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Teamwork at the Chalkface: an Integrative Approach to Technology and Design*

R. B. CLARKE and B. McCLELLAND
University of Ulster, Newtownabbey, BT3 0QB, Northern Ireland, UK. E-mail: rb.clarke@ulst.ac.uk

This paper describes a relatively new honours degree programme in Technology and Design provided by the University of Ulster. It is of interest because of the level of partnership between the two faculties, Engineering and Art and Design, sponsoring the programme and because of the nature of the programme and its students. The programme is genuinely cross-disciplinary, multi-campus and has attracted students with entry qualifications different from those normally encountered within engineering programmes. There are already indications that the programme is becoming successful, and well accepted by industry and academia alike. Students are responding well to the programme and, in addition, valuable lessons are being learned by staff about the nature of teaching and delivery of the material. Such lessons are the result of exposure to a wider variety of student backgrounds, and the experience of working with colleagues from a substantially different working environment.

INTRODUCTION

FIFTEEN YEARS ago the Lickley Report concluded [4]:

> 'We have been impressed by the weight of opinion deploring the present schism between engineering design, with its tradition growing out of Mechanics Institutes, and industrial design, wholly rooted in Art Colleges. Whilst it may be argued that the complexities of modern life prevent any but the most gifted of individuals to be expert in both fields, it surely cannot be right for the products of Colleges of Art and Design to be so lacking in training related to the disciplines and analytical strengths of engineering and for engineers to neglect the value to them of the aesthetic and innovative strengths of the industrial designer.'

Times have changed since this statement was written. At tertiary level, there are now a number of integrated programmes in the UK, Ireland and the European mainland combining Engineering and Design disciplines at undergraduate and postgraduate levels.

The Lickley Report and other reports by the Engineering Council [1, 3, 7, 10], Design Council [2, 6, 7, 9], Royal Academy of Engineering [5], and NEDO [8], as well as SERC [4], all conclude with the need for change in the education of designers, from the traditional methods of our system in the UK, i.e. the separation of the two cultures, art and science, to a more enlightened joint system adopted by our competitors in the world who, in general, have a system of education where industrial design is an integral part of the education of students at all levels. Likewise, the education of engineers has been undergoing change with the emphasis changing from engineering science to design. This move has arisen as a consequence of the philosophy expounded in the Fielden Report [1], the Moulton Report [2] and the Finniston Report [3], that:

> 'Engineering should be taught in the context of design, so that design is a continuous thread running through the teaching of undergraduate engineering. Courses should expose the students to a proper mixture of analysis, syntheses, conceptual design and other wider issues.'

With the introduction in 1992 of the Northern Ireland Curriculum, Technology and Design is now an area of study for all pupils aged 5 to 16 with consequential effects on A-level courses. Taking cognisance of the emergence of this new subject at pre-tertiary level and the evolving international trend of integrating the expertise of engineers and designers, the University of Ulster is in a unique position within the island of Ireland, having the resources to provide an integrated Technology and Design programme with the potential to become a flagship of design excellence.

The programme has been made possible by the university's policy of modularisation. The Schools of Design & Communication and Electrical & Mechanical Engineering have been able to pool their resources to develop a programme which draws on the combined module bank and industrial links of both schools. Both schools have a strong background in producing graduates (both designers and mechanical engineers) well regarded by industry. A strong emphasis on market

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relevance and commercial viability permeates all of our programmes, including this one, and the expertise of visiting professionals complements the theoretical and applied study programme.

Ken Friedman writes [11]:

> '*University education is rooted in the sciences. Even the arts and humanities attempt to understand "how" and "why" in contrast to the simple exercise of personal taste. As a result, university-based professional schools in disciplines such as business, law or engineering struggle with the challenge of educating for a core profession in a broad intellectual framework. Herbert Simon [12] contrasts the older professional schools against the newer, defining the dilemma that schools face as they grow from professional education to education for the professional practice of a design science.*'

The programme planning team was very aware of this problem and endeavoured to construct a BSc Hons Technology and Design Programme which offers an opportunity to present a truly cross-disciplinary syllabus by providing students with interpersonal skills, thinking processes, technological information, market awareness and the opportunity to apply their creativity and technical expertise in the pursuit of innovation.

> Through programmes like this one, a new generation of professionals will emerge with an insight and the know-how to have a direct and positive effect on the way industry operates.

PLANNING

Although teamwork is at the core of all manufactured commodities, the United Kingdom has been slow to develop an integrated approach to product development. The CBI in a recent report stated [14]:

> 'In 1997, a CBI report found that UK companies are good at developing technology strategies, and formal processes are in place to generate new product concepts. But many companies still suffer from an inhibited business culture that does not encourage innovation throughout the organisation. They are still slow—and lag behind the competition—in bringing products to market, because of a lack of integrated teams, concurrent engineering and systematic cost control.'

From the outset of planning, it was decided that all of the modules studied should be common to other interrelated programmes on the Belfast and Jordanstown campuses; thus students would be provided with the unique opportunity of working and mixing with other disciplines and the consequent breadth of insight and understanding which follows.

> Team working is an integral part of the programme, and in many cases the teams are multi-disciplinary. This is seen as a very important aspect of the students' learning experience.

Team working is not only an integral part of the programme, but has been a fundamental activity of the multi-disciplinary staff team since the outset of planning. Many barriers had to be overcome, both perceptual and actual. Firstly, all the old pre-conceptions emerged such as: 'those artists are a weird lot' or 'those engineers only know what to do if they have a spanner in their hand'. With reasonable good humour, good will and open dialogue, these pleasantries were soon put to one side as it was quickly discovered by all participants that everyone had a valuable contribution to offer. Mechanistic barriers were also quite quickly resolved, such as sequencing of campus location per semester and 'fair' distribution of student teaching loads so that all staff felt an equal ownership of the programme. The most difficult task however, was establishing the learning objectives for each of the taught semesters and to match these to existing module content. Key questions had to be asked and answered, i.e.

- What added value could a student gain from studying across a broad discipline range embracing design and engineering?
- How broad, in practical terms should the subject range be?
- How best could the content and structure facilitate a cohesive learning environment?
- What are the expected levels of attainment per year?
- How should the students work be assessed and by whom?
- Would the programme be debased through not initially being accredited by a professional body due to non-conformance of existing guidelines?

. . . and many more. The existing strong industrial links of both schools and their experience in negotiating 'live' projects, consultancy, teaching companies and research grants already demonstrate an enterprise culture. Ongoing relationships exist with a broad range of companies ranging from large to small, and from light through heavy engineering. Staff are regularly involved in supervision of undergraduate placement project work as well as advanced postgraduate technology transfer activities.

The planning team utilised this experience to establish a core learning ethos for the programme based on **enterprise skills.** (All new programmes planned within the University of Ulster are expected to address these issues at both planning and delivery stages.) The added value of including visiting professionals to contribute to the teaching programme was seen as a fundamental requirement to further enhance the programme's ability to instigate meaningful and constructive interaction with outside agencies.

Building on the positive aspects of Enterprise in Higher Education, the programme is structured to promote development of evaluative and communication skills in Year One, requiring in the student a confidence to interact with peers and staff. In Year Two, group skills involving personal and group management and a significant level of interaction with industry demanding well focused rationalisation of creative and industrial influences form a major element of the studies. Final Year enables students to consolidate all previous experience and refines their competence through the generation of a more personal programme of work which requires a holistic approach to the development of personal and professional management, industrial effectiveness and interpersonal skills.

In addition to requiring worked-out solutions that depend on information-based technological or scientific facts, the design process often demands an ability to make intuitive decisions and a willingness to take risk. These factors are inherent in the majority of coursework projects, as is the aim of developing in students the ability to communicate succinctly, to evaluate logically and to work with others in team situations. Through 'peer tutoring' a further dimension of enterprise is also added to the learning experience. The specific enterprise skills are mapped across the programme's eighteen modules, as appropriate and as shown in Table 1.

Through undertaking this interdisciplinary programme, it is intended that students will have gained an insight into the vast array of attitudes and opinions which should help develop their understanding of the complexity of multi-subject activity called 'Technology and Design'. Graduates from the programme will be suitably equipped to make a valuable contribution and even to lead the product design activity within industry. Alternately, for those graduates wishing to follow a career in teaching, the programme will provide an essential undergraduate experience for the new curriculum area of Technology and Design.

Projected career pathways are illustrated in Fig. 1.

Within industry, graduates will contribute to the product design/development activity and may aspire to becoming Chartered Designers or ultimately Chartered Engineers (pending accreditation of the degree by an appropriate institution). There exists a definite demand within the UK for suitably qualified Design and Technology teachers with appropriate industrial backgrounds. Opportunities for research into basic product design and related activities and implications are also increasing within the UK.

Typical candidates for entry to the programme usually possess neither the 'traditional' requirement for a design programme (strong portfolio) nor for an engineering programme (physics and mathematics). Candidates applying for this programme will tend to have a broader general education, yet will be aspiring towards a career in

Table 1. Enterprise skills in programme modules

Enterprise skill	Engineering modules (Jordanstown campus)	Design modules (Belfast campus)
Communication skills	• Engineering Communications and Applications	• Design Knowledge
	• Design and Industrial Applications (II)	• Business of Design
	• Design and Industrial Applications (III)	• Major Project—Report and Presentation
	• Market Intelligence	
Group work	• Engineering Communications and Applications	• Designing (II)
	• Design and Industrial Applications (II)	• Major Project—Designing (III)
	• Design and Industrial Applications (III)	
Personal skills	• Engineering Communications and Applications	• Designing (II)
	• Design and Industrial Applications (II)	• Major Project—Designing (III)
	• Design and Industrial Applications (III)	
Organisational skills	• Engineering Communications and Applications	• Design Knowledge
	• Design and Industrial Applications (II)	• Business of Design
	• Design and Industrial Applications (III)	• Major Project—Designing (III)
		• Computer Aided Design
Interpersonal skills	• Engineering Communications and Applications	• Design Knowledge
	• Design and Industrial Applications (II)	• Designing (I)
	• Design and Industrial Applications (III)	• Designing (II)
		• Major Project—Designing (III)
		• Computer Aided Design
Problem solving	• All modules	• All modules
Social and community awareness	• Engineering Communications and Applications	• Design Knowledge
	• Environmental Engineering	• Business of Design
	• Design and Industrial Applications (III)	
	• Market Intelligence	
Resource management skills	• Environmental Engineering	• Design Knowledge
	• Design and Industrial Applications (III)	• Business of Design
	• Market Intelligence	• Designing (II)
		• Major Project—Designing (III)
		• Major Project—Report and Presentation
Information technology skills	• Engineering Communications and Applications	• Visual Information
	• Materials and Manufacturing Processes	• Designing (II)
	• Design and Industrial Applications (II)	• Major Project—Designing (III)
	• Automation	• Major Project—Report and Presentation
	• Design and Industrial Applications (III)	• Computer Aided Engineering

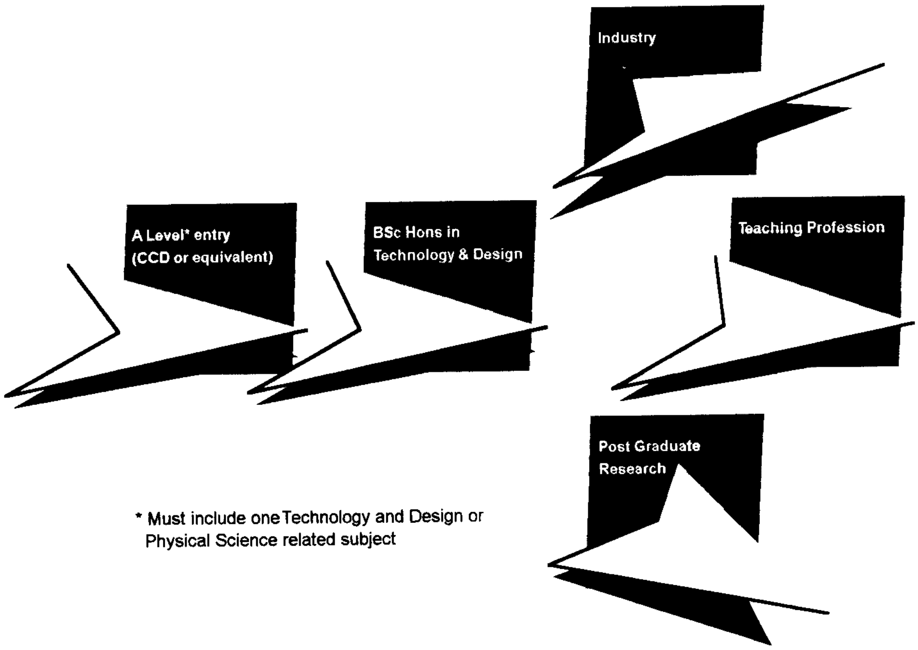

Fig. 1. Career pathways.

industry without necessarily having Mathematics, Physics or Art and Design at A-level. The majority of entrants, however, have studied Design and Technology to A-level and will have made up the appropriate A-level points through studying two other subjects.

Admissions tutors for the programme need to be satisfied that candidates have the potential to cope successfully with both the technology and the design aspects of the programme. Consequently, it is expected that a student will have attained at least a pass at GCSE Mathematics and English and will have some basic drawing capability. Such requirement may be demonstrated through having studied appropriate subjects or, in some cases, through attendance for interview at the university prior to admission.

PROGRAMME STRUCTURE

As already mentioned, the programme is modular in structure. All modules taken are in common with at least one other degree programme and this serves the objective of exposing the students to the differing cultures of the two main disciplines. In addition, it so happens that the two faculties involved are on different campuses and so the result is that students spend half of each academic year (one semester) on each of two campuses. The structure of the programme is illustrated in Fig. 2.

In summary, it is seen that:

- The programme is constructed of eighteen modules, each having an equivalent value.
- There are three taught levels (years 1, 2, and 3).
- Each level is comprised of two semesters, each containing three modules of study.
- Each module of study is of twelve weeks' duration followed by a three-week period for Assessment/Examination for that semester's three modules of study.
- There is an opportunity to take a sandwich year of Industrial Placement between year 2 and year 3.
- Nine modules are taught on each of the Belfast and Jordanstown campuses.

The first two academic years of the degree provide the basic technology core and design skills needed and can therefore be considered introductory in nature. Modules are presented through a variety of techniques and are assessed by a mixture of both examination and continually assessed coursework and project work. The university's strong links with industry enables us to make such project work and case study material industrially relevant as well as appropriate to the level of study. In addition, use is made of guest lecturers from industry, and visits to industry to provide relevant, up-to-date and, to a degree, motivational, material for the students.

Completion of the first two years of study therefore provides most of the tools needed to function as a competent technician within an industrial situation. These years are therefore a valuable preparation for those who subsequently undertake a placement year. Placement is regarded as an important value-added element of the programme. Students are expected to undertake a placement year when appropriate and if available.

Placement provides a worthwhile and rewarding learning environment which usefully complements the normal three years of academic study.

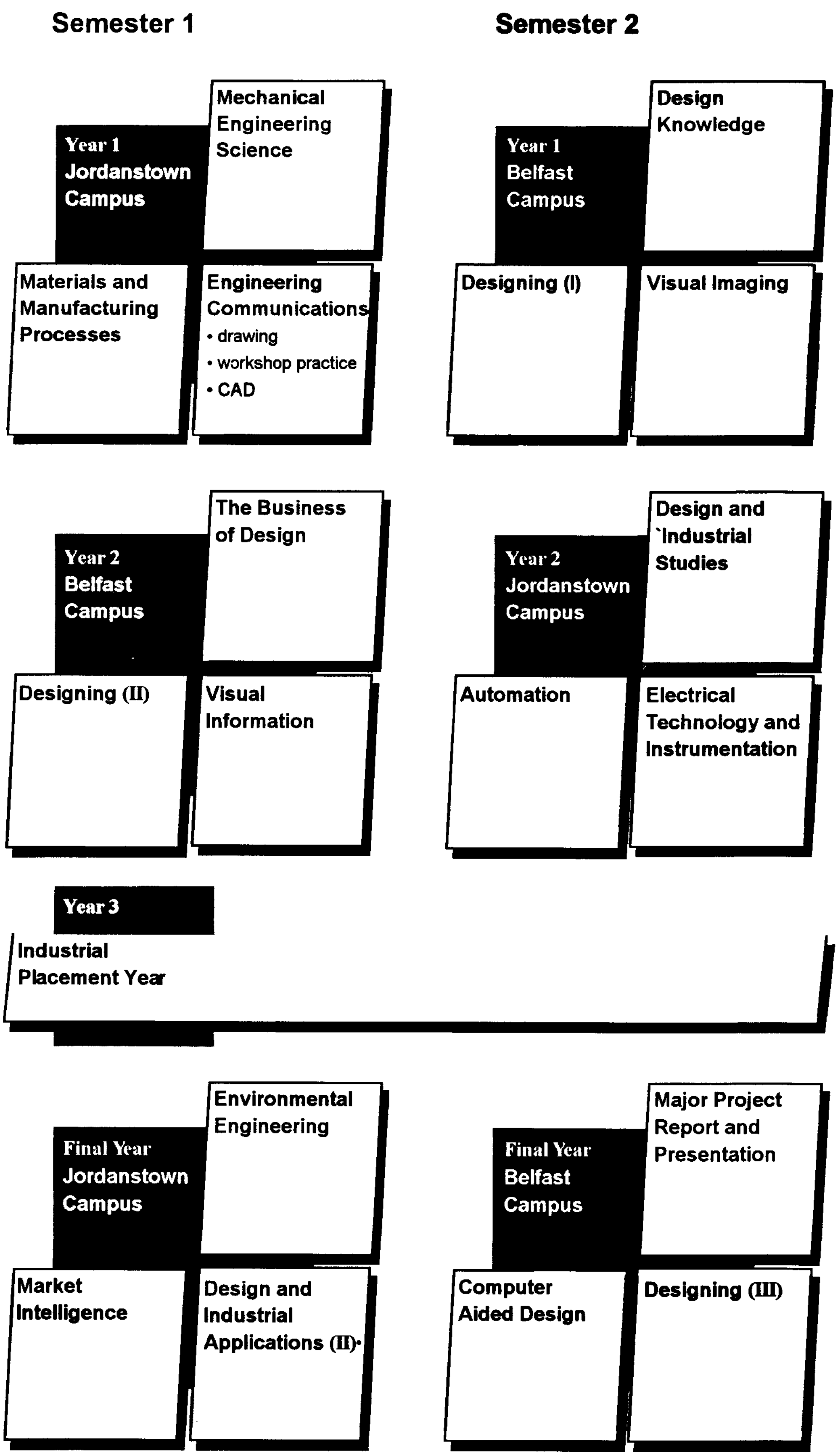

Fig. 2. Programme structure.

Furthermore, the kinds of work experience which are engaged in during this period will not only add a further perspective to a student's academic development, but will also enable a more informed approach to future career opportunities. The period of placement is supervised and assessed both by an academic representative of the programme, and by a work advisor appointed by the employer, according to the regulations for the DIS award.

Successful completion of the placement period entitles the student to receive the Diploma of Industrial Studies, which is awarded upon graduation, in addition to the appropriate degree. Alternatively, a number of students have already opted to undertake a year's experience abroad, some in the United States. The university will accommodate such students and will agree a suitable supervisory regime, usually with a local university. Such students may then be awarded a DAS, Diploma in Area Studies, award.

The final academic year then enables students to consolidate all previous experience and refines their competence through the generation of a more personal programme of work which requires them to focus on their holistic development in the context of personal and professional management, industrial effectiveness and interpersonal skills. Boundaries between modules and campuses become blurred in this final year as students embark on a more integrated programme of study leading to completion of major project work which is of direct industrial and commercial relevance. Such project work is frequently generated in response to a real commercial need and supported by local companies.

EXPERIENCES

Experiences so far of running the programme have been very encouraging. Recruitment has been healthy and, at a time when numbers applying for engineering programmes is declining in the UK, we were able to meet our initial target and begin with a cohort of 35 in our first intake in session 1995/96 and have maintained quota in subsequent intakes. Average intake qualifications have not been lowered to maintain numbers and, indeed, have slightly increased in the past couple of years.

An interesting comment concerning recruitment is that we find ourselves now with the highest proportion of female students (over 25%) on any programme within electrical and mechanical engineering, which has had low representation in the past. It is our experience that young women have come on the programme, keen to become product designers and have performed as well as the main student body. In 1996/97, a female student took the Smallpiece prize for top 1st year performance and in 1997/98, a female narrowly missed 3rd place. It would seem to us, in the light of these facts that it is proved that there is something wrong with the perception of engineering for girls at schools, but the area of design does not have the same negative connotations. Although we are convinced that it is more than just the word 'design' in the degree title, it probably helps.

Although we are encouraged by the recruitment and subsequent performance of the majority of students, we have also found a slightly higher fall-out rate in the first few weeks of the first year of the programme. This is the result, we feel, of two factors. Firstly, the broader range and variety of subjects studied by students at school may tend to indicate less clarity on their part initially regarding career direction. This decision towards product design is then confirmed or rejected in the early stages of the programme. Secondly, the early exposure on the programme to highly disciplined technical subjects like Electrical or Mechanical Engineering Science brings such a decision into sharper focus. Nevertheless, overall we have retained the vast majority of students and see them progressing satisfactorily through the assessments.

Within the University of Ulster we have a long history of successful placement of 100% of our student body from engineering programmes. The placement year within this programme was made optional because at the outset we were unsure initially as to how industry would respond to the new undergraduates. Our concerns, however, were unfounded as we were able in the first placement session to find positions for all students requiring the experience. Twenty-three students were found places within Ireland (North and South) while the remainder (through preference or through being mature students with experience) moved direct to final year. It is not the intention to make the placement year compulsory in the future, although we are confident that all students requiring the experience will be able to obtain it.

Overall, this acceptance by industry is a very encouraging sign and bodes well for employment of graduates form the programme. The first year graduating was small as a result of the success of the placement effort and therefore perhaps not fully representative of the ultimate output from the programme. Nevertheless, we were pleased to award one 1st class honours degree out of seven students graduating in 1998 and are very encouraged that 4 out of the 7 had positions arranged before even receiving their final results.

From the above, it almost goes without saying that performance throughout the programme has been good. Although both engineering and design staff initially viewed these 'hybrids' with some concern, experience proved that they delivered comparable results to colleagues on the 'pure' degrees and in a number of notable cases performed considerably better. It must be remembered that these are not students with arts backgrounds.

It would appear that traditional assumptions regarding the necessity of a good score in maths/physics or a good portfolio can be challenged and that lessons may be learned about recruitment in general.

Important lessons may also be learned about teaching delivery. Although good performances were achieved there were some difficulties as staff initially delivered material in the same manner as they had always done. Although our students were clearly capable, their differing backgrounds meant that their ability to readily assimilate the material was different to those on pure engineering or design programmes. This has proved to be a very beneficial experience for staff as it has called into question some traditional assumptions about teaching. For example we have found that our students find some difficulty with a very analytical presentation of engineering science but respond very well indeed to a more applied and practical problem-oriented approach. The end level of achievement has been the same, but we are sure that the quality of teaching overall has been improved as a result of the experience. Similar examples may be found within the design orientated modules and we are sure the disciplined approach of our students has encouraged greater focus in some areas.

Some difficulties remain. As well as difficulties inherent in presenting modules to very large student numbers (often over 100 on a module), there is a severe culture shock experienced by students as they move between the engineering and design faculties. It is probably fair to say that the two cultures represent two extremes of academic experience within the university. Good students benefit and take the best of both worlds. Other students find a degree of difficulty making adjustments and this has contributed to some of the fall-out mentioned earlier. Such problems are difficult to resolve because the two faculties exist on physically different campuses and we want, to a certain extent, to expose the students to the two situations. Nevertheless, in the light of experience gained we are currently considering whether we may adjust the order of delivery of modules to allow, for example, 1 + 2 and 2 + 1 modules to be taken at each campus during the two semesters. Such changes would reduce the culture shock and present students with a more integrated and consistent regime of pastoral and tutorial support.

CONCLUSION

To quote Mollerup [13]:

> 'Designers must have a broad enough background to understand the wide range of issues that will affect their work. In design, as in any problem-solving process, it pays to analyse the problem before creating the solution. It is better to use 10% of the resources to find out how to use the remaining 90% properly than to use 100% of the resources the wrong way. Problem solving and analysis must be the foundation course of any design education.'

As the programme has just had its first graduating cohort the quotation above is rather apt. On reflection, the members of the team are now asking themselves if they invested wisely, in terms of planning time and programme delivery. The answer is a qualified 'Yes'. The graduates clearly demonstrated a confidence in addressing problem-solving issues in a holistic manner and were capable of providing feasible, creative solutions. First signs would indicate that employment prospects are good (all successful graduates were placed before graduation) and feedback from employers of the Industrial Placement students is all positive. The integration of module content during Final Year especially, proved to be a very positive experience for both staff and students. Such integration is seen as ultimately desirable as it encourages students to see the broader picture and to apply knowledge gained from a number of sources to the practical solution of real project problems. Thus, preparation for employment is further enhanced. A small percentage of the original cohort graduated this year due to the fact that the majority of this first cohort are currently taking the placement year in industry.

During the first two years, this cohort built very strong bonds with each other and took a pride in their status. This had both a positive and negative outcome. On the positive side, it was the best demonstration of peer support yet seen within either School. (Students booking classrooms and running self-help tutorials was a phenomenon previously only dreamt of by staff.) On the negative side, this may have proved a barrier to the cohort integrating more fully with peers from other shared programmes. The team is currently deliberating on how best to achieve this ultimate integration.

Having now identified and delivered a solid core of disciplines, the team is considering what, if any, better means of module sequencing and content could be introduced for new intakes. It is fair to say that the teaching staff have built a strong collegiality which augers well for the future development of this inter-disciplinary programme. They are also considering if it is now appropriate to seek professional accreditation as the programme is beginning to deliver that which has been missing in the majority of the industries to date.

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Robin Clarke is a lecturer in engineering design within the School of Electrical and Mechanical Engineering at the University of Ulster. He has responsibility for the design and management of degree programmes at both undergraduate and postgraduate level. In addition, he has extensive contact with industry through collaborative projects and technology transfer. Dr Clarke's main research interests are in the areas of design and the integration of design with the total development and production process.

Brian McClelland is Professor of Design and Head of School of Art and Design at the University of Ulster. He has gained international recognition for his work on the design and development of advanced electromechanical cardiac devices and is currently coordinator for Research Unit 64—Art and Design at UU. During the past twenty-five years Prof. McClelland has sustained a proactive role in the development of design education at both secondary and tertiary levels.