the weight of the body, and to some extent the type of wood selected, but there is no essential form. A huge variety of designs have emerged, including of course the Gibson Les Paul, the Fender Telecaster and Stratocaster, but there are many others. They appear in different colours and materials eg wood, of course, but also bronze, aluminium, acrylic, polymer foams etc

The nature of innovation

So within one product family, it is possible to identify all three of Thistlewood's categories. Artefacts which have essentially ceased to evolve and where at least some designers have re-presented familiar forms. Clearly, some humans are not satisfied with simply reproducing artefacts, but wish to 'leave their mark' or to give the product something of their individual character. Evolutionary steps are constantly being sought and when no essential form is required (historicist designing) abundant variations ensue. When Dasgupta was considering whether creativity could be considered to be a Darwinian process, the lack of randomness in the ideas which emerged was a key argument in his rejection of the idea (2004). He examined three case studies from the histories of natural science, technology and art[7] and concluded:

> … a fecundity[8] in the generation of variations on which the selection is supposed to work according to the variation-selection model is not evident in any of the examples.
> In none of the case studies presented here is there any evidence whatsoever of blind variations being generated. On the contrary, the cognitive process in each instance was goal driven and knowledge driven.   (411-412)

Certainly much of the evidence presented in relation to guitar development (see Norman, 2006a for more detail) supports Dasgupta's findings of goal-directed, rather than random activity, but there is also some support for designing which is more analogous to the concept of 'random mutations' (eg some electric guitar designs). The evolution analogy is stronger when looking at a whole product family than particular case studies of individual design activity.

For guitar development, Thistlewood's concept of evolutionary designing can be seen as related to periods of static technology and fixed goals. It is interesting to note how the emergence of new materials technology has re-awakened some innovative ambitions. Carbon fibre has been explored by Greg Smallman (in collaboration with the guitarist, John Williams) as a material for Spanish guitar components in order to improve the soundboard response. It has also been explored by the Rainsong company in order to make complete steel-strung acoustic guitars from carbon-fibre composites. The 'polymer guitar project' at Loughborough University has been seeking to develop guitars using thermoplastic (expanded polycarbonate) soundboards, resulting in the business venture, Cool Acoustics (www.coolacoustics.com). There is comparable experimentation in the violin family (Revkin, 2006).

The development of the guitar seems to be characterised by issues relating to 'technical and cultural lock-in' of particular designs, but with a constant probing at the boundaries of the guitar family. Whether it is re-presenting archetypal designs, seeking new evolutionary steps or generating more historicist possibilities it seems never ending.

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[7]The case studies were in natural science, Jagadis Chandra Bose (1858-1937) and his 'Monistic Thesis'; in technology, James Watt (1736-1819) and his 'Separate Condenser'; and in art, Pablo Picasso (1881-1973) and his 'Picture from Afar' (Guernica)).
[8] Within biology or demography fecundity refers to the ability of an organism or population to reproduce

Why do designers re-examine the existing boundaries of the guitar family? Certainly the reality that at least some of them do provides supporting evidence that the first of Langrish's five basic requirements for a Darwinian model can be met, but can this be explained by anything more fundamental than some perceived dissatisfaction with some aspect of a product's performance? (Petroski,1993). It is possible that Doyle's concept of 'technicity' (2004) can help to move the argument on. This term might be seen as one of many expressions of a similar concept eg 'graphicacy' (Balchin,1972), 'technik', (Fores and Rey, 1979), 'designerly ways of knowing' (Cross, 1982), 'technacy' (Seemann, 2006), or indeed Archer's concept of 'cognitive modelling' perhaps (1981). It is not appropriate to review and distinguish these concepts here, simply to note that 'technicity' is but one expression of a number of related ideas.

Technicity

Doyle presented his concept of 'technicity' in 2004. It appears that some evidence from the field of evolutionary psychology suggests that technicity, rather than language, can be seen as the driving force underpinning the evolutionary success of humans. So the seeking out and exploration of new possibilities is at least partly 'simply what humans do'.

> *Technicity might best be characterised by a creative capacity to:*
> *a) deconstruct and reconstruct nature, and*
> *b) communicate by drawing*   (Doyle, 2004: 67)

Doyle's hypothesis was that 'innovation is to be expected [and that] technicity is its intellectual driver' (*ibid*: 71).

A neo-Darwinian perspective on design and technology education: learning by doing

Is it plausible to take the 'technicity hypothesis' view that to be human is to be innovative and, if humans engage in activities of this nature, then innovation is inevitable? Human decision-making is an expression of the art of making judgements based on incomplete information about existing factors and future consequences. This is the essence of design activity, and hence then of the existence of products and their associated technology. In the same way that each game of chess is highly likely to be different, so with product design dependent on a multitude of sequential decisions, the designs will inevitably be different. So, in some respect, every resolution of a design problem could be seen as innovative, in the sense that with respect to some factors it is a 'better fit' for the design intentions than its predecessors. It is a matter of judgement as to whether the better fit is of more value than other better fits.   So, on the view that technicity can be understood as the capability underlying human decision-making in the face of uncertainties, perhaps innovation can be interpreted as inevitable and product evolution considered the survival of the most valued.

The constant probing at the boundaries of the guitar family could be seen as a demonstration of technicity, perhaps a 'curiosity gene', or, given the potential planetary consequences, even a 'self-destruction' mechanism. Much recent research by Baynes has focused on understanding the behaviour of very young, pre-school children when designing (1992, 1994, 1996)[9]. The playful behaviour of the young of a species is often

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[9] These 'Orange Series' publications are dowloadable from Loughborough's Design Education Research Group website at www.lboro.ac.uk/idater/

strongly indicative of what the adults must do to survive, and the exploratory behaviour of young children demonstrates the fundamental nature of 'learning by doing'.

Learning by doing is one of the ways in which designers develop the 'recipemes', a form of memes (Dawkins, 1976) which Langrish describes as transmittable ideas about how to do things' (2004:17). He uses Abu-Risha's concepts (1999) in order to describe designing in terms of the 'purposive pattern recognition (PPR)' between the recipemes and the 'selectemes', which are 'ideas about the sorts of thing you want to do. Selectemes are involved in making decisions between alternatives. They provide motivation; they are values' (*op cit*: 17). As Langrish noted both recipemes and selectemes can 'sometimes be transmitted without formal language' (*ibid*:17), and this view of designing is supportive of Doyle's analysis of technicity as the essential human characteristic which has led to human domination of the planet. Some of the replicators of product evolution are the products themselves, which embody the thinking of their designers, and hence the importance of museums for design education. Similarly, other replicators are embodied in the skills and know-how which are passed from one generation to another through 'teaching by showing' (Norman, 2000).

Langrish also describes a third type of meme.

> … the "explaneme," must be added because of the human propensity to ask "why?" As long as humans have had a language, they have told stories, and good stories get replicated. If someone discovers a new recipe, people will ask why it works. Explanemes are the ideas that provide the basis for answering the "why" questions. They range in sophistication from simple stories to complex mathematical concepts, but they have two things in common, they offer an explanation and they need a language to be transmitted." (2004:17)

The designers' judgements (Norman 2006b) and the discipline of the market provide Langrish's second basic requirement for a competitive selection system, and design education can be seen as providing the third ie a system 'which replicates the 'winners' or some proxy for the winners'.

Probing at product boundaries and the generation of alternatives can be seen as inevitable consequences of human behaviour. No design 'strategy' or process, singular or plural, is needed for this to be the outcome, and design education can perhaps be best seen as taking the form of 'sports coaching'. 'Sport for all' programmes from which the most talented emerge, and the recipemes available to these few are gradually increased until the 'PPR' associated with highly skilled designing becomes routine. Technological literacy is largely about the understanding of the selectemes that enable participation in a democratic society. Technological capability, if this concept is interpreted as the ability to intentionally bring about a specified outcome, requires 'PPR', and bridging the gap between technological literacy and technological capability could be considered to be the ultimate goal of design (and technology) education. Explanemes are the province of science, and on such a neo-Darwinist view, they are not always an essential feature of designing or product evolution, and consequently neither are formal languages a requirement. The significance of the role that formal languages play in designing will be a matter of context, and the nature of the design task.

Returning (briefly and for the last time) to guitar development, many people have relevant selectemes which could define worthwhile goals (literacy), a small minority have the recipemes required to do anything about them (capability). Science provides few explanemes and their foundations are not secure (Norman 2006a). That is why

luthiers exist, and that Cool Acoustics work with Rob Armstrong, who has now made around 750 instruments, all successful and all different, and nobody gets lucky that many times in a row! Rob Armstrong believes in self-enlightenment and learning by doing, and, although guitars are but one product, they nevertheless illustrate the potential strength of the case for taking a neo-Darwinian perspective on design (and technology) education.

An outcome of such a view, which some would regard as optimistic, is the steady-state that Langrish predicted: a guitar perceived to be perfect. So, perhaps a key goal for design (and technology) education should be minimising the changes in the product environment that lead to unnecessary innovation and the related over-consumption of the world's resources. Products that are 'eternally yours'[10].

As stated earlier IDE programmes seek to educate their students through a series of designing tasks, 'learning by doing'. Engineering programmes are more likely to devote significant curriculum time to the development of knowledge relating to specific technologies, prior to the students engagement in significant designing. The forms of evidence most likely to reveal the balances and tensions in IDE programmes would be related to the treatment of the designing tasks (or 'design practice') within the programmes and their timing in relation to associated 'technology' inputs.

For the pilot comparative study the data collected were images of typical products that the students would be expected to design during such integrated degree programmes. It was believed that these designed objects or systems could be interrogated to reveal the associated knowledge, skills and values, rather than focussing on curriculum documents. In order to connect the products of the students' designing to issues like creativity and innovation, Thistlewood's categories of designed products as archetypal, evolutionary and historicist were adopted (1990).

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[10] The home page for the Eternally Yours organisation used to be http://home.planet.nl/~muis/eternal.htm

7. The Design and Technology Department at Loughborough University

This case study reviews the emergence of design courses offered within what was the Department of Design and Technology at Loughborough University in the UK, particularly in the light of the ideas that shaped them.   It is inevitable that models of design education are related to the models of design and designing that underpin the thinking of their advocates, and it is intriguing to explore the drivers of this evolution. Two publications have made this exploration possible. Firstly, a collection of writings edited by G T James in 1980, which covered the period from the initial work in teacher education in 1930 to a perceived watershed in 1980. Secondly, a Special Edition of *Studies in Design Education, Craft and Technology (SDECT)* written by members of the academic staff in 1988 to describe the work of the Department of Design and Technology Department, as it had become known by then. Across the modern Loughborough University campus a variety of design areas are represented. 'Engineering design' programmes in a number of disciplines are offered within the engineering faculty and 'art and design' programmes specialising in a variety of media are offered within the School of Art (formally LUSAD, the Loughborough School of Art and Design),and previously the Loughborough College of Art prior to its merger with Loughborough University in 1977. However, this review is not about these mainstream traditions, but about the 'hands-on' integrated product design, which is the hallmark of the current Design and Technology Department.

7.1 Handicraft to industrial design and technology: the emergence of a discipline

G T James wrote as follows in his foreword to the historical account of the first 50 years:

'*If one accepts Thomas Carlyle's contention that history is 'The essence of innumerable biographies', it must follow that the history of an institution is enshrined in the lives of those who worked there. A mere chronicle of events cannot convey the essential liveliness of human history, but it might nevertheless, be a useful adjunct: it serves to show how the 'innumerable biographies' came to be thus interwoven.*

Accordingly, this brief history of the Department of Creative Design at Loughborough is divided into two parts. The first … is an attempt to present a chronological record, subjective only to the extent to which the author has been selective. What follows … is a little more subjective, but comes nearer, perhaps, to extracting the 'essence': it names more names.'
                                                                                       (1980)

This second section contains recollections and individual views of the work of the Department relating to furniture and woodwork, metalwork, ceramics, technology, plastics and materials science. By the time of the 1988 Special Edition academic staff were writing about group task management, drawing as the language of design, information and the design process, core design, technological capability in design, materials for product design, product analysis and the use of computer systems and software tools for modelling products. The 1980s was clearly a time of rapid visible change, but the origins of this step function in the Department's evolution can be traced to much earlier ideas. So where did it all begin?

The handicraft years

The founding Head of Department in 1930 was Dr J W Bridgeman and reflecting in 1980 on those early years he wrote:
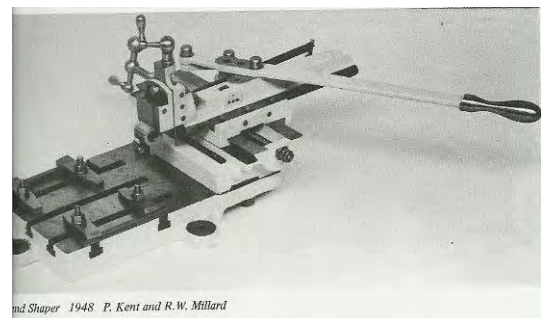
> 'The early teachers of the subject (Handicraft) were usually either class-room teachers who became craftsmen, largely through their own efforts, or practising craftsmen who by taking a short course, obtained a qualification to teach only this subject. The first group tended to be insufficiently skilled in the craft selected and not infrequently returned to the chalk and talk of the class-room while the craftsmen from industry were often segregated by lack of education and training, from the general body of teachers.

> The task facing Loughborough in 1930 was to devise a course which gave the normal academic education and training to students while devoting sufficient time to practical work to achieve the high standard of hand-skill which had been found to be the sine qua non for the successful teacher of Handicraft in the schools. This concentration on first class craftsmanship pervaded the early over-crowded time-table, the selection of students, the appointment of staff, the supplementary courses and the extension of the period

Fig. 7.1 The 'Garage Block' and its 'Top Shop'

> of training to three and four years. Such emphasis is the secret of whatever successes Loughborough-trained teachers of Handicraft have achieved and will be an essential priority in the wider basis of study and research now to be offered in the Department of Creative Design of the Loughborough University of Technology.'

So, at the very start of the Department's history as the *East Midlands Training College for Teachers of Handicraft* in September 1930, one of the key challenges was bridging the divide between the practical and the academic. This 'Cartesian' divide can be traced to the ideas of the Greek philosophers of the Ancient World, and it is only perhaps in the 1980s that the emerging programmes can be clearly seen as challenging this ideology. But the post-Cartesian ideas driving the changes in the 1980s did not emerge quite as suddenly as might be assumed. Figure 7.1 shows the building in Loughborough town centre where the first courses were taught and where the Top Shop for woodwork was opened in 1936. A metalwork shop was added in 1952. Figure 7.2 shows some of the craft pieces produced in these early years. At this stage lectures in English and education were being provided by

nd Shaper 1948 P. Kent and R.W. Millard
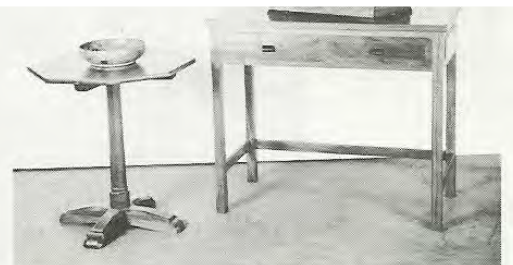
Bowl Birdseye Maple Casket English Walnut
Pedestal Table A.G. Page Black Walnut
Writing Table 1942 J.C.H. Cowen Black Walnut

Fig.7.2 Craft pieces produced in Loughborough's early years

Nottingham University, to which the Loughborough handicraft students travelled once a week. So there was a 20 mile geographical divide between the practical and the academic to overcome as well!

The first iteration

In 1960, the first purpose-built workshops were opened on the 'playing fields' site, which was by now becoming established as the Loughborough campus. These workshops were extended in 1971 and the whole building is now known as the Bridgeman Centre, named, of course, after the founding Head of Department (Fig.7.3).

Initially this remained a handicraft department, but in 1965 Geoffrey Harrison was appointed as Head of Department to rethink the Department's courses and direct 'Project Technology' (a curriculum development project funded by the Schools Council). He brought an engineering background into the mix.   This is how G T James wrote about the subsequent changes in 1980.

Fig.7.3 The 1960 purpose built workshops and the home of the Department of Design and Technology: the Bridgeman Centre

'The underlying reasons for, and subsequent effects of, the changes which began in 1966 remain a matter of opinion. Undoubtedly, the strong public and official interest in technology accounts for the introduction of that subject into the Departmental syllabus: there was no significant dissent from this decision. With regard to the proposed changes in other areas of the work, much of which involved greater aesthetic and craft components, feelings became divided, and to some extent remain so today.

At that time, in many institutions of Higher Education (eg Industrial Design Departments in Colleges of Art), the concept of 'design' as a process operated through a clearly-defined system was becoming established (and in due course found its way down to Secondary level). During the sixties, particularly, the pendulum swung violently away from teaching design either from a materials base or in the context of intuitive decision-making, to one in which the all-embracing 'system' was invoked to solve the widest possible range of design 'problems': for all design became 'problem solving'. The initial educational aim, namely that of involving the student (or pupil) in the activity as a whole, seemed somehow to have become distorted by the over-formalisation of the process. In seeking to embrace the 'new' philosophy it was for a time feared that many values for which Loughborough had stood in the past might be endangered. Diversification and expansion, it seems, must inevitably bring in its train a measure of over-reaction from all sides. Hopefully, this is often followed by adjustment and compromise yielding in the end both retrieval and gain; a course of events which now, (in 1980) it is generally felt has taken place.'   (ibid: 18)

So, what exactly happened in 1966? Essentially the Department began to offer two courses, 'Design Technology' based on work centred on mechanical and electrical technologies and 'Environmental and Aesthetic Design'. This latter course sought to

extend the traditional handicraft course and, perhaps surprisingly, this was the source of the controversy.

> 'The traditional main course areas were extended to include – as well as woodwork and metal – boat building, silversmithing, electrical and electronic work, rural crafts, sculpture, pottery, plastics and courses in materials science: in the first half of the course students were expected to experience a wide range of craft areas at an introductory level, before concentrating on more specialised work in the later stages. Additionally, each student was required to take a newly-structured 'Basic Design' course, occupying much of his practical time during the first term of the first year'
>
> (ibid: 1)

So here it was. The teaching of 'Basic Design' and the expectation that it might be easily related to a seemingly diverse range of design areas. Perhaps the controversy was not so surprising after all.

The 1970s

This first iteration away from intuitive, materials-based designing reached its maturity of expression during the 1970s. In 1975, two BA courses were offered for the first time 'Creative Design with Education' (4 years, including a Teacher's Certificate) and a Joint Honours course 'Creative Design with one other subject (3 years, initially 'other subjects' were mathematics, physical sciences, biology, English, drama, history or music). Two types of Creative Design course were drawn up, one concerned with 'Design in Technology', which became known as 'Scheme A', and one concerned with the 'Decorative Arts', which became known as 'Scheme B'. The topics covered in these course variations are shown in Table 7.1.   In both schemes design work in Year 1 consisted of a Foundation Course concerned with 'the handling of form and colour, the manipulation of materials and with graphical presentation' (ibid: 20).

> ### Scheme A
> Man&Design in the Twentieth Century
> The Physical Basis of Technology
> Materials and Processes
> Ergonomics
> Technology in Design
> Dissertation
> Design Practice in Mechanics or Electronics
>
> ### Scheme B
> Man&Design in the Twentieth Century
> History, Theory and Philosophy of Design
> Materials and Processes
> Dissertation
> Studio Design Practice in either Furniture, Ceramics or fine Metalwork
>
> **Table 7.1 The 1975 variations on creative design (ibid: 20)**

An interesting quotation appears in the 'Technology' section' in Part Two of James's account concerning Scheme A.

> 'This course, initially 'Technical Studies', and currently designated 'Scheme A', (because of the semantic difficulty in finding a simple, all embracing title), has developed strongly and has maintained the initial concept that the theoretical study of technology should at all times be closely integrated with projects undertaken in the design practice element of the course.'   (RWM *et al*, 1980: 36)

In retrospect it is clear that Scheme A flourished as a continuation of the materials-based designing which had always been at the Department's heart. Electronics and

Mechanics were being regarded as one of the technologies just like 'Materials'. This kind of theoretical position must account for the title 'Design in Technology', which perhaps looks a little curious now, but 'Design in wood' or 'Design in plastics' remain familiar usages. In essence, Scheme A was about designing in particular areas of the design field, albeit different areas to those that had been traditionally pursued within the Department. Scheme B was designing beginning to detach itself from a particular knowledge base or area of the design field, and hence became the greater potential cause of controversy.

It is also worthy of note that in 1975, the degrees were offered with 'joint honours' as an academic protection perhaps, and it was not until 1976 that the Scheme B course was extended to include a single honours course in Creative Design. It was interesting that the controversial process-based extension of studio-based designing was the variation selected to be the basis of the first single honours degree programmes. Perhaps, Scheme A was at risk of giving the (unfounded) impression of being a 'watered-down' version of the engineering degree programmes on offer at Loughborough.

As the amalgamation of Loughborough College of Education and Loughborough University of Technology approached in 1977 …

> … the Department has established the beginnings of diversification in students graduating from its courses; while the majority still take up teaching careers, and will continue to do so, several have also moved into post-graduate courses to equip them for careers in industry and to study the broader aspects of design. (ibid: 22)

The second iteration: convergence

In 1982 the Creative Design courses evolved into Design and Technology degree programmes, which integrated Scheme A and Scheme B into a common course structure. The version of this existing in 1988 is shown in Fig.7.4. Students were awarded either a BA or a BSc degree depending on the main option they selected in Year 2. Year 1 had a common structure for all students and it was only 'Ergonomics or Education', which separated the single honours from the 'with education' students. (This was the only joint honours course remaining.) There was a similarly unfortunate pairing of subjects for 'with education' students in Year 2, but Ergonomics and Design for Plastics were covered at an introductory level in other modules and these were regarded at the time as specialist areas.
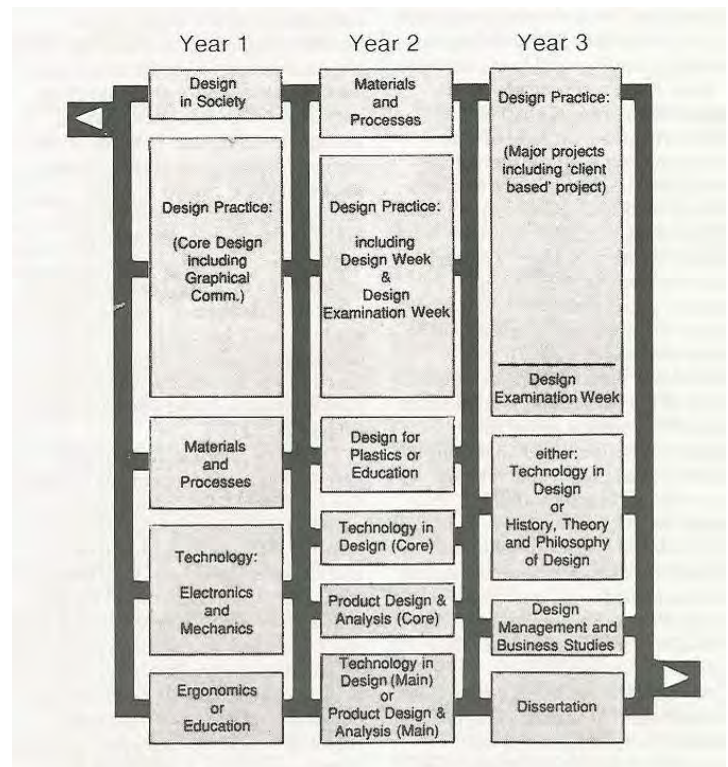
Fig.7.4 Design and Technology BA/BSc honours degree programmes in 1988 (Denton,

In 1988 these programmes were described as follows.

> 'Design and Technology at Loughborough has been developed specifically for those who wish to combine creative flair with the application of scientific knowledge in the field of Technological Product Design. The course shares many similarities with

*Engineering Design and Industrial Design degrees. The degree course at
Loughborough develops a competence in electronics, mechanics, and computing as
well as aesthetics and modelling. It develops in students the ability to communicate
effectively through technical drawing, sketching, verbal presentations and a
professional level of written work.*

*Undergraduates are actively involved in designing, making and evaluating
prototypes in all three years. This may range from consumer product designs to
hospital or research equipment. The department actively encourages contact with
commercial clients, and the professional skills developed through this cooperation
considerably enhance the candidates' position in the job market'.*

<div align="right">(Denton, 1988: 148)</div>

Loughborough's Design and Technology courses were examples of a number of very
successful degree programmes of this type that emerged in the 1980s and ran
successfully throughout the 1990s. The reason for their success is partly evident in the
above passage. Their development rested on the clustering of particular knowledge,
skills and values and associated pedagogy, which was the dominant model of design
and technology at the start of the 1980s. They were not developments of a process
model of designing. Consider the following passages also taking from the 1988
Special Edition of SDECT, firstly concerning Year 1 Core Design, which refers back to
Walter Gropius's work at the Bauhaus in 1923.

'A new foundation has been developed at Loughborough specifically to combine the
best of the traditional model with the requirements of today's society. It seeks to
maintain the provocative and liberating elements of a traditional foundation and yet
build upon that. Great faith is still placed in practices that aim to sensitize students.
Activities take place that can be identified with Gropius' 'breaking down of
conventional patterns'. However, the subject of these cognitive strategies at
Loughborough is just as likely to be electronic or mechanical as painterly or
sculptured. The entire first year of the Design and Technology Course may be
viewed as an example of this new foundation. Many contemporary 'Core'
programmes offer the inputs of skills and knowledge but omit the vital sensitization
activities and project management skills which are essential to a sound and fulfilling
manipulation of technological information.' (Atkinson *et al*, 1988: 149)

The academic staff responsible for the Core Design module were clearly focusing their
pedagogy on a particular design area, and this was no less the case in other areas of
the degree programme. For example, those developing the Technology modules were
similarly trying to focus their efforts. Figure 7.5 shows an adapted version of the
product design spectrum, of which the original appeared in the Design Council's Carter
Report (1977). The authors explain their intentions as follows.

*For the products in region C the design considerations are mainly aesthetic.
Industrial designers and craftsmen using inherited and adapted skills of craft-based
design and manufacture have produced products for which technology is secondary
to other considerations such as appearance, ergonomics and material suitability.*

*The products in region A are very different; they are highly technical and require
specialist engineers and technologists for many parts of the design. Technological
factors can no longer be secondary. (…)*
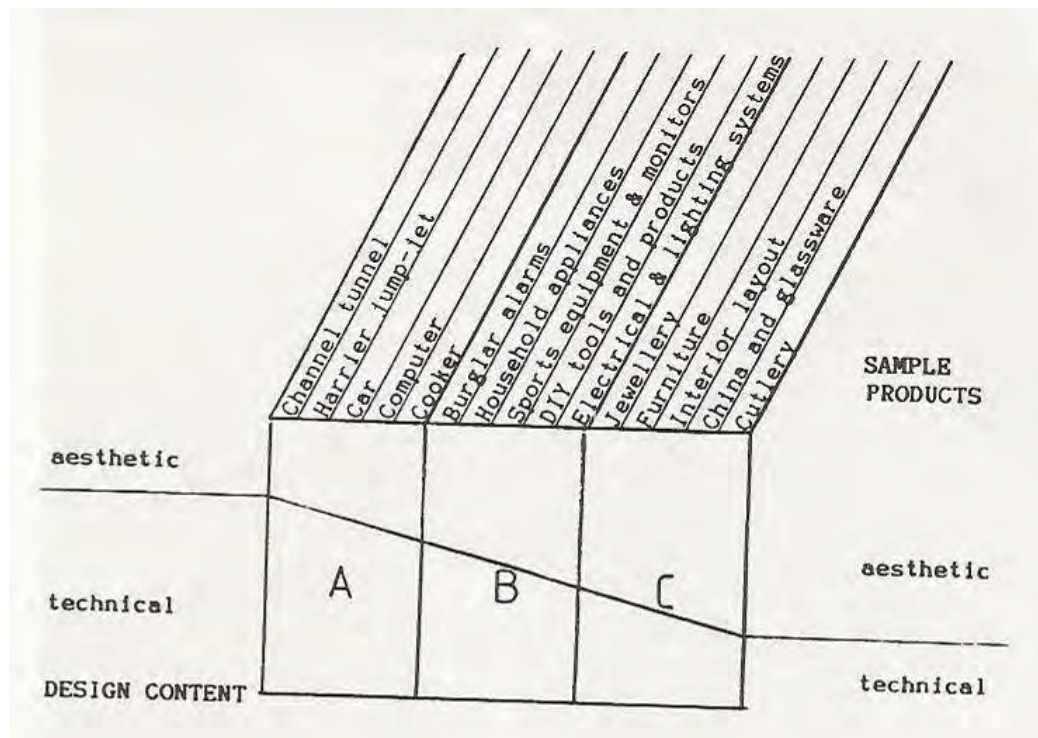
Fig. 7.5 An adapted version of the product design spectrum (Norman and Riley, 1988: 154)

> *The central region B (in Fig.5) is comprised of comparatively small-scale products for which aesthetic factors are important but also a knowledge of the appropriate technology is necessary. Products of this nature require both technological and creative design considerations. (…)   (Norman and Riley, 1988: 154)*

This strategy of focusing the development of technological capability on carefully identified knowledge, skills and values echoes the findings of the Myerson Report concerning *Technological change and industrial design education* (1992). Fortunately Loughborough's degree programmes had grown to be of sufficient size in order to allow the appointment of engineering specialists (eg Norman and Riley) as part of the course team. Although particular teaching materials and strategies were developed, any analysis which suggested that the success of such a course was a result solely of the internal development of appropriate pedagogy would be misleading. There were clearly also external factors exerting strong influence, such as the economic issues highlighted by Bruce Archer in the quotation below.

> *'There was another force precipitating change. The worldwide economic recession of the 1980s hit Britain rather early. There were bankruptcies and unemployment on a massive scale. Many manufacturing industries, already reeling from price competition and design innovation from Japan and the Pacific Rim, collapsed. International monopolies gained control of the design, manufacture and marketing of many classes of products. Whilst many of these industrial groups employed British design groups as product and advertising design consultants, there was a sudden drop in the demand for traditionally trained engineering graduates. Where small/medium sized companies were surviving, their need was not for specialist engineers, but for individuals with a*

range of skills, capable of dealing equally with research, concept design, styling,
detail design and preparation for production ...' (2004: 13)

So the success of the degree programmes offered by the Department of Design and Technology has partly been a result of their timely and appropriate development, and partly, their perhaps fortuitous, convergence with the externally-driven context emerging in the latter part of the 20th Century. An appropriate assembly of knowledge, skills and values were brought together to form the curriculum for these particular programmes and arguably that is precisely the same mechanism through which other areas now conventionally regarded as academic 'disciplines' developed.

7.2 New directions: divergence

The word 'Industrial' was added to the titles of Loughborough's degree programmes in 1990 following the introduction of the UK National Curriculum in Design and Technology in secondary education. It is not that there were no links, but that those links were not as direct as having the same title would imply. Otherwise the programmes continued to evolve on much the same model, becoming modularised and semesterised in the 1990s. These were university-wide initiatives and had no clear benefits for design programmes apart from facilitating curriculum developments. A national conference was held concerning the impact of modularity on art and design in higher education at Dartington Hall in 1994 and 'no positives' were reported from amongst the 115 delegates who attended (eg Norman, 1994). Nevertheless, this was the period in which ideas about 'High Design' were emerging: design as Art and Poetry rather than a tool of marketing and with an associated move towards being more user-centred (eg Carrubba, 1993). So for Loughborough's programmes, modularisation and semesterisation probably facilitated the evolution of their curriculum content under the leadership of the then Course Leader, the late Mike Hall.

However, by 2006 the pressure was building for more substantial changes and new BA and BSc programmes were launched as shown in Fig 7.6. Either of these programmes could be taken with a DPS year, and it is shown in the BSc programme to illustrate how it relates to the other modules. These were essentially a response to the widening of the demands on the design profession. These strains were particularly evident in relation to the approach to technology in Year 1. Pedagogy derived from the more formal analytical approaches to electronics, mechanics and materials was becoming increasingly perceived as problematic by the BA students and a further shift towards 'learning by doing' became appropriate. The BSc programmes remained centred on the Department's traditional philosophy of focused knowledge, skills and values. There remains strong demand for such graduates despite the widespread expansion of design programmes in higher education, and Loughborough's degree continues to be regarded as one of the leading courses of this type in the UK, if not the world. The title of the BSc programmes was changed to Product Design and Technology and they became accredited by the Institution of Engineering Designers. The BA programme retained the title of Industrial Design and Technology.

There has been a gradual shift in emphasis away from 'designing and making' and towards designing without the constraints implied by a physical outcome (in secondary and higher education, as well as within the design industry). The need to move from a product to a service-based economy in order to ensure a sustainable future, both economically and environmentally, creates further pressure for change. Innovation is the prize, and design education is sure to continue to evolve in the pursuit of a suitable model. It is possible that a process-based conception of design and technology might yet have its day – perhaps founded on interpretations of the meaning of design thinking

- but it is improbable that the eventual outcome will closely resemble the process models which were essentially rejected in the early 1980s.
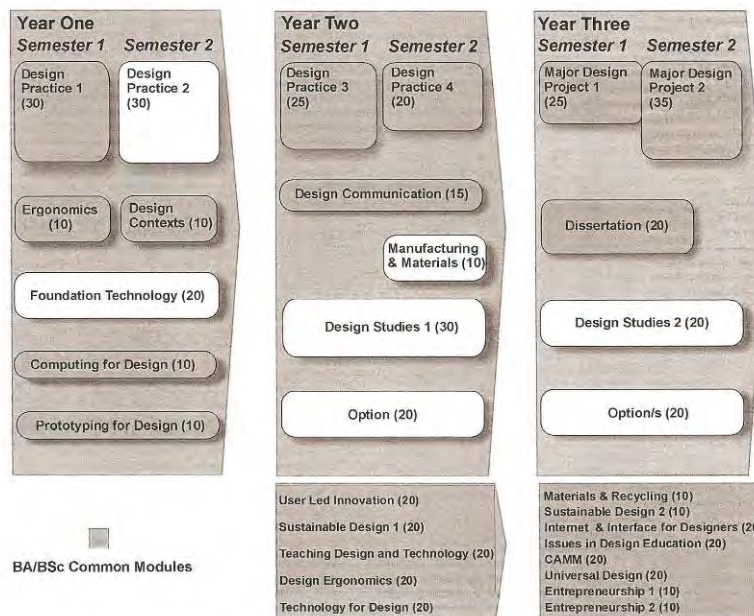
Fig 7.6 The BA and BSc programmes introduced in 2007
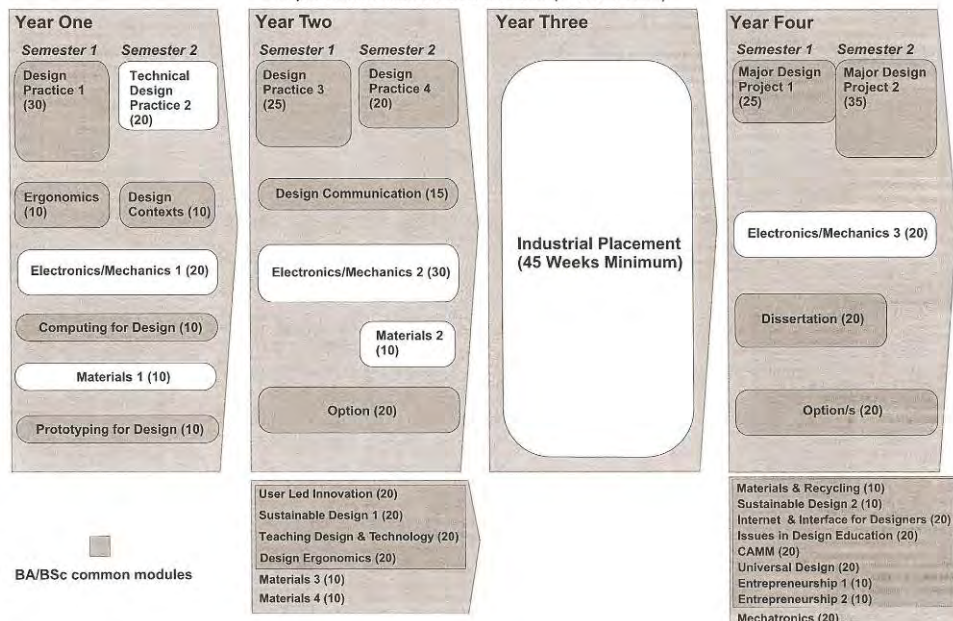
The future must lie beyond post-Cartesian ideas which challenge the two cultures model and with post-modernist conceptions which recognise a wide range of influences, perspectives and positions. The Department introduced a range of masters programmes in response to some of these pressures, and some of those available in 2009 ie Industrial Design, User-Centred Product Design, Sustainable Product Design, and Virtual Product Design are shown in Fig 7.7. There was also a masters programme in Industrial Design with Business.

The students entering these masters programmes have already acquired designing skills from undergraduate programmes, and they are assessed for entry partly on the basis of their design portfolio. So, they are not 'conversion courses' in the same sense as the RCA/ICST programmes where technology competent students are introduced to industrial design. They can all be seen to be taking a user-centred approach, but they are essentially about developing competence in one of the specialist design areas.
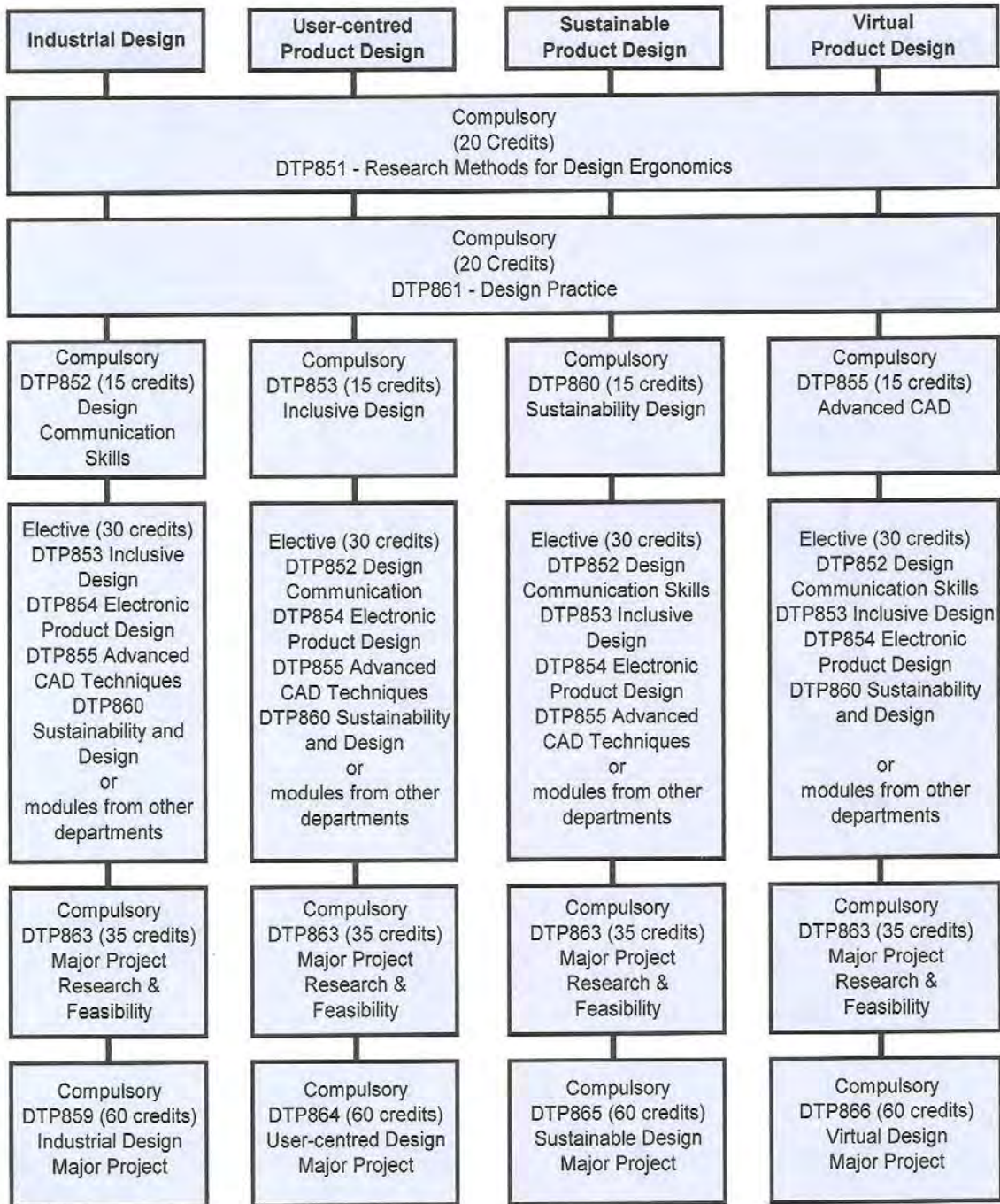
The Department of Design and Technology was amalgamated with the Ergonomics & Safety Research Institute and part of the Department of Ergonomics to form the Loughborough Design School on 1 August 2010.

Department of Design and Technology

Masters Programme in Industrial Design with different named routes:

Masters in Industrial Design
Masters in User-centred Product Design
Masters in Sustainable Product Design
Masters in Virtual Product Design

Industrial Design	User-centred Product Design	Sustainable Product Design	Virtual Product Design

Compulsory
(20 Credits)
DTP851 - Research Methods for Design Ergonomics

Compulsory
(20 Credits)
DTP861 - Design Practice

Compulsory DTP852 (15 credits) Design Communication Skills	Compulsory DTP853 (15 credits) Inclusive Design	Compulsory DTP860 (15 credits) Sustainability Design	Compulsory DTP855 (15 credits) Advanced CAD
Elective (30 credits) DTP853 Inclusive Design DTP854 Electronic Product Design DTP855 Advanced CAD Techniques DTP860 Sustainability and Design or modules from other departments	Elective (30 credits) DTP852 Design Communication DTP854 Electronic Product Design DTP855 Advanced CAD Techniques DTP860 Sustainability and Design or modules from other departments	Elective (30 credits) DTP852 Design Communication Skills DTP853 Inclusive Design DTP854 Electronic Product Design DTP855 Advanced CAD Techniques or modules from other departments	Elective (30 credits) DTP852 Design Communication Skills DTP853 Inclusive Design DTP854 Electronic Product Design DTP860 Sustainability and Design or modules from other departments
Compulsory DTP863 (35 credits) Major Project Research & Feasibility	Compulsory DTP863 (35 credits) Major Project Research & Feasibility	Compulsory DTP863 (35 credits) Major Project Research & Feasibility	Compulsory DTP863 (35 credits) Major Project Research & Feasibility
Compulsory DTP859 (60 credits) Industrial Design Major Project	Compulsory DTP864 (60 credits) User-centred Design Major Project	Compulsory DTP865 (60 credits) Sustainable Design Major Project	Compulsory DTP866 (60 credits) Virtual Design Major Project

Fig 7.7 The masters programmes available in the Department of Design and Technology in 2009

7.3 Further interview evidence

As a result of the numerous initiatives being taken in response to the Cox Report, this investigation was being pursued in parallel with the development of the Post-Disciplinary Design Group, comprising the Universities of Brunel, Loughborough, Napier and TUDelft. As part of its early activities, one very successful alumni from each of the universities was interviewed and a summary published in *New Design* magazine (Rodgers, 2008).

The four alumni were all asked the same questions and Table 7.2 below shows some of the interview answers that are particularly relevant to this report given by Rob Woolston, who is now the Managing Director of DCA in Warwick, and was a student at Loughborough in the 1990s. DCA have employed a number of Loughborough graduates over the years.

Table 7.2 Interview responses from Rob Woolston

Question	Response … Rob Woolston
What were your favourite projects whilst at Loughborough?	… in terms of the design projects themselves, the ones that I enjoyed the most were those that were focussed in the real world, on products that could be high volume commercially successful products. Those were really the ones that switched me on. The two that stuck out particularly were: a project to design a toaster and a project to design a steam iron. They were just great fun; having to deal with all the detail from start to finish with projects like that was enormously enjoyable. … the toaster project that I did was in the third year. It was a minor project, and I elected to start it before term started, so I got a bit of momentum on it because there was such a lot to be done in the term. So, by the time the term started, I was quite well progressed with the project work, and it was coming together really well. It was one of the points I think where all the things I'd learnt in the previous years really came together, gelled, and went up a level. So that's why I enjoyed that one so much. I actually took that design out to one of the toaster manufacturers, and they were really keen on it. It went up to their board and they were going to decide whether they were going to go in that direction or not. As it turned out, there was also an RSA brief at the same time for that product type, so I had to decide with the lecturers whether to put it in for that award, and I was proud of the work, so I was quite hopeful, or whether to continue with the company who were interested in it. Unfortunately the company concerned didn't have the momentum to want to carry it forward. It was a new approach to that sort of product. So looking back, they were probably never really going to do that, so perhaps I should have … *IV…gone for the RSA.* Yes. However, I really enjoyed that project. It was great fun. The rest of my career has followed that 'whole' product design route, right from product direction, creating the means of operation, through all of the design detailing, and typically right through to manufacture. The other project was a steam iron, which was a very similar type of project trying to start in the same realms of questioning actually what do users really want, and where is the evidence for it; picking the directions to go for based on this, then coming up with the means of doing it; then detailing right through, and so on and so forth. So very similar projects, if you like; very similar breadth to them; reflecting the breadth of the Loughborough course, and that's the sort of project work, or approach to project work that I enjoyed at University.

What do you feel are the main things that you learnt whilst at Loughborough?	Okay. Well, I think the things that held me in good stead have been the fact that it was a broad course looking at all the basic skills necessary to design complete products, and at that point, also beginning to direct me towards an evidence based design process and pushing me in that direction. And that's very much what DCA, a big part of DCA is about; and has grown into more and more over the last decade, a very strong evidence based design process, and focus on whole product design. So that's what I learned, all of the basic elements and how all those elements can come together. What I've done subsequently is broaden that right out to cover more elements for product direction, so product road-mapping, technology road-mapping, helping companies to think about what products they want to have on market to generate income in five years time, eight years time, and designing those projects themselves, showing how we're going to look at the risks in those projects, mitigate the risks in those projects, create a high probability of success of actually getting the right sort of product to market in the right sort of timescale; transparently illustrating that and talking that through with the client so that they understand the strategy for the project and how that's going to come together; and understand what the risks are. And then, as you go through the project, producing the level of evidence we've decided meets the risk level the company is having to take on in order to drive that design right through from start to finish. So it's very much this whole product design approach. *IV … Yes, which Loughborough's always tried to encourage, hasn't it?* Absolutely. So the same things happened really. It's rolled on through to my career the same as the pace of work has continued through. So those were very much the groundings for me in terms of the beginnings of evidence-based design.
How do you feel your time at Loughborough differed from other design students' experiences?	I think one of the differences with the Loughborough design course was the amount of timetabled work as well as amount of continuous assessment work there was compared with the other courses at the University. And then if you look externally, there are other design courses that had some similarities in approach, but when we've seen the students coming through, we have found that the Loughborough students have often been a better fit for DCA. Some other universities running very similar courses have had a slightly different course focus and haven't always quite fitted us so well, and then some other courses we've seen where they're not so broad in the course itself, the students don't have so much grasp of some of the practicalities of some of the design issues.
Do you feel that Loughborough missed anything in their curriculum?	I would say I'd want to see even more focus on users, evidence based design decision making and project strategy; together with more on IP. And then also, at the other end, even more on manufacturing techniques. *IV … Some of those things, when you were there, were in their infancy.* Yes. That's where it started for me, the beginnings of the evidence based design definitely started at Loughborough, and if I look now and say, well, Yes, what would I grow into Loughborough, I would grow more of what we're doing now, inevitably, otherwise we wouldn't be doing what we're doing now, because we believe in it very strongly. So if I came and looked at the course now, I'd be trying underpin it with my design philosophy. I would want to see it reflected in the course because the design philosophy we've developed at DCA is all about delivering products to market with a high probability of success at an understood risk levels to create bottom line for companies. *IV… I think that's happening but slowly.* Well, the students we're seeing coming through have a lot of what we need. There's always going to be elements you could take forward and move forward, but it's producing excellent graduates.

10 What do you think the most important issues in Product Design are currently? Would it be useful to introduce topics like brand strategy and innovation management?	Well, when, for example, you mentioned the brand side of things, so for me, what that boils down to yet again is the evidence base. You have brand, usually based on evidence, that you need to reflect in the product, so you need to understand what that brand is and why so that you can reflect it in the product. So some of the work we do is exactly around that; understanding that brand or helping to define that brand. Perhaps if it's largely on the visual side of the design, then being able to have a methodology for reflecting that brand, i.e. creating a brand language to determine how you reflect that brand. So you will design this product, it's going to look like this. Why is it going to look like that? Because it's reflecting an evidence base, or a set of reasoning. And as part of our work we might question, why is that brand like that? Who are the key stakeholders? You might define who those stakeholders are; naming them, using them as a tool to help make design decisions. So every aspect of design for me comes down to this evidence in some way…
	IV…So the key is really evidence base.
	If in the course you actually build in and understand the importance of the evidence base, you're questioning every single element that goes into the design, and every single element of that design will have a level of evidence, and you'll be deciding on how much evidence you need. And obviously, on some of the products we produce, you have huge amounts of evidence in certain places, because, in terms of strategy, that is an area that's considered to have very large risk, so to reduce that risk, you bring an evidence base into play, so you've got the information to make the decision, because design is all about making decisions continuously through the process. So if you actually put a strong philosophy through the course, you don't necessarily have to do such a huge amount of work on aspects such as brand, because you're actually producing people who fundamentally ask the right questions, because they want the right decisions to go into the design.
	IV…So it's less about looking at specific things like brand and innovation, and more about that actual part of it.
	What that then means is, picking up on one of the elements that you selected, one doesn't necessarily have to have a really in depth course on brand within a broad product design course. You need some good understanding of what it is, why people are doing it, etc., but you come down to the evidence based decisions that we make. Typically creativity and innovation are used within the framework of the evidence.
	IV …I think something like that overall philosophy is very helpful because if you keep picking up each individual topic that comes up and try to build in a module on that, it just grows.
	Product design is so hugely diverse, you need to have a focusing philosophy

Table 7.3 gives some of the responses from the other 3 participants for the *New Design* article … Tjeerd Hoek, Executive Creative Director at Frog Design and a graduate of TU Delft, Rob Lister, Head of Technical Strategy at IDEO Europe and a graduate of Brunel University, Neil Poulton, an independent product designer and graduate of Napier University. The whole article is worth reading, but these quotations give a flavour of the responses.

Table 7.2 Interview responses from Tjeerd Hoek, Rob Lister and Neil Poulton

Questions	Responders and responses
What did you least enjoy at	**Tjeerd Hoek …** Topics like manufacturing techniques or metallurgy

University?	didn't inspire me. It was so utterly alien and uninteresting to me to hear about cutting steel and messing around with giant machines to make what appeared to be useless scraps of metal. I was 18, and soon realised that this was a critical part of the design process. It had just never occurred to me how messy, ugly, and frankly dangerous some of those processes actually are. This subject remained probably my least favourite but at least it gave me a deep respect for that part of the process.
What was your favourite project as a design student?	**Rob Lister …** The most insightful project I remember was a simple challenge – each student was given a household object of some sort with the brief to tell the class about it. I was given a cheap hairdryer – initially quite uninspiring. As I learned about the materials used to make the fluid mechanics that drove it and its ingenious circuitry, I began to appreciate the intelligence and cunning of the designer. I came away with a totally new appreciation of this cheap, ugly hairdryer including the fact that whoever designed it was much smarter than me. Some of the most elegant design choices are in cheap, initially unimpressive items.
What would your advice be to product design students today?	**Neil Poulton** … I'd say be creative, be original, be innovative, be brave but don't forget the 'execution' skills. For every creative post there are ten 'execution' posts and, if some graduates do become overnight superstars, most juniors have to start at the bottom and work their way up. 'Execution' skills means design and development technique skills. There was a time when the requisites were good sketching, drafting and physical modelling abilities, but the computer changed all that. Today's juniors need to know their software inside out. Lastly, I would advise product design students to get to know Asia and China. Asia is already the worldwide manufacturing capital, and western industry is becoming more and more dependent on China. Some analysts predict that the Chinese economy will overtake us in less than ten years, so there's a good chance that some of Napier's current students will end up working in Asia.

8. Wider curriculum convergence

8.1 Designing tasks within the Loughborough, TUDelft and RCA/ICT Curriculum

There are major differences in the origins of IDE programmes and in the backgrounds of their students. Loughborough University's Industrial Design and Technology programmes have their origins in education and teacher training, TUDelft's IDE originated in a School of Architecture and the RCA/ICST postrgraduate IDE programme in a conversion programme for engineering graduates. It is not therefore realistic to make detailed comparisons, but in order to shed further light on the nature of the issues, the modelling strategies taught and the designing tasks that have evolved as part of the pedagogy for these programmes are discussed. This is essentially to explore the nature of the innovation that these programmes are seeking to develop as suggested by Thistlewood's categories of designing (see section 6.2). As modelling methods and design innovation are closely related (Baynes 2009), it might be that a comparison of the modelling methods being taught could yield further understanding of expected interpretations of innovation that these programmes embodied.

In order to explore this possibility the PowerPoint presentation shown below was prepared and circulated to academic colleagues at Brunel, Napier, TUDelft and RCA/ICST. The primary focus of the comparison was the shaded area shown in Slide 4. However designing tasks are also set in the first year of the ICST/RCA IDE Masters programme as part of the introduction to industrial design for the engineering graduates. Examples of these for 2005 were downloaded from www.designcreate.info and they comprised *Power of Form*, *Folding Structures*, *Go Global: Thailand*, *Opera Set, Workspace design and a Lighting Project.* The students also undertook a materials investigation. Feedback to this PowerPoint was invited, but it was only obtained through the visits made.

Initial pilot study

Year post-18	Loughborough (2007)	TU Delft (2007)	ICST/RCA (1987/2007)
1	Undergraduate Y1	IDE Bachelors Y1	
2	Undergraduate Y2	IDE Bachelors Y1	
3	Undergraduate Y3	IDE Bachelors Y1	
4	One Year Masters	IDE Masters Y1	IDE MDes Y1
5		IDE Masters Y2	IDE MDes Y2

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Loughborough University

Initial pilot study: LU ID&T

- 7 design projects over 3 years
  - 1700 hours Y1-Y3 (BSc)
- Progressing from ID skills to client-based work
  - Y2 opposite (200 hours)
- 3 masters programmes

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Loughborough University

Initial pilot study: TU Delft

- 7 design projects over 5 years
  - 1000 hours, Y1-Y3
  - 400 hours, Y4
  - 1040 hours, Y5
  - 35% of study time
- Progressing from ID skills to client-based work
  - Y2 opposite (180 hours)
- 3 masters programmes

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TU Delft … Institute of Design Education

- Provides design education at the Industrial Design Faculty
- Through a series of projects (Design 1-6)
- Project leaders, co-ordinating ~50 staff
- Backbone of the IDE curriculum

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Initial pilot study: RCA/ICST 1987

- Lectures
- Y1 focus on studio skills, industrial design
  - through a series of 6 projects (23 weeks)
- Engineering design
  - 3 projects (6 weeks)
- Year 2 major project
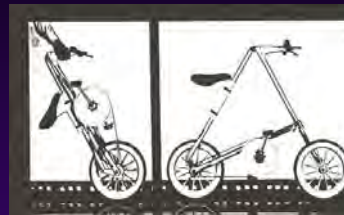
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Initial pilot study: RCA/ICST 2007

- Y1 … design (70% of studio time)
- … digital methods (20% of studio time)
- … creative business (10% of the studio time)
- Y2 … 2 large self-managed projects
  - One in a group

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Loughborough Y1

- Design Practice 1 *2D and 3D modelling, developing creative and imagination, sketching and engineering drawing* (300 hours)
- Individual and team projects
- 4 short projects and Design Week eg 'Nomadic structure', user-centred design, love it, hate it and product re-design, product analysis and re-development

Loughborough University

Loughborough Y1

- Design Practice 2 *Electronic product and mechanical product* (BA 300 hours, BSc 200 hours)
- Individual and team project
- Design folio, blue foam model, presentation boards including ergonomics, functional prototype

Loughborough University

TU Delft Y1

- Design 1 *Introduction to product design* (240 hours)
- Individual project
- Static design tasks
- Low complexity eg lamp, display, communication device
- Creativity, modelling and visualisation techniques
- Design theory lecture programme

Loughborough University

Loughborough Y2

- Design Practice 3
*Concept generation,
design development
and presentation,
modelling product form*
(200 hours)
- Individual project
- Eg electronic product or
communication device

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Loughborough University

Loughborough Y2

- Design Practice 4
*Injection mould tool
design, 3D CAD
modelling, CAD/CAM,
product design and
presentation* (200
hours)
- Individual then team
project
- Eg small, low cost/high
volume products

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Loughborough University

TU Delft Y2

- Design 2
*Understanding and
practicing design
methods* (180 hours)
- Individual project
- Mechanical, dynamic
design tasks eg home
trainer, water play
mobile
- Defining users and
needs, structured idea
generation, mind
maps

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Loughborough University

TU Delft Y2

- Design 3 *Ergonomics, semantics, sketching and modelling* (180 hours)
- Individual project
- Hand-held electronic tools or devices eg digital wallet, hand-held navigation system
- Product vision, 1:1 modelling, design semantics, mass production

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Loughborough Y3

- Design Practice 5 *RSA Design Competition and Design Week* (200 hours)
- 2 individual projects
- Briefs set nationally (RSA) and by companies (design week)
- Project management, integrating creative strategies and technological knowledge

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Loughborough Y3

- Design Practice 6 *Concept design feasibility study* (200 hours)
- Individual, but a group project could develop
- Develop design brief and specification, innovative concepts, concept selection with users and/or client company, analysis to establish feasibility both for commercial manufacture and prototyping

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90

Loughborough Y3

- Design Practice 7 *Prototyping and evaluating a major design project* (400 hours)
- Normally individual, but group project possible
- Project planning and management, making, product evaluation methods, costing, design for manufacture, presentation and communication techniques

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Loughborough University

TU Delft Y3

- Design 4 *Manufacturing and cost, working models, user testing* (280 hours)
- Individual, then team project
- Carefully structured brief for electronic or pneumatic appliances eg button maker, toaster, foam cutter
- Working prototype, videoing user trials, new working principles and features

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Loughborough University

TU Delft Y3

- Design 5 *New business development, sustainability, teamwork and communication* (120 hours)
- Team (role play)
- Business case: company with strategic gap in product portfolio eg bicycle appliances, food packaging and dispensing

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Loughborough University

TU Delft Y4
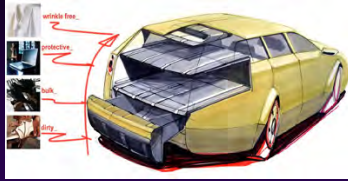
- Integral Design Project *New business development through design for an actual company* (400 hours)
- Team project
- As for Design 5, but this time for a real company ie Business case: company with strategic gap in product portfolio eg shopping display, bicycles, strollers etc

Loughborough University

RCA/ICST Y1 (ie Y4)

- Design *Innovation, drawing and model-making, form-finding, socio-cultural research, materials technology and manufacturing* (70%)
- Digital methods *CAD/CAM, RP, animations, WWW* (20%)
- Creative business (10%)

Loughborough University

RCA/ICST Y1 (ie Y4)

- Range of projects eg power of form, folding structures, go global (Thailand 2005), opera set, workspace design, lighting project
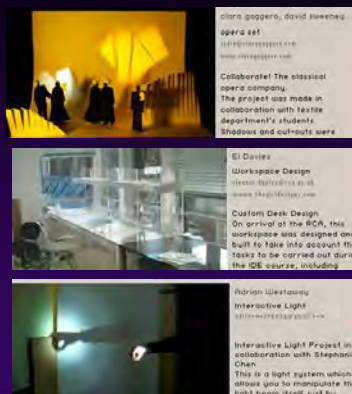
Loughborough University

TU Delft Y5

- Graduation Project (1040 hours)
- Eg Crijn Bouman's *Silent, exhaust fumes-free scooter* (2006) and Helma van Rijn *Language development toy for autistic children* (2007)
- … completed in a company setting or within one the research groups in the Faculty of Industrial Design Engineering

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RCA/ICST Y2 (ie Y5)

- 2 large self-managed projects
- One group, one solo

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Loughborough University

RCA/ICST Y2 (ie Y5)

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Loughborough University

8.2 Discussion of apparent curriculum convergence

The 1977 Carter Report on *Industrial Design Education in the UK* made these comments in relation to undergraduate programmes..

<u>Undergraduate programmes</u>

4.4.4   'The project system, on which most existing degree courses are based, has proved to be a successful method of educating designers – so long as it is supported by lectures and seminars to provide the necessary body of knowledge and understanding of the nature and purposes of design. Considerable care is necessary, however, in the selection of project subjects not only to ensure that they embody useful educational possibilities, but also that they are not wastefully large and time consuming. This is particularly important in a student's final major project, which may have considerable influence in determining the future development of his career.

4.4.5   In view of the dominant role that the project method of learning plays in the structure of design courses, the committee recommends that a special study be undertaken to examine how the method is currently practised, how it might be improved and how alternative learning methods may be developed – such as the use of analysis and design case histories.   …

4.4.6   The committee believes that properly run sandwich courses are the ideal way for students to gain adequate industrial experience. However, it appreciates the difficulty of establishing continuous and productive relationships with appropriate sections of industry. It feels that, on balance, for first degrees, students might gain more from conventional courses with planned periods in industry during vacations than from inadequately organised sandwich courses that aspire to unrealistic standards.'   *(16-17)*

So teaching through projects can be taken as long established for undergraduate degree programmes. This publication is essentially exploring a particular strand of such a 'special study' of practice with the 'project method' in the context of IDE. The IDE context brings into sharp focus the tensions between projects set and the supporting lectures, and particularly those that develop knowledge, skills and values associated with technologies.

A survey of higher education, employers and relevant literature concerning technological change and industrial design education was conducted by Myerson in 1991. The core areas of technology to be studied by industrial design students were recommended as materials, processes, human factors, computing, workshop practice and manufacturing. In the survey four other areas were identified as then being taught (somewhere, but presumably only necessarily at 1 of the 25 institutions visited). These were information management, engineering science, mechanical engineering and electrical/electronic engineering. Table 8.1 shows the topics identified in these 10 different areas. Course leaders seemed to be uncertain about these later four areas. They were being taught (presumably) because someone felt that industrial design students needed to know something about them - typically through service teaching from an engineering department - but the course leaders were not reported as being convinced of the relevance of this teaching. No detailed statements were included concerning these areas in the recommendations, but the following statements were made relating to mechanics;

'Additionally, course teams should pay attention to the following aspects of course content:

- *courses should endeavour to develop in students an ability to calculate order-of-magnitude estimates about, for example, load-bearing capacity of structures or strength of materials;*

1. **MATERIALS**
    Classes
    Properties
    Structure
    Strength, testing and failure
    Selection

2. **PROCESSES**
    Metals processing
    - methods, applications and design constraints
    Polymer processing
    - methods, applications and design constraints
    Other processes
    Finishing processes
    Joining, fastening and fabrication

3. **HUMAN FACTORS**
    Aesthetics
    Anthropometry
    Anatomy, physiology and psychology
    Ergonomics
    Man/machine systems

4. **COMPUTING**
    Organisation and presentation tool
    2D draughting
    3D modelling and design
    Engineering analysis of software model
    Computer-aided design and manufacture (CAD/CAM)

5. **WORKSHOP PRACTICE**
    Safety
    Hand and power tool operation
    Joining and forming
    Model-making
    NC machining
    Engineering drawing

6. **MANUFACTURING**
    Systems aspects of design for manufacturing
    Techniques used in design for manufacturing
    Planning
    Costing

7. **INFORMATION MANAGEMENT**
    Libraries and sources
    Product data: location and usage
    Standards
    Databases

8. **ENGINEERING SCIENCE**
    Forces
    Stress and strain
    Energy and power
    Control
    Thermodynamics and fluid dynamics

9. **MECHANICAL ENGINEERING**
    Structures, sections and loading
    Friction, fatigue, creep
    Mechanisms
    Pneumatics and hydraulics

10. **ELECTRICAL/ELECTRONIC ENGINEERING**
    Components and identification
    Terminology and definitions
    AC, DC and simple circuits
    Electromagnetic induction and electric motors
    Digital electronics and microprocessors
    Transducers, signals and signal processing

Table 8.1   Range of technological content found on product and industrial design courses in the UK   (Myerson, 1991:27)

...
- *students should gain experience in the testing and evaluation of the technical performance of designs, including test rigs and working prototypes where appropriate; ....'* *(op cit., p.65)*

It would appear that there was a belief that industrial design students should know something about these more technical topics, but there is no clear understanding of exactly what this should be.

In classifying the industrial design courses surveyed as 'Low Tech', 'Mini Tech', 'Midi Tech' and 'High Tech' attention was paid to the level of competence required in these 10 areas. This was defined in terms of mastery, proficiency, familiarity and awareness. Even for the 'High Tech' courses it was only familiarity which was required in mechanical engineering, engineering science and electrical/electronic engineering. Familiarity was defined as:

> *'- a knowledge of a subject, its capabilities and limitations, the ability to understand the language and communicate with specialists in the field;'*
> (Myerson, 1991, p.34)

Perhaps the most important contribution of the Myerson report was to make it clear that 'technology' is too broad a term. Technologies is both more appropriate and helpful, and it facilitates the discussion of research evidence indicating that different technologies present different issues. And in the context of this report it seems reasonable to suggest that similar spectrums of pedagogical issues would arise in relation to other disciplines, whether, for example, that is art, business studies or the human and social sciences. One of the major concerns with debates concerning programmes that embrace 'design, engineering and art' is that they are conducted at too high a level of generality in order to engage with the issues that are likely to prove problematic.

The notion of 'cognitive mismatches' in the form in which modelling was occurring (eg visual and symbolic) was explored as a possible cause of such difficulties in Norman (1999). The evidence presented was not conclusive, but sufficient to suggest the importance of 'graphicacy and modelling' and the visual communication of technology as important research areas. These were pursued in an IDATER Online conference in December 2010, which was jointly organised by Loughborough University's Design Education Research group (DERG) and the newly formed Technology Education Research Unit at the University of Limerick (Norman and Seery, 2011).

Graphicacy was the subject of a PhD research programme being undertaken by Xenia Danos (eg 2009; 2010) and the visual communication of technology was the subject of a PhD programme being undertaken by Cheng-Siew Beh (eg 2010), who also designed the image shown in Fig 8.1.
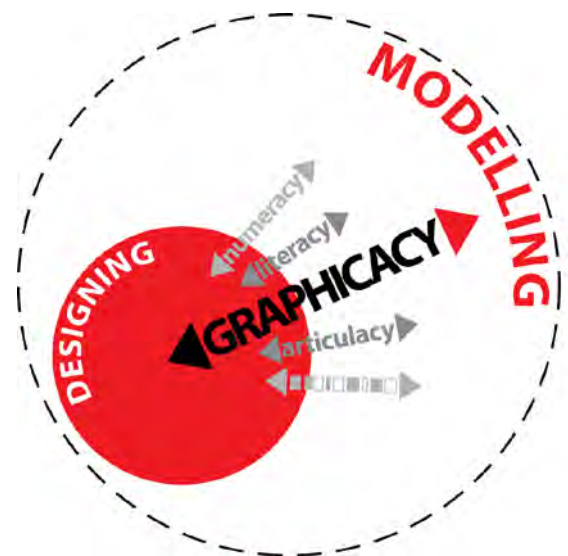
Fig 8.1 The relationship of graphicacy and modelling

A comparison of the 'undergraduate years' in the initial pilot study shows some apparently significant convergence of practice between Loughborough University's Industrial Design and Technology programmes and IDE at TU Delft. As would be expected the early focus is on the core skills of designing and the technologies with which the students are first engaged are the most straightforward to model – materials, manufacturing, static, low complexity are some of the descriptors. Engagement with 'engineering mechanics' was seen as having a longer lead time (Roozenburg, 2007), which echoes Norman's findings (2002), and reflects the RCA/ICST practice of recruiting technologically competent graduates.   Elements of strategic product design are introduced towards the end of the TUDelft 5 year IDE programme, which can again be seen to parallel the RCA/ICST practice, but that is perhaps less surprising, because the RCA/ICST model was cited as one of those that inspired the design of the TUDelft IDE programme.

Core designing skills can be seen to be developed in largely artefactual designing contexts ie where there is no essential form to the design outcomes eg barbecues and multi-media terminals at TUDelft, Nomadic structures and foam modelling exercises at Loughborough, folding structures and opera sets at RCA/ICST. Engagement with technologies brings with it associated artefactual constraints, and these can be seen to be systematically introduced as the designing tasks progress ie mechanical, ergonomic and electronic or pneumatic constraints at TUDelft over Design 2-4, mechanical, electronic, ergonomic and manufacturing at Loughborough over Design Practice 2-4. The IDE programmes might be thought to be only aspiring towards evolutionary steps, but in reality, the final year projects can be seen to incorporate the re-presentation of artefactual elements and historicist designing. They are characterised by the engagement of designing with technological constraints and it is from this interaction that I at least would suggest, the creativity and innovation they embody stems.

8.3 Post-Disciplinary Design Group

One parallel activity to these investigations was the formation of the Post-Disciplinary Design Group, comprising Brunel, Loughborough, Napier and TUDelft Universities. The following statement was prepared in November 2008 in order to describe their approach.

Designers no longer fit into distinct categories. Social, economic and technological changes require designers to be highly flexible and able to adapt to different contexts by blurring traditional boundaries.

Post-disciplinary design is characterised by multi-disciplinary working that enhances people's lives. It is an all encompassing, inclusive activity which begins by carefully observing and understanding people and sensitively shaping solutions.

Post-disciplinary design transcends traditional academic boundaries. The emphasis is placed on identifying opportunities and solving problems using knowledge and methods supported by the social and physical sciences, engineering, technology, human factors, business and management.

It is able to seamlessly mix relevant activity, skills and knowledge in a creative approach that is appropriate for 21st century endeavours.

A paper was published in 2009 by Paul Rodgers and Joseph Giacomin introducing the Post-disciplinary Design Group's manifesto, which was intended to serve as a rallying point for redeveloping aspects of the design curriculum. The Post-disciplinary Design Group was seen as transcending traditional academic boundaries.

> *The emphasis is on the identification of opportunities and on the solving of problems using appropriate knowledge and methods from areas such as business studies, computer science, economics, engineering, human factors, management, physical sciences, psychology and the social sciences. It does not recognise barriers and limitations to creative activity in support of people, and it does not limit itself to a specific sector such as fashion, product or graphic design.*
>
> *The approach is a response to the growing need for training and professional practice, which can contribute effectively to any area of the modern global economy. It emphasises the many benefits that derive from the combination of a solid grounding in social and technological knowledge, coupled with strong emphasis on personal expression and creativity.* (31)

It is certainly important that the challenges facing students in engaging with a wide range of technologies should not be underestimated, and in the context of design education, perhaps the major issue is the extent to which post-disciplinary designing is referring to individuals, developing T-shaped capabilities perhaps, or team-based interdisciplinary strategies.

9 Discussion

9.1 Undergraduate programmes

It is evident that the essential difficulty with designing undergraduate IDE curricula is that the material that would be covered in an ideal 'IDE' curriculum would take rather longer than 3 years. It would probably be readily agreed that it would not be necessary to cover all the topics in say industrial design, engineering and business degrees, but there would be sound arguments for a good proportion of them. So, the curriculum is going to be less than 'ideal'. There are pedagogical issues that will drive some choices, such as the need to initially develop the core skills of designing and engage with technologies in a progressive manner depending on their associated lead times, but there will also be value driven choices. The pressure on this situation is increasing as topics related to the 'fuzzy front end' become increasingly important, and consideration must be given to aspects of the social sciences, rather than more engineering related design areas.

Roozenburg (2007) believed that the TUDelft IDE model was only suitable for some students, and that other students preferred the softer user-centred areas. He also noted an increasing demand for design programmes in other specialist areas, such as arts-based courses that could lead to further divergence in undergraduate provision. The experience at Loughborough that led to the introduction of separate BA and BSc routes would support the position that there is an increasingly strong case to be made for different pathways. There is only so much that can be expected of a 3 year programme and there is a need for choices to be made. Providing students with such choices either means institutions specialising in particular pathways, or being large enough to support a number of routes. Providing a single pathway (with minor variations), as Loughborough's Department of Design and Technology might be seen to have been doing in the 1980s and 1990s, might well have been appropriate then, but the greater possibilities offered by the newly-formed Loughborough Design School seem more appropriate for the demands of the 21st century.

By the time of the visit made in relation to this Report (ie 2007), Napier University had already moved away from the Industrial Design (Technology) which had been favoured by Ewing in his 1980s research. In 2007 Napier were running 4 Bachelor programmes: Consumer Product Design, Design Futures, Interior Architecture and Graphic Design (new for 2007) and an MDes programme in Interdisciplinary Design. It was the Consumer Product Design programme that was closest to those run by Brunel, Loughborough and TUDelft, and some degree of merger was already being considered between the Consumer Product Design and the Design Futures programmes. The programmes still retained their interdisciplinary structure, but the programmes were clearly 'moving on'. `

IDE programmes like those offered by Loughborough University have essentially converged to become a discipline: using the 'T-shaped terminology', they are not producing T-shaped designers as such, but a particular kind of 'I'. Their graduates have highly developed modelling skills – cognitive, 2D- and 3D-modelling – that support the 'hub' discipline that IDE has become. In a world of rapidly changing technology and social agendas, the ability to bring such modelling tools to bear on designing tasks supports collaboration and participation. IDE programmes are not new anymore, or even contentious in the way they were in the 1980s and 1990s, and it remains a peculiarity that the role they can play is not widely recognised by policymakers.

9.2 Postgraduate programmes

In relation to postgraduate programmes it is salutary to begin by noting some further extracts from the 1977 Carter Report on *Industrial Design Education in the UK*.

> 4.5.4   '*Colleges offering postgraduate courses have a responsibility to ensure that the objectives of such courses are clearly stated. These might be:
> a   to provide, after a first degree in industrial design, the additional training necessary to prepare students for professional practice and to acquaint them with the complex technological, commercial, legal, professional and human activities in which they will have to work
> b   to provide an opportunity for the study of a specialised area of industrial design in greater depth than is possible during a first degree course. Such specialisation might be: the design of particular classes of products; design within the framework of particular materials or processes; or the study of special aspects of design-related subjects such as safety, ergonomics or energy conservation
> c   to provide a conversion course to industrial design practice for graduates from other disciplines, for example from engineering or architecture
> d   to provide a course to prepare those from various backgrounds who wish to work in design education
> e   to provide opportunities for design research*

> 4.5.5   *The committee recommends that new postgraduate sandwich courses should be developed, arranged around the facilities, skills and specialisations of appropriate companies. As with all postgraduate courses, the academic objectives must be clearly defined and the industrial element carefully related to them. Any operational details would have to be worked out to make these courses operate satisfactorily, but their essential feature would be the provision of a flexible three-cornered relationship between student, college, and sponsoring industrial organisation.*

> 4.5.6   *The committee recommends that postgraduate course geared to familiarisation studies in industrial design should be offered to graduates in disciplines other than design. These studies would be of particular value to management graduates, whose future influence in industry will be affected by their understanding of the importance of good design, not only in relation to production costs, sales and profits, but also to the human and sociological factors that shape consumer demand. The committee believes, however, that Masters degrees in industrial design should not be awarded on completion of these familiarisation studies. It recommends instead that a system of awards such as diplomas or certificates) should be established as alternatives to Masters degrees in design to distinguish those with an ability to practise design from those who are knowledgeable about it.'*   (1977: 17-18)

And the fundamental question must be: What can we add to this three decades later? The experience gained has led to greater understanding of the core designing skills that need to be taught and some of the pedagogical issues associated with technologies. There is greater appreciation of the importance of an interdisciplinary approach, but

'4.5.6 above' was already referring to 'the human and sociological factors that shape consumer demand'. Perhaps what is really new is the recognition that dealing with the interdisciplinary demands of some designing tasks might be best approached through teamwork, facilitated through prototyping as the Design Council Working Party reported from their visits to America, Europe and Asia. The assessment of group performance for the award of higher degrees can now perhaps be more easily facilitated. Clearly the advantage of bringing together experts in a discipline, and supporting their development as T-shaped individuals, is that it avoids the risk of an incomplete grasp of a new discipline as a result of a conversion course. For example, consider the following quotation from Ewing's report.

> *'It is accepted that all designers must be able to draw well. And have the skill in the manipulation of colour, form and texture, to design. Therefore the course is structured in the first term to enable the students to learn these skills. It is an interesting fact that we can teach the engineers to draw very quickly things they can see in from of them, eg still life, but they have a mental block, and the skills they have learned seem to disappear rapidly, when they are in the process of designing conceptually. There is a psychological problem in transferring ideas in the mind to the sketch pad, which can only be explained as a lack of training in visualising ability. The visual awareness projects are used to overcome some of these problems, but in terms of lost time during the students' educational life, the course is too short to overcome them all. Nevertheless great strides have and always will be made by the students. This difficulty, however, may also be evident in students who are visually gifted but usually at a far earlier age, and has been overcome by their art and design education. Certainly the industrial design students at the RCA do not have this problem, but then they have been educated in the art-design environment for at least four years prior to coming to the RCA.'* (Ewing, 1987:76)

So the report was recognising that even though the postgraduate IDE masters programmes for graduate engineers was being described as a success, from an industrial design perspective its potential weaknesses were being identifed. Cognitive modelling, seeing in the 'mind's eye', and using drawing to externalise such thinking are fundamental matters for designing. Without success in these key matters, there is doubt about the efficacy of the strategy. Or, in the same terms that Ewing used to describe the likelihood of art-based graduates at Stanford being successful on postgraduate IDE programmes, the level of industrial design achieved by IDE masters graduates was being called into question. The RCA/ICST graduates are known to be very successful, and there is not likely to be anything further to gain from incremental course improvements. It is more to do with the strategy embodied by conversion courses

The key matter must be to understand the essential nature of cognitive modelling and to design and develop pedagogy in response to that understanding.

A Design Commission has now been established and it produced its first report in 2011 (co-chaired by Vicky Pryce and Baroness Whitaker). It revisited much of the territory covered by previous reports, but in relation to Higher Education there was perhaps a change of tone.

> *'Higher Education centres of excellence – resource intensive high-quality centre teaching tomorrow's innovators and researching future practice – need protecting and funding.*

Design doesn't exist in a vacuum, and this is true of design education as it is of design in industry. A central tenet of our argument is that design is an important contributor to interdisciplinary practice and innovation in HE, particularly with the STEM subjects and business. In order to fully unlock the innovation potential of our academic institutions, universities must promote interdisciplinary practice. Whilst some examples exist, there is always room for more. The onus for developing such activities is very much on the institution.

It would be advantageous to develop clarity about centres of excellence: UK universities must consider their strengths and play to them. This is already happening as institutions see the benefits in terms of attracting students and research funding. In order to continue to compete for home students in the new, allegedly 'free', market, and in the face of increasing competition from abroad as overseas institutions improve their offerings, specialising at a higher level will help universities to differentiate their offering. Clarity over centres of excellence would also help employers locate the skills they need.

Further, advanced design research needs to actively apply itself to other domains, learning more about other disciplines, and build up its supporting library of rigorous academic literature. It is in this area that the UK is best-placed to retain a global lead'

Maybe, but there is some excellent international design research, and it might be a matter of 'running to keep up' in that area as well. However, there is a clear suggestion here that HE institutions need to work out the implications of interdisciplinary practice for themselves, and it is no longer a 'one size fits all' model of combining engineering, art and business at postgraduate level. Perhaps the day for post-modernist conceptions of design education in HE has finally arrived. There will be great rewards for those that succeed, and in my view, progressive decline within the strongly emerging global design education markets, for those that do not.

Loughborough Design School has the building to succeed in the 21st century, so it is just the small matter of evolving curricula to match.

10 Moving Forward

10.1 Conclusions and Recommendations

- The project model for design education that embraces learning by doing is well-established for IDE programmes.

- The pedagogy associated with the engagement with technologies within IDE programmes must deal with elements that are either hierarchical or progressive and should not be generalised. This could also apply to aspects of other disciplines that might be introduced in the future.

- There are evident signs of convergence in the pedagogy of IDE programmes in using comparable designing tasks to integrate and update inputs from mono-disciplines.

- There are growing pressures on undergraduate IDE programmes as a result of the increasing requirement to incorporate learning related to the fuzzy front end of designing, such as design thinking. This has led to some divergence in programmes.

- Such divergence leads to the possibility of meeting the expectations of a greater range of stakeholders, both students and future employers, providing the institution is sufficiently large to support the diversity.

- Responses to change should be founded on a general course philosophy, such 'evidence-based designing' as suggested by Rob Woolston, rather than piecemeal responses to particular issues.

- It would be useful to reconsider the undergraduate programmes in the light of the 'major – minor' structures being adopted in Europe in order to forward the provision for diversity

- It is essential to identify those human capabilities that make designing possible and which enable designers to resolve conflicting constraints and develop appropriate products, services, systems and strategies in determining preferred human futures.

- Modelling, including cognitive modelling, and its role in designing needs to be thoroughly researched in a X-disciplinary context.

- Prototyping plays a key role in facilitating X-disciplinary, and particularly group designing tasks. LDS should develop resources that show its power in order to support undergraduate and postgraduate students eg a permanent exhibition or library, physical or virtual, illustrating prototyping techniques.

- The role of graphicacy, as well as those of literacy, numeracy and articulacy in determining the human modelling capability, and its relationship to designing, needs to be researched and defined.

- Design innovation essentially results from the survival of the most valued, and hence understanding the roles that values play in design decision-making is crucial.

- Innovation in the context of designing must be seen as embracing the re-presentation of artefactual and historicist designs in response to different value positions, as well as evolutionary steps. This is reflected in the final year projects from IDE programmes and the curriculum design implications of this reality need to be fully recognised.

- Strategic Product Design, or business considerations, is an appropriate further step for masters programmes that follow-on from an IDE undergraduate course, although some aspects are developed within the undergraduate programmes.

- A new masters programme should be developed for Loughborough Design School that audits and develops the core human designing capabilities, and then exploits these through both interdisciplinary group projects and individual projects linked to client companies and organisations. This should take advantage of LDS' strong human factors capability.

- The design and development of such a masters programme would be appropriately pursued as a participatory action research project, engaging with postgraduate students, prospective employers and academic staff in defining its goals, and evaluating progress towards achieving them.

- A 'X-disciplinary' project centre should be established to initiate, support and assess interdisciplinary group projects for undergraduates and postgraduates across Loughborough University.

- An effective way forward would be the formation of a Curriculum Development and Education Research Group within the newly formed Loughborough Design School in order to take responsibility for curriculum renewal.

10.2 Curriculum Development and Education Research (CDER) Group

One useful way forward would be the formation of a Curriculum Development and Education Research (CDER) Group. Design programmes do not have centrally agreed curricula agreed by accreditation bodies. They are also the subject of rapid change. Some research groups within LDS (eg SDRG, DErgRG) pay attention to the curriculum in their areas of interest, but that is insufficient to ensure curriculum renewal. Learning & Teaching, Programme Review and External Advisory Committees all have roles to play, but, in the end, it is essential that some academic staff have their focus on ensuring that LDS' design programmes are up-to-date and of high quality, and, no doubt, they need to operate in response to numerous inputs. This is LDS' core business and major source of income. It is not enough for this to be the 'second priority' of all academic staff after their 'externally focussed' research, which, in responding to promotion policies, can form the basis of their career development.

It is for these reasons that 'design education' cannot be appropriately regarded as a 'theme' (such as health, or transport perhaps), which are essentially externally driven. In some areas (eg engineering), it might well be that the traditional academic concept of

'linking research and teaching' is sufficient to ensure curriculum renewal, but it is too weak an approach to ensure curriculum renewal in design programmes that can be out of date in 5 years … obsolete in10.

The need for change could develop from emerging pedagogy or changing requiements concerning the content of design education. Current pedagogical research agendas might include assessment for creativity (student-centred), learning styles and visual learning (graphicacy), mobile and distance learning (apps). Current 'design education' research agendas might include materials-based innovation (sensorial properties), interdisciplinarity and designing in teams (prototyping), the need to teach 'design thinking', and perhaps using a case study approach as in business schools. In 5 years' time, these are all likely to be central to successful design school curricula, and the question is where will LDS have got to?

The Design Education Research Group (DERG) has provided useful foundations on which the work of the CDER Group could be developed.   The DERG has focussed on action research as a methodology that enables its academic staff members to develop conference and journal papers concerning the development of the LDS programmes, both undergraduate and PGCE. Current examples are:
- Dr Tom Page's research relating to electronics and interaction design
- Ian Storer's research relating to developing modelling capability and the making of meaning (semantics)
- John Twidle's research concerning innovative ICT for use in science education
- Sarah Turner's research concerning trainee teacher's well-being.

In order to support action research in general education, the DERG has focussed its efforts on the research infrastructure (essentially for teachers and teacher educators, and hence the need for open access rather than 'subscription' publications'). Current examples are:
- IDATER (1988) > IDATER Online (2012) (http://idater.lboro.ac.uk/)
- The **D**esign **A**nd **T**echnology **E**ducation **R**esearch hub (www.dater.org.uk)
- *Design and Technology Education: an international journal*

These have been the recent focus of Prof Eddie Norman's research, and also, more recently, Nigel Zanker's, in partnership with the Design and Technology Association.

This has proved a successful approach in attracting overseas research students to work within the DERG, with many of them being lecturers in universities (eg Sumath Awsahulsutthi (National Science Museum, Thailand), Cheng-Siew Beh (Ministry of Higher Education, Malaysia), Alexandros Mettas (University of Cyprus), Aede Hatib Musta'amal (University of Technology (UTM) Malaysia), Sara Pulé (University of Malta), Victor Ruelé (University of Botswana), Gisli Thorsteinsson (University of Iceland).

External research funding is particular difficult to obtain in design education, with John Twidle's participation in a Leonardo Bid and several staff collaborating with Practical Action and the Centre for Alternative Technology in developing the Sustainable Design Awards perhaps being the most successful recent routes. The formation of a CDER Group could substantially develop the DERG's previous efforts in relation to gaining external funding.

Possible Terms of Reference for a CDER group

- To provide an organisational structure through which LDS' academic staff can focus some (or all) of their research efforts on LDS curricula, whilst remaining members of other research groups as they choose.

- To act as a research group for those members of LDS's academic staff that choose to commit all of their efforts to education research, whether within LDS or beyond it eg in general education.

- To develop two-way partnerships with other LU organisations, such as the Centre for Engineering and Design Education, the Mathematics Support Unit etc

- To be the focus for active responses to current design education research agendas eg as evident from E&PDE (Antwerp, 2012), or the DRS/Cumulus (Oslo, 2013) conferences

- To monitor (and research) curriculum development initiatives stemming from internal or external sources

- To manage curriculum development where there is a need to engage with external agencies and internal research groups and particularly where there is no existing LDS staff expertise within the teaching teams.

- To act as a focus for external funding bids relating to design education.

- To attract, supervise and support research students in the area of design education and particularly international research students.

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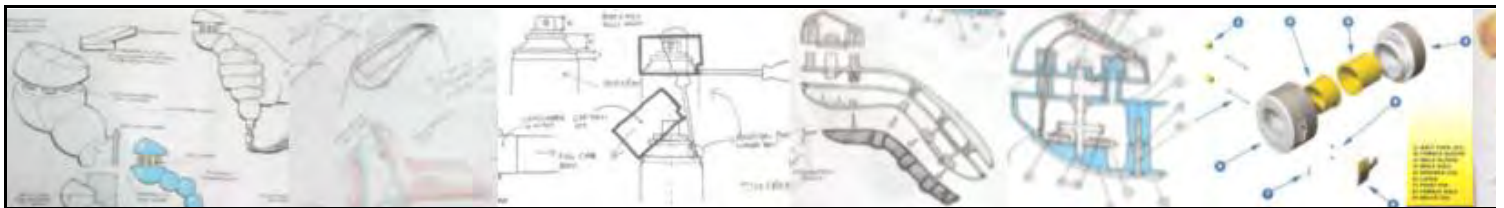
13. Appendices

13.1 Appendix 1 … Designing tasks within the Loughborough Curriculum (2007)

Descriptions of the modelling activities contained within Loughborough programmes are shown below.
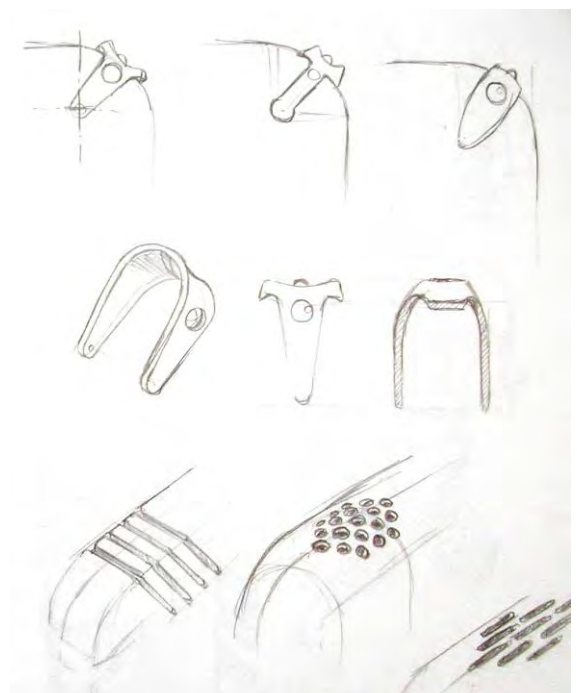
- **Design Practice 1** *(Year 1, 300 hours)*

Module Leader: Dr Howard Denton

Aims To develop good working practices and specific skills in design including two and three dimensional modelling; to develop and foster imaginative and creative capabilities, both individually and in teams; to develop and practice skills in safe working practice.

The module has three components in parallel; **design practice** sessions where we introduce exercises and assignments; **drawing for design** sessions where you develop the drawing skills you will need and sessions which develop the **engineering drawing** skills needed by designers

Outline
Week 1	*The 'Nomadic structure' exercise*
Weeks 2 and 3	*User Centred Design exercise*
Weeks 4 and 5	*Love it, hate it + product Re-Design*
Weeks 6, 7 & 8	*Product analysis and re-development*
Week 9	*Design Week*
Weeks 10 – 12	*Drawing sessions only*

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- **Design Practice 2** *(Year 1, BA 300 hours, BSc 200hours)*

Module Leader: Dr Howard Denton

The modules (Design Practice 2 for BA, and Technical Design Practice 2 for BSc) are made up of the following common elements, worth 20 weight. In addition the BA students add the 'styling' assignment to the value of 10, making their 30 total:

- electronic product (completed in weeks 1 - 6)
- mechanical product (completed in weeks 7 - 12)
- engineering drawing assignment (runs over weeks 1- 6 only)
- drawing for design assignment
- +
- For BA only: product styling assignment (runs over whole semester)

The Electronic Product

You will design a simple hand-held, battery powered, and mass produced electronic product with, primarily, an injection moulded case.

In 6 weeks and with your current experience, it would be impossible to fully prototype such a product. So, by the end of week 6, you will produce:

- A folio of design work including consideration of user needs, interaction with the product, the development of the form and detailing for manufacture as an injection moulded product.
- 3D models, using a range of materials and including a blue foam, high quality presentation model which could be used as a part of a client presentation.
- A pair of presentation boards designed to be used as a part of a client presentation (assessed as a part of drawing for design)
- An A3 ergonomics 'report' board
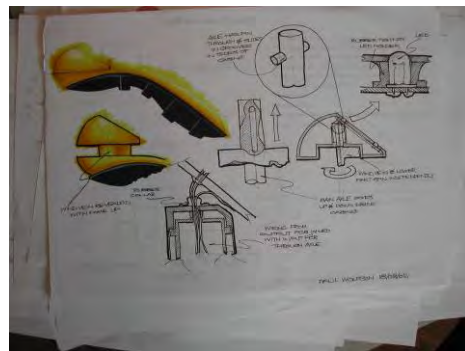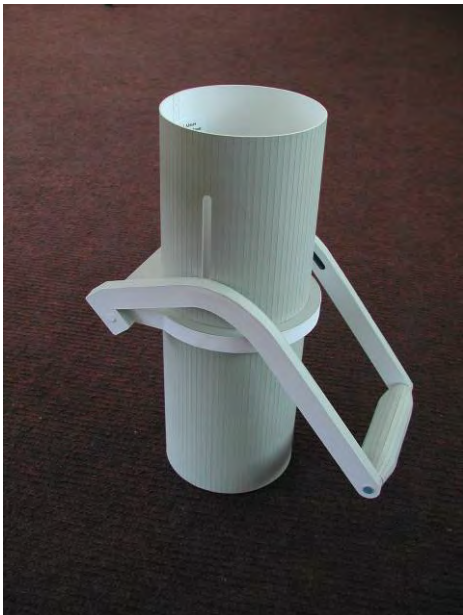
- **Design Practice 3** *(Year 2, 200 hours)*

Module Leader: Dr Mark Evans

The aims of this module are for the student to: manage effectively a programme of industrial design involving concept generation, design development, and product presentation; focus on the specification of product form and user interface; extend and enhance skills and knowledge developed in Year 1 Design Practice modules.

Contents
Staged situational problem assignment involving investigation, design development, experiment, graphic communication of various types, modelling, and evaluation. The assignment is a controlled practical media experience involving individual work that seeks to unite theory and practice.

On successful completion of this module, students should be able to:

- demonstrate knowledge and understanding of the definition and communication of product form to meet the visual and ergonomic needs of a specific market and the process applied to industrial design activity

- originate design concepts and refine these through development to a final specification and identify user/market requirements and translate these into an industrial design proposal.

- undertake the industrial design of an electronic product, produce a mood board, appearance model, exploded view, and specify form and report in support of an industrial design proposal

- articulate ideas and information in visual, oral and written form; analyse information, formulate independent judgements and articulate reasoned arguments through reflection, review and evaluation.

- **Design Practice 4** *(Year 2, 200 hours)*

Module Leader: Kevin Badni

The aims of this module are for the student: to complete a project which develops capability in injection mould tool design and CAD/CAM; to design an innovative low cost/high volume product; to exploit skills learnt in year 1 foundation modules (e.g. design contexts, design practice, graphic modelling, materials processing and foundation technology); to exploit skills newly acquired in year 2 modules (e.g. presentation techniques and computing for designers); to experience group working and project management.

Contents
Design of products for manufacture in plastics by injection moulding involving investigation, design development, graphic communication through display modelling, tooling, prototyping and evaluation. Design of an injection mould tool. Knowledge of prototype and commercial mould tool design. The development of 3D solid models using CAD systems. The post-processing of CAD solid model data to provide CNC output.

On successful completion of this module, students should be able to:

- demonstrate knowledge and understanding of the design of products for manufacture in plastics by injection moulding; the design of injection mould tools, including commercial mould tool design; 3D solid models using CAD systems; how to post-process CAD solid model data to provide 2 1/2D CNC output and image output; manufacturing and materials technology required to design and make a prototype injection mould tool.

- visualise a product in 3D and develop an appropriate CAD modelling strategy to represent it as a CAD model; describe, justify and substantiate proposed design development.

- design a simple, prototype, injection mould tool; plan the manufacture of a simple mould tool; produce detailed part drawings and assembly drawings; use 3D solid modelling CAD systems to represent simple products; use CAD/CAM and conventional machining to make a simple prototype mould tool; use CAD and graphics software to develop and produce graphic presentation boards.

- articulate ideas and information in visual, oral and written forms; interact effectively with others, working as a member of a small group/team; analyse information, formulate independent judgements and articulate reasoned arguments through reflection, review and evaluation.

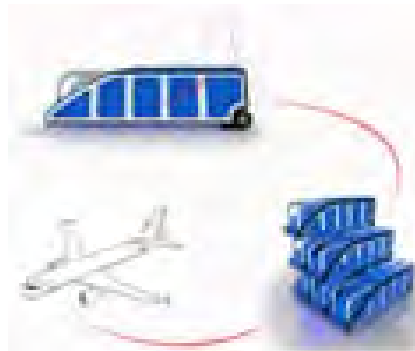- **Design Practice 5** *(Year 3, 200hours)*

Module Leader: Paul Wormald

The aims of this module are for the student: to implement and exploit design capabilities and skills acquired in years 1 and 2 in typical product design briefs; to improve skills in project management; to have the opportunity to enter an international student design competition; to integrate creative strategies and technological knowledge in resolving typical product design briefs.

Contents

The module builds on knowledge, skills and understanding gained from Part B modules Design Practice 3, Design Practice 4, Design Studies, Computing for Designers 2 and Presentation Techniques. The module develops the capability to integrate creative and technological skills in two design projects. Both project briefs will be provided by the Department and one may form part of an international design competition (such as the RSA student design competition). The other will be completed in a short block of time. The submission requirements are prescribed.

On successful completion of this module, the students should be able to

- demonstrate knowledge and understanding of: the demands of an international student design competition; the requirement for rapid concept generation and development in a short-term, 'typical' industrial design exercise.

- exploit relevant modelling techniques to generate, evaluate and communicate well developed product design proposals.

- investigate a design problem, generating relevant data; exploit relevant technologies and media to graphically communicate product design proposals.

- source, navigate, retrieve, evaluate, manipulate, and manage information from a variety of sources; use creativity and innovation in problem solving.

- **Major Project 1** *(Year 3, 200 hours)*

Module Leader: Kevin Badni

The aims of this module are for the student to:

- integrate and apply knowledge, skills and values from earlier modules in a significant design project; normally work with a client company, establishing and developing effective communications
- manage a design project over an extended period, meeting deadlines set by the Department and any client

Contents

The concept designs are developed over one semester. The brief must be agreed with tutors. Students will learn how to write a product design specification, produce a project plan, generate innovative concepts, analyse proposed concepts from different perspectives (eg technical, ergonomic, time available, cost, ecodesign), select a concept and present a detailed project feasibility study. The result should be an effective design.

On successful completion of this module students should be able to demonstrate knowledge and understanding of:

- design processes related to an extended project, possibly for an external client and a specific user, task and environment; problem investigation, solution generation, evaluation and development, detailing and presentation; appropriate technology for the design and testing of design concepts generated.

- analyse a specific design context and develop a product design specification; generate ideas, working both individually and in groups; identify and use of a variety of resources to support design development, including empirical testing; constantly review their progress and manage the extended project.

- write a product design specification, produce a project plan, generate innovative concepts, analyse proposed concepts from different perspectives (eg technical, ergonomic, time available, cost, eco-design), select a concept, develop design proposals and present a project feasibility study. Exploit relevant modelling techniques to generate, evaluate and communicate a well developed concept; apply and integrate knowledge, skills and values from other modules such as human factors, materials, and manufacturing.

- manage their time and project, setting goals and meeting deadlines; identify, gather and analyse data; communicate clearly and effectively using oral, visual

and written forms; present their ideas at appropriate stages using appropriate techniques.

- ## **Major Project 2** *(Year 3, 400 hours)*

Module Leader: Tony Hodgson

The aims of this module are for the student to prototype and evaluate a major design project integrating and applying knowledge, skills and values from earlier modules. Also, opportunity is provided for students to implement time management and project planning in carrying the project to a conclusion, and communication skills in the project presentation (visual, written and oral).

Contents

The completion of the major project prototype and its evaluation takes place over one semester. The project is likely to be based on the feasibility study completed for Design Project 1 but the proposal must be agreed with tutors before commencement. A project supervisor will be allocated to guide the detailed design and development of the project and students will attend compulsory weekly lectures and tutorials. Students will learn to make detailed plans for making a prototype and its evaluation.

On successful completion of this module, students should be able to demonstrate knowledge and understanding of:

- the need to plan and manage project development; a range of commercial manufacturing processes; how to estimate product costs

- apply and integrate knowledge, skills and values from other modules such as human factors, materials selection, manufacturing and marketing; undertake detailed design development as part of an iterative design process; identify and record, in an appropriate form, the significant design and prototyping developments, and any issues that arise from these developments, including the product evaluation, manufacture, marketing and cost.

- develop and document the method(s) of making appropriate prototype(s) suitable for final user evaluation; plan and execute the manufacture of an appearance prototype (or combination of other prototypes, as agreed with a project supervisor), exploiting a range of modelling and manufacturing techniques; plan and execute the evaluation of a major project prototype(s); analyse product evaluation and propose any required, further, product development.

- articulate ideas and information in visual, oral and written forms; analyse information, formulate independent judgements and articulate reasoned arguments through reflection, review and evaluation; present information in an appropriate format for a range of different 'clients'.

13.2 Appendix 2 … Designing tasks within the TUDelft IDE Programme (2007)

Descriptions of the modelling activities contained within the TUDelft progammes are shown below.

The TUDelft IDE programmes were fully revised in 2007/8 as indicated in section 6.1, so the following are brief descriptions of the IDE programmes in earlier years. All the information in this section was downloaded from the TU Delft website in February 2007.

The Bachelor programmes are essentially concerned with the integration of issues deriving from users, technology and business requirements.

Overview of the Bachelor IDE programme

- Where do all these new gadgets come from?
- How can you make Olympic skate champions skate at higher speeds?
- How is it possible that people from all over the world all understand the signs at Schiphol Airport?
- How can you make cars more environmentally friendly?

These are only a few of the many questions that concern industrial design engineering.

Creating products people love to use!

That is our motto. Industrial design engineers design new products. They also improve existing products. In doing so, the wishes of user and producer of the product are taken in consideration.

The range of products that industrial design engineers work on is impressive: from hospital beds to blow dryers, from mobile phones to websites and corporate (visual) identities. In short: products that people use in day-to-day life. You will design products for all kinds of people, healthy or handicapped, Dutch or Chinese, cyclist or air traveller. As an industrial design engineer you will design products that people use intensively at work, at home, at school, for transportation, communication or leisure.

(TUDelft, 2007)

The TUDelft website also gave the following overview of the 'backbone' of the Bachelor program.

Design	Design Projects form the backbone of the educational program. They cover and combine different aspects of product development methodology, production and construction technology, ergonomics, aesthetics, marketing and management.
Technology	During the courses in Technology, you will learn about different characteristics of materials. You learn which production methods you can use for which materials. You also learn more about the construction of a product, to see if your design can be realized. The use of electronic components in products is covered as well.
Engineering Mechanics	Engineering Mechanics is used to calculate how much stress and deformation a product can stand before it breaks.
Mathematics	During the first two years of the bachelor program you will follow a number of courses in mathematics.
Formgiving	Formgiving combines form, colour and texture. You will learn about different aspects of form theory and colour theory and apply this in practical projects.
Product information and presentation techniques	How are you going to present your design ideas to others? You will follow courses in using the computer program Solid Works for making 2D technical drawings and 3D renderings. You also learn to use interactive computer programs like Macromedia Director. The courses in drawing techniques will teach you how to present your ideas in sketches and final presentation drawings using colour pencils and colour markers.
Ergonomics and human-product interaction	The field of ergonomics is concerned with human measurements and how human interact with products. It focuses on adapting products to the abilities and disabilities of humans, both physically and psychologically.
Product development	Before you can introduce a new product to a market, you first need to do consumer research. What price is the consumer prepared to pay for the product? What type of, for example, coffee machine do they prefer? You will learn which methods and tools you need for doing this kind of research.
Business, organisation, innovation and marketing	You learn how industrial companies work and how a new product is developed and introduced in the current business and organisation process. You also learn more about the marketing of products.
Research	You will learn tools and methods for gathering information and analysing this information. You practice these tools and methods in a research project.

Designing tasks within the TUDelft curriculum

The Institute for Design Education organises and provides design education at the Industrial Design faculty. The various specialisms of the faculty departments are integrated in design education; as a result, a project organisation was set up in the past in which approximately 50 lecturers from the faculty departments work together. The Institute provides a series of 6 design exercises. Each of these subjects is the responsibility of one lecturer and is taught by a team of lecturers.

The education takes place in the 18 design studios on the first floor of the building. In addition to the facilities in the studios, students can of course also use the other faculty facilities, such as the Technical Information Centre, the Repro, the Photo Studio and the model construction facilities of the Model Construction and Manufacturing lab (PMB).

Design projects in the IDErriculum

An important objective of the IDE curriculum is to develop the student's ability to design and develop consumer and professional products. A professional designer must have a sound knowledge of form giving, engineering, manufacturing, ergonomics, consumer behaviour, etc., yet integrating this array of knowledge into designs for new products can only be learned in practice. Therefore, from the first year on, IDE students take part in a series of design projects. This series forms the backbone of the IDE curriculum; theoretical and practical courses are grouped around the design exercises, providing the students with the knowledge, methods and skills of the discipline.

The basic teaching philosophy of IDE Delft has always been that of experiential learning. Students learn to design by working on a series of realistic design problems. Initially, the students follow a largely predefined design process, but gradually they are left free to make their own decisions regarding tasks to perform, steps to take and methods and tools to apply. The design projects are structured concentrically, i.e. in theory, every project addresses all major aspects of designing a product, while the projects increase in scope, depth and complexity over the years. Table 1 shows an overview of the present series (ie in 2007 Ed) of design projects in the curriculum. The 6 design projects amount to 1400 hours and if the final degree project (1040 hours) is included, then the IDE students spent some 35% of their total study time in practical design projects … 'This is less than in art-based architectural and industrial design education, but considerably more than in typical university level engineering design programmes'.

Project	Phases	Focus	Work mode	Design task	Example
Design 1 Year 1 (240 hrs.)	All	Introduction to product design	Individual	Static, low complexity	Lamp, Display, Communication device
Design 2 Year 2 (180 hrs.)	Conceptual design, embodiment design	Understanding and practicing design methods	Individual	Mechanical, dynamic	Home trainer, Water play mobile
Design 3 Year 2 (180 hrs.)	Conceptual design, embodiment design	Ergonomics, semantics, sketching and modeling	Individual	Hand-held electronic tools or devices	Digital wallet, hand-held navigation system
Design 4 Year 3 (280 hrs.)	Detail design	Manufacturing and cost, working models, user testing	Individual - team	Electronic or pneumatic appliances	Button maker, toaster, foam cutter
Design 5 Year 3 (120 hrs.)	Product planning	New business development, sustainability, teamwork and communication	Team (role play)	Business case: company with strategic gap in product portfolio	Bicycle appliance company, Food packaging and dispenser company, etc.
IDP - Integral Design Project Year 4 (400 hrs.)	Comprehensive, all phases	New business development through design for an actual company	Team	As in 5, but this time for a real company.	Shopping display, bicycles, strollers, etc.

Table 1 The principal characteristics of the six IDE design projects at TUDelft (in 2007)

Details of the design projects

- **Design 1** *(Year 1, 240 hours)*

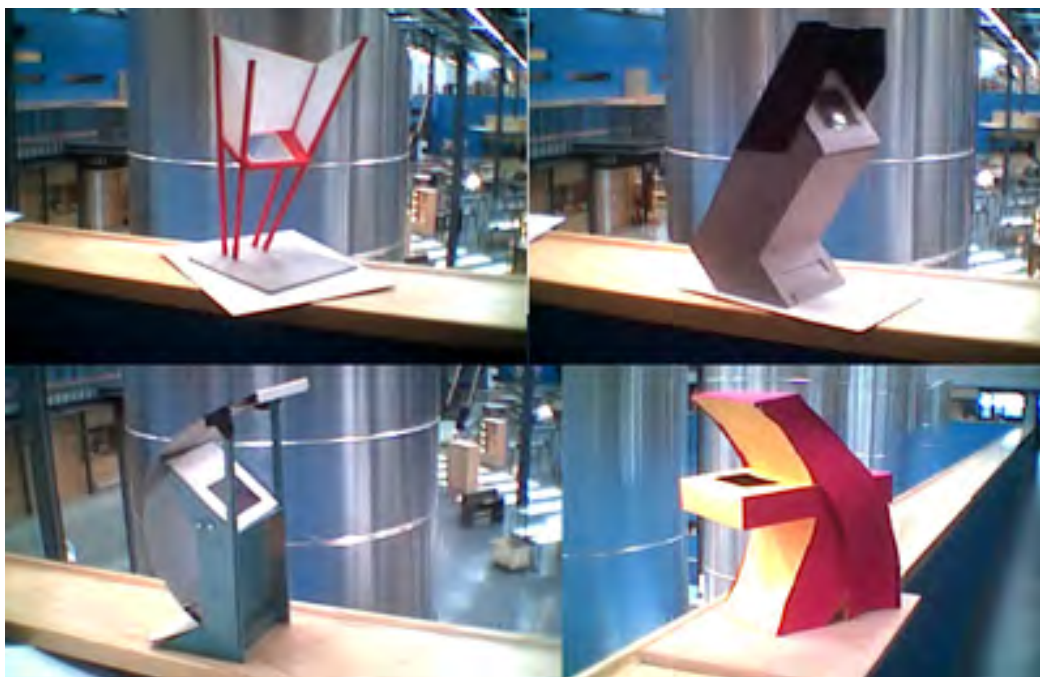**Responsible lecturer: C.M. Kornmann**

The first year design project is an introduction to product design by means of a series of four assignments with gradually increasing time and depth. The first year design programme has the following principal learning objectives:

1. develop design ability;
2. intensify the grasp of the design process; and
3. develop an individual design vision.

The main teaching approaches are to integrate design methods into the project and to supply the student with individual feedback/assessment.

Supplying and practicing with a broad array of design tools, such as creative problem solving, evaluation techniques, various types of models, visualization, etc. provides the student with a sound base for developing a personal vision on design. Students examine design methods in theory, as well as attending weekly instructions and workshops. They apply the methods in their design projects and are given feedback right away. At the end of each project, there is a plenary presentation.

Students start with a design problem that can be solved with skills and knowledge gathered from secondary school. For instance, the first assignment is to design a barbecue to be built in our workshop and to be used by the designers themselves on a summer evening. The final assignment requires much more integration of knowledge from related domains. One example is the design of a multi-media terminal, in which students need to consider issues like form, production, electronics, and ergonomics.

- **Design 2** *(Year 2 180 hours)*

Responsible lecturer: Ir. S.G. van de Geer

The objectives of the course are to teach the students how to generate ideas, identify solution principles, generate concepts, and develop and implement concepts into a final design with an emphasis on form, construction, ergonomics, usage and functionality. Additionally, Design 2 addresses the application and integration of methodological knowledge. Students are asked to reflect on their approach in conjunction with the studied and lectured design methods. Work is done primarily on an individual basis.

The project starts by asking the student to define an early design direction by identifying the users, the environment the product is used in and the product's key functions. This design direction is then formalized as a solid problem description, a collage and a set of design criteria. In this phase, students use methods for structuring their thoughts, such as brainstorming and mind maps. Idea generation is supported by morphological analysis and idea selection methods leading to a first design concept. Each time a particular method is used, students are asked to reflect immediately on how they experienced the method.

In the second phase, a comprehensive list of requirements is set up through life cycle analysis. From this point on, students are urged to find their own strategy in further developing the product. Some design strategies are pointed out in lectures, but the students have to find their own way through and they are asked to reflect on their behaviour.

- **Design 3** *(Year 2, 180 hours)*

Responsible lecturer: Mrs. Annemiek G.C. van Boeijen (MSc.)

Design 3 focuses on elements like creating a design goal (product vision for a specific user group in a specific user environment or context), generating ideas, developing concepts and developing these into design proposals that can be produced. Students themselves are free to choose a user group and a context of product use. This freedom is provided in the exercise in order to help the students to develop their individual styles and preferences. An additional objective in Design 3 is to provide the students with experience in making 1:1 models.

The supporting design method for the whole process in Design 3 is Muller's 'Fish trap model' [Muller, W. *Order and meaning in design*. Lemma, Utrecht, Netherlands, 2001.], a step-by-step approach to form giving of products. The model starts by characterizing the product to be designed in terms of its desired semantic characteristics, such as business-like, fun, macho or impressive. Semantic characteristics are then translated into form characteristics, such as type of geometry, colour, textures, and materials. Design alternatives are first generated on a 'topological' level (that results in structural concepts). The final step in the model is the development of alternatives on a 'typological' level (that results in formal concepts).

In Design 3, a mass-produced or series-produced handheld/portable device (wearable) is developed. An assignment always includes designing a plastic casing that contains electronic and electrical components. This type of product ideally suits the objective of making 1:1 models. One example is a 'Geocam' device for rescue workers (see figure) – the user group - in the mountains – the environment of use. As a special requirement, use with one gloved hand should be possible.
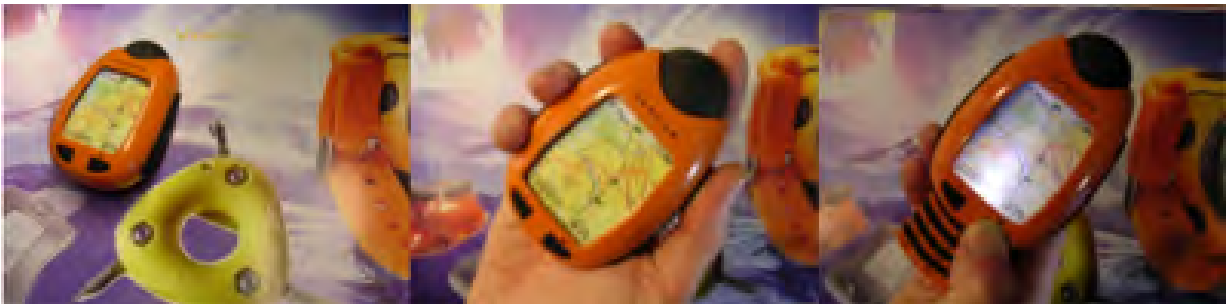
Model of a 'Geocam' device. Design: Stefan van Cleef, 2003.

- **Design 4** *(Year 3, 280 hours)*

Responsible lecturer: Ir. J. Prins

In this project, students go through the length of a complete design process: they start with problem analysis and finish by producing a prototype and conducting user tests with that prototype. The way we organize the design process is strongly influenced by having this prototype at the end of the design course. User testing consists of interviewing users and monitoring their actual use of the prototype. The user response is monitored on video.

In this project we emphasize the phases of embodiment design and detail design, which means that students rapidly go through the early phases of the design process. During the conceptual phase, students work primarily individually. In the second phase, students work in groups of approximately 5 students. Each group selects one conceptual design for further development.

The assignment in this course concerns electrically powered products. An example assignment is a hot-wire foam cutter with a moving wire (see figure). To help students to manage the short time span, we prepare a detailed assignment and an almost ready-to-use design brief. Developing good assignments is critical: students need to be challenged to design new principles and new features rather than to copy the mechatronics of a competing product and merely to design a new shape.
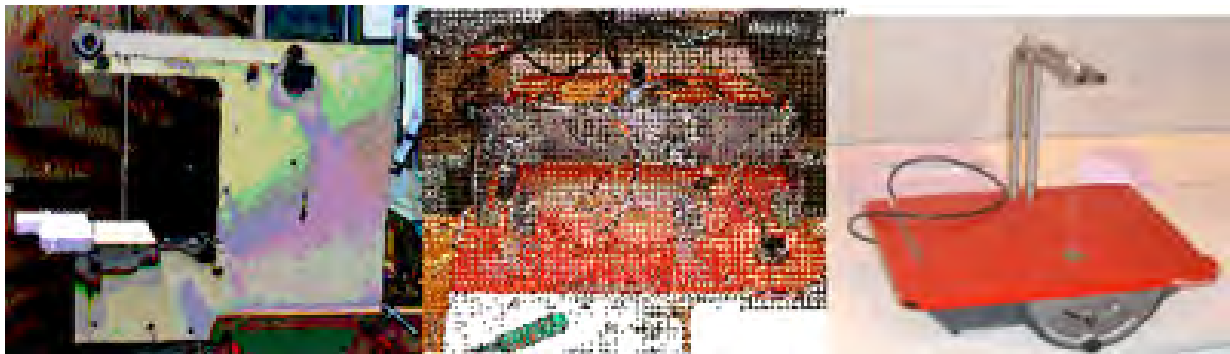
Left to right: Test model, Building the interior, Prototype ready to be tested

- **Design 5** *(Year 3, 120 hours)*

Responsible lecturer: Dr. Ir. R. van der Lugt

Design 5 is aimed at the fuzzy front-end of the product development process with an additional focus on sustainable product development. In addition to design related objectives, explicit attention is given to teamwork issues, project management, presentation skills and other aspects involved in product development within a business context. Design 5 is the first time that students work in-depth on issues relating to strategic product design.

The project is part of a third-year cluster on business aspects in product development, together with a course on business aspects of product development and a course on marketing & consumer research. In close coordination, these courses provide the students with just-in-time knowledge on the aspects that are dealt with in the design project.

In Design 5, students and staff engage in a role-play activity. Using a case based on an existing company, students work as a design agency for a client. Teams consist of five students. One design teacher performs the role of client, while a second design teacher functions as a coach. In a short timespan, student teams start by building a long-term vision of the context of product use and end with a concrete new product business plan, based on a preliminary product design.

Rather than defining a specific product range, the exercise is built on cases from real companies with a need for innovation. An example of a case covered in the past is a bicycle accessory company. In the cases, these companies share a gap in their product portfolios. It is up to the design teams to discover the gaps, to convince the client, and to search for substantial solutions.

- **Integral Design Project (Year 4, 400 hours)**

Responsible lecturer: Ir. H. Kuipers

The project is intended to confront the students with daily practice in industry. It is a complete innovative product development process carried out in cooperation with an industrial company, starting with a strategic product plan for the company and resulting in a design assignment. The project groups have to develop their own ideas about which product they are going to design for the company. The design project concludes with making a prototype of the designed product and a plan for market introduction.

The students work in teams of 4 to 6 people. Each project team has two teachers: a 'coach' (the teacher personally involved) and a 'detached critic'. The project groups have access to a studio with essential facilities.

In earlier design projects, the activity of new product development is trained within a given context. In contrast, at the start of IDP, the context and the product (function) are unknown. Students must find a relationship between a context and a product to design in that context. The students have to cope with this 'fuzzy front-end' of product development and with all related problems.

Unlike the first five design projects, no specific design methods are incorporated in the learning objectives in IDP. The assumption is that at this point in their education, the students know the different models of the design process and can apply the regular design methods and techniques. The challenge for the students is to select the most fruitful method for the situation at hand.