HOW WELL IS MECHANICAL-ENGINEERING DESIGN TAUGHT IN AUSTRALIAN UNIVERSITIES?

Alex Churches and Douglas Magin

School of Mechanical and Manufacturing Engineering, The University of New South Wales

TABLE OF CONTENTS

KEY WORDS

Mechanical-engineering design; design teaching; staff qualifications; design mentoring.

SUMMARY

Eleven Australian universities out of a survey population of 26 provided details of undergraduate courses in mechanical-engineering design. There is cause for concern regarding the low total lecture and/or tutorial time allocated to design at some campuses. There is greater cause for concern regarding the absence of design specialisation and practical design experience of staff at some of the responding campuses. Of greatest concern in the latter case is the lack of an adequate design mentor. We believe there are serious risks to overall course integrity when a high proportion of design lectures are delivered by visiting designers, in the absence of a full-time academic design specialist, as appears to have happened on at least one campus. We are concerned that the design-teaching situation on the 15 campuses for which no response was received may be of significantly lower standard than those reviewed in this paper.

We suggest that the time has come for a full survey of design teaching on all Australian campuses in order to ensure that all graduating students have the ability to carry out standard engineering-design tasks in the industrial context. We suggest a "designer-in-

residence" scheme at one or two specialist campuses across Australia as the ideal way to provide experience and adequate mentoring for Australia's future top designers.

1. INTRODUCTION

The past decade in particular has brought significant changes to mechanical-engineering schools and departments in Australian universities. Whilst there is a need to consider the effects of those changes on mechanical-engineering courses in their entirety, this paper has a narrower focus - the teaching of mechanical-engineering design.

Design plays a unique role in mechanical-engineering courses. It is our contention that engineering design is the integrator of the engineering science which is taught in undergraduate courses, as well as being the end point of every endeavour which results in an engineering product being put on the market. A review of design teaching alone may therefore provide useful pointers to the quality of the whole course, although that is not our primary purpose.

In this paper, we question in particular:

How well is the whole cohort of mechanical-engineering graduates equipped to carry out routine design tasks in an industrial context?

How well are those who want to become specialist designers equipped for a career of design innovation?

Who have been students' mentors on the way through their design course?

2. BACKGROUND

By the early 1990s, most design academics had become aware of the new generation of powerful solid-modelling packages, which were sufficiently "user friendly" (to use the jargon of that era) to be viable for undergraduate courses. At the same time, workstations had become much more powerful and their cost had plummeted. Solid modelling was suddenly within reach of the masses.[1] Some of us may have wondered whether we had entered the golden age of engineering design, with the achievable design outcomes from our students limited only by young and fertile imaginations.

The reality has turned out to be somewhat different, for two main reasons. Firstly, the power of the solid-modelling software is beyond challenge but, like all powerful tools, it must be comprehensively understood if it is to achieve its potential.[2-4] Most students cannot be expected to reach even a basic level of understanding in less than two solid-modelling courses, although the models they create may, to the untutored eye, look deceptively well designed and "robust" examples of solid modelling. Secondly (and this was recognised from the start) the software cannot of itself instil design knowledge and experience. Students do not yet know what is good design layout, or even design detail – a sense that this is the way it is done because this way has been found to work and it simply "looks right". The potential for design excellence is within reach, but only after significant effort.

This is not the place to argue the pros and cons of pencil and paper versus solid modelling, or "the carbon/silicon transition", as one of our colleagues so aptly puts it. However, it is true to say that design iteration (and thus design experience) can be gained more rapidly and with greater facility on a solid modeller because design changes can be made rapidly and with relatively little drafting effort. Whilst it has been argued that the 3D power of a solid-modelling package reduces the need for the student to have a well developed ability in visualisation, the available research[2,5] strongly suggests that the designer's need in this area is greater than ever before. It is also true that design for manufacture, and manufacture itself, have already moved irretrievably far down the solid-modelling path[5]. Solid modelling is therefore an established and essential part of the designer's tool-kit. The principal point to be made is that the need for our students to acquire good design skills and good design experience has not decreased as a result of the implementation of solid modelling. It has in fact very significantly increased. The corollary is that the need for well qualified and experienced design teachers has also increased.

A decade ago, the effects of funding cuts were beginning to be felt in many universities, but the number of academic positions had not at that stage decreased greatly. Although they were able to fulfil the long-standing requirements of the Institution of Engineers, Australia to achieve a minimum design content in order to have a course recognised, it is our impression that not all universities in 1990 were able to staff their design courses with experienced designers. In fact, it appeared that some campuses had no specialist designer and that design lecturing and tutoring might on occasions be allocated to staff simply because they happened to have a few spare teaching hours.

The design-teaching situation has certainly not improved over the decade, with all campuses having suffered staff attrition through various mechanisms, with little if any replacement. We are not aware of any published data on how these staff changes have affected design teaching and thus the standard of Australia's engineering graduates. For that reason, we now provide a preliminary assessment, based on responses from staff actively involved in design teaching at a number of campuses, of the design content of courses, and of the qualifications and design experience of staff who are currently teaching our student designers.

3. STAFF SURVEY

In 1999, a survey form was circulated to contacts in design teaching at 26 Australian universities running mechanical-engineering courses. The survey requested information on the contact hours of their design courses, details of interests and experience of staff involved in lecturing and tutoring these courses, and information on the course content. Despite several follow-up communications, only 11 replies with sufficient data for analysis have been received. Several other responses gave comments or explanation and, where appropriate, these have been included in the **DISCUSSION**.

4. RESULTS

4.1 Design Course Provisions

Table I summarises the data on design teaching provided by the 11 respondents. The first draft of this table was submitted to the respondents for checking. As a result, some corrections were made, but it remains possible that some misconceptions, different interpretations or errors remain.

Table I shows general data on courses at the responding universities. The data include the number of students enrolled in mechanical engineering at each campus, and the number enrolled in allied courses, such as robotics, mechatronics, manufacturing, etc. This is followed by data on the number of design subjects, and their respective lecture and tutorial hours.

Enrolments on individual campuses in purely mechanical courses range from less than 50 to more than 450 (mean of 192) and in allied courses from 0 to more that 400 (mean of 112). The number of design subjects in each course ranges from 2 to 8 (mean of 4.8). In Table I, the total lecture and tutorial hours have been calculated on the basis of session hours. Thus the total of 12 lecture hours for Campus 1 might represent 4 one-session subjects of 3 hours per week, or 3 full-year subjects of 2 hours per week, or any other combination. Total lecture hours reportedly range from a low of 2 to a high of 16 (mean of 9.5). Total tutorial hours, calculated in a similar manner, range from 2 to 18 (mean of 9.0). The combined total of lecture plus tutorial hours ranged from 5 to 47, with a mean of 21.1.

4.2Teaching Staff Profile

Table II gives a breakdown of the interest and experience of staff involved in design lecturing and tutoring at 10 of the 11 universities (Campus 11 did not provide data for this question).

Lecturing: Full-time specialist design staff were available at only 6 of the 10 universities and, where they were available, these accounted for 50-80% of design lecturing (mean across all campuses of 40%). In addition, full-time academic staff with design interests were available at 7 universities, where they accounted for 20-100% of the design lecturing (mean across all campuses of 39%). None of the universities responding was without a full-time academic having either design specialisation or design interest. Three universities had staff in both categories. Two universities used part-time design lecturers, with 10-30% input. Only two universities made use of visiting designers from industry and, where these were used, their input ranged from 40-80% of design lecturing. No university used technical staff or students for design lecturing.

Tutoring: Table II also includes information on staff engaged in tutoring design classes. It is interesting to note that, at one university which reported the use of full-time academic staff with design specialisation in lecturing, these staff were not involved in tutoring. The other five campuses where design specialists were involved in lecturing reported their involvement in tutoring, ranging from 20% to 60% of the total staff involved in tutoring. Averaged over the 10 campuses, 17% of the tutoring input was by full-time academic staff designated as ‘design specialists’. All seven campuses which had full-time academic staff with design interests involved in teaching also made use of these staff in tutoring, although their input varied widely, from 10-100%. Averaged over the 10 universities, 39% of the tutoring input came from this category of staff.

Technical staff were used as tutors in two universities (10-30%). Although two universities engaged visiting designers from industry to give lectures, only one university reported their use as tutors (50% of total input for tutoring at that campus). Postgraduate students were used as tutors on six campuses, generally coinciding with those having full-time academic specialists. The students’ contributions ranged from 10-50%. Averaged over all campuses, 19% of tutoring input came from postgraduate students. Only one university used undergraduate students for tutoring, with an input of 10% at that campus.

4.3 Practical Design Experience

Lecturing: When asked about the practical design experience of staff lecturing design (Table III), two universities reported 100% of staff with ‘extensive’ practical design experience, and five universities reported 50-80% of staff in this category. The remaining 3 had no staff with ‘extensive’ practical experience. Taken over the 10 campuses responding, slightly more than half (54%) of their design-teaching staff were described as having ‘extensive’ practical design experience. Eight universities had full-time staff with ‘some’ practical design experience (15-80%, average 31%), and no university was without at least some staff having either ‘extensive’ or ‘some’ practical experience. Two universities used design-lecturing staff with ‘little’ practical design experience (25-33%), in each case coinciding with an absence of staff having ‘extensive’ practical experience. Three campuses employed design-lecturing staff with ‘no’ practical design experience (20-50%), with 2 of these cases coinciding with an absence of staff having ‘extensive’ practical experience. The respondent from campus 11 did not provide data for this question but commented that of the 18 staff in the department, ‘only four full-time staff have industry design experience, and only two have extensive design experience’.

Tutoring staff: Responses to this question were received from nine campuses. As displayed in Table IV, five campuses had tutoring staff with ‘extensive’ practical design experience (20-100%), with no such staff on the remaining 4 campuses. Tutoring staff had ‘some’ practical design experience on 6 campuses (10-100%), ‘little’ practical experience on 4 campuses (20-100%) and ‘no’ practical experience on 3 campuses (40-50%). One campus had no tutorial staff in any category. Averaged over the nine campuses, 39% of tutoring input was given by staff with ‘extensive’ practical design experience; 23% by those with ‘some’ experience; 23% with ‘little’ experience; and 16% with ‘none’.

4.4 Design Course Content

When asked about the nature of the design-course content (Table V), 9 of the 11 respondents reported some purely theoretical machine-element courses (10-40%, average 19%), all 11 had some practical design focussed on established machine elements (20-70%, average 46%), and all included at least some creative design (10-70%, average 36%).

Table VI shows that 5 universities included 5-15% project management in their design courses. The same 5 campuses taught solid modelling to undergraduates, occupying 5-15% of course time. Three campuses reported that no course time was devoted to these areas, with one of these campuses reporting that both project management and solid modelling were taught elsewhere in the course. Averaged over the 9 responding universities, 5% of design course time was devoted to project management, and 6% to solid modelling.

A breakdown of the creative design content (Table VII) revealed that all 11 universities included some creative design content. Two universities included a creative design exercise in first year. In the second year of the course, all except one of the responding universities participated in the Warman Student Design Competition. The Competition was allocated subject time at 9 of these 10 competing universities, varying from 6-54 hours (average 30 hours), and was awarded subject marks on all competing campuses, ranging from 15-50% (average 29%). Six universities included other creative design exercises in the second year, and eight in third year. A further two campuses indicated that the project work in fourth year incorporated creative design. As footnoted in Table VI, one university included private study time in calculating subject hours devoted to creative design, and calculation of averaged subject hours has excluded these data. Creative-design subject provisions were concentrated in years 2 and 3, for which an average of 39 course hours in second year (Warman Competition and other exercises) , and 41 course hours in third year were devoted to creative design. Excluding data from campus 6, the time commitment varied from 3 to 54 subject hours in second year, and from 9 to 56 hours in third year. Three universities did not incorporate creative design exercises in third year. One university made course provisions for 4 creative design exercises from year 2 to year 4, and allocated the fourth project 40 subject hours and 100% marks in the final year.

5. DISCUSSION

As a result of both government and business decisions and policies, mechanical-engineering design has not flourished in Australia in recent times. It is unfortunately true that the employment opportunities for designers are severely restricted, and relatively few engineers are able to make design a full-time career. Nevertheless, design tasks are undertaken by many, if not most, engineers at some stage of their career and it is important for all engineers to have a firm grasp of the principles of good design. The design-teaching task of a university therefore embodies two separate streams: creating and maintaining the pool of Australia’s future specialist designers; and teaching those who will routinely, if only occasionally, be called upon to produce sound, economical, sustainable and safe engineering designs.

One of the greatest difficulties in attracting good staff to teaching engineering design has always been the impression that design is a soft option, lacking the rigour of the more mathematically- and scientifically-based subjects. In the promotion stakes, and when the pressure is on to publish or perish, design is not an attractive academic career choice. This is highlighted in the despairing comment from an academic at one responding university: "Design just crawls along…….". It would not be surprising to find that the morale of design staff, as a group, is lower than in any other engineering discipline.

Further, the design teacher is called upon to create class projects with sufficient scope for students to demonstrate their design flair, and he or she will inevitably be required to demonstrate his/her design ability by producing an outstanding and eminently practical design solution as an example for the students. In contrast with mathematical subjects with a single correct answer, he/she will also be required to make judgements on the worth of student designs, each one different, and explain in detail just why one was awarded more marks than another. The need for teachers to have both design ability and real-life design experience is obvious. It is only then that students have a mentor to lead them into the vague but esoteric realms of creative engineering design. One of our colleagues got it right with his comment that "design is not taught, it is caught".

We have reached the conclusion that an ideal arrangement would be for design courses to be taught by experienced designers who are full-time academics, in collaboration with a "designer-in-residence" seconded from industry for a defined period, say 6-8 months (ideally March-October). The commitment of a designer-in-residence is several orders of magnitude greater than that of a visiting designer. This scheme provides the continuity essential to a university course, while introducing fresh ideas and projects in line with current industry practice. It provides the essential mentoring process, as well as providing a role model, particularly for those students who have the potential to be developed into Australia's top designers. The reality in Australian universities is far, far short of the ideal.

From the results reported above, it might appear at first sight that the teaching of mechanical-engineering design within Australian universities remains reasonably well catered for in a time of increasing stringency in university teaching. Nevertheless, there is cause for concern where total lecture hours can be as low as 2 hours per week for one single session, or where there appear to be no tutorial staff allocated to design subjects. Furthermore, we are concerned that the 11 respondents out of the 26 universities asked to participate in the survey represent those universities which are best equipped in design teaching and that the standard may be significantly lower on other campuses.

Of the 11 respondents, only 6 had the full-time specialist designer which we believe is the essential foundation for an acceptable design course. The great risk is that, in the absence of a specialist, "design" becomes little more than a series of lectures in applied mathematics drawn from a text-book on standard machine-element design. There are numerous text-books which provide theoretical analysis, but none can provide the practical design experience, coupled with careful mentoring, which must be the core of a design course. Extrapolated across Australia, there could be up to 75% of courses open to challenge on this basis alone.

Four universities reported using part-time design staff or visiting designers from industry to give lectures. Also, there were four universities reporting that they had no full-time design specialists. In three of these cases, the majority of the design lectures were given by other academic staff with ‘some’ design interests. In the fourth case, the visiting designer delivered 80% of the lectures with the remainder given by a full-time academic having ‘some’ design interests. In cases such as the latter, there is a serious risk of losing coherence in course philosophy and content. A full-time academic specialist to set and maintain course direction and continuity is considered to be essential.

In the case of visiting lecturers, it may also be difficult for students to gain adequate access to tutorial advice if the principal lecturer is available only to give lectures, appearing on campus for perhaps only half a day per week. It is our experience that scheduled tutorials do not and cannot fulfil all reasonable student needs, particularly at critical stages of a project, and that reasonable access to tutorial advice at other times is highly desirable. A further difficulty arises when the visiting lecturer is the only person able to give authoritative tutorial advice and fulfil the mentoring role, due to lack of practical experience on the part of full-time staff. Viewed in this context, the undesirability and impracticality of complete or near-complete outsourcing of design-lecturing and -tutoring staff becomes apparent.

Earlier in this paper we espoused the concept of a "designer-in-residence" as the ideal way to provide quality mentoring and a role model for students and to give real-world design experience within a university course. The concept is similar to an "artist-in-residence" scheme, in which an established and respected practitioner guides and demonstrates, rather than lecturing, to later-year students. In the present climate, such an arrangement would not be easy to achieve even in the larger universities, and would be completely impractical on small campuses. However, since only a small proportion of the student cohort will have the ability and the desire to become specialist designers, the concept of setting up one or two centres of design-teaching excellence Australia-wide, each with dedicated design staff and a designer-in-residence, may be worth investigating. The concept might apply to either a final-year undergraduate or a one-year postgraduate course. The strong focus of the designer-in-residence on specialist designers is justified by the crucial need to boost Australia’s diminishing band of skilled and experienced mechanical-engineering designers.

6. CONCLUDING REMARKS

The data on university design courses and design-teaching staff reported in this paper suggest at first sight that design teaching is faring reasonably well in a time of increasing financial stringency. Nevertheless, there is cause for concern over the total design-teaching hours reported on some campuses, over the experience and interests of some staff involved with design teaching, and over the low morale of design-teaching staff in general. Furthermore, we are concerned that the standards at the 15 universities which did not respond to the survey may be significantly lower than those reported in this paper.

We suggest that our data have identified a potentially serious downward trend in the quality of design teaching in Australian universities. We believe there is a need for a more complete survey and for the results, campus by campus, to be compared with the standards set by the Institution of Engineers, Australia for course accreditation. However, there is much more to this issue than total course hours and course content. A major concern lies in the quality, experience and dedication of staff charged with teaching engineering design on some campuses.

We recognise the extreme difficulty smaller campuses have in employing specialist designers and put forward a suggestion that final-year undergraduates with specific design interests and ability might be grouped at a centre of excellence in design teaching. Alternatively, a one-year postgraduate course might be considered. Whichever level might be chosen, a designer-in-residence scheme, run on one or two campuses across Australia, each having full-time design-specialist academic staff, is suggested as an ideal model for training Australia's future top designers.

REFERENCES

Magin DJ, Churches AE. A designer's package in a first-year mechanical engineering course: impact and prospect. Trans Mechanical Engineering IE Aust ME17 1992;4:251-8.

Churches AE, Barratt AJ, Challen JM, et al. The impact of computer graphics in developing students' visualization and mechanical engineering design abilities. *Proc 6th Int* Conf *on Engineering Computer Graphics and Descriptive Geometry*, Tokyo, August 19-23, 1994:771-5.

Churches AE and Magin DJ. From pencil and paper to Silicon Graphics: implementing solid modelling computer graphics in engineering design courses. *Proc IEEE First Int Conf on Multi-Media Engineering Education*, Melbourne, July, 1994:166-71.

Churches AE and Magin DJ. Solid modelling for mechanical engineering students: foundation or capstone? Hewson L, Toohey S, eds. *Proc Education '95 Conference: The Changing University*, Professional Development Centre, The University of New South Wales, Sydney, November 8-9, 1995, 1996:362-75.

Jensen J. The impact of computer graphics on instruction in engineering graphics. *Engineering Design Graphics Journal* 1986;**50**:24-33.

Churches AE and Magin DJ. Solid modelling in a changing engineering environment. Loughran J and Domanti S, eds. *Proc. World Congress Manufacturing Technology: Towards 2000*, James Cook University, Cairns, September, 1997:435-444.

BIOGRAPHICAL DATA

Alex Churches began his engineering career as an apprentice before moving on to a part-time Diploma, one-year conversion to BE, then PhD, before joining the academic staff at the University of NSW. His teaching interests have been in the engineering-design area, and he was Head of the Design Department in the School of Mechanical and Manufacturing Engineering during 1991-95. His research interests are in bio-engineering and teaching, with more than 60 publications. He retired from UNSW in 1996, but continues as part-time lecturer and tutor with an appointment as Adjunct Associate Professor. He continues to act as a consultant to Unisearch Limited, with particular interest in motor vehicle accidents, occupant injuries and mechanical failures in the automotive area. He has for a number of years been Chairman of the National Committee on Engineering Design, and is actively involved in the Warman Student Design Competition and in judging the engineering-design category of the Australian Design Awards.

Table I: Summary of engineering design subject provisions in Mechanical Engineering degree courses

	Enrolled Mech Eng courses	Enrolled in allied courses	Mech Eng Design subjects	Total *lecture* hrs per week[a]	Average *lecture* hrs per week[a]	Total *tutorial* hrs per week[a]	Average *tutorial* hrs per week[a]	Total hours per week[a]	Average hours per week[a]
Campus Code	N	N	N	N	Mean	N	Mean	N	Mean
1	280	100	6	12	2.0	8	1.3	20	3.3
2	100	3	5	-	-	-	-	47[b]	5.2[b]
3	180	120	8	9	1.1	18	2.3	27	3.4
4	365	408	7	15	1.7	12	1.3	27	3.0
5	246	286	4	10	2.0	6	1.2	16	3.2
6	120	50	5	10	2.0	10	2.0	20	4.0
7	147	56	4	8	2.0	10	2.5	18	4.5
8	118	0	2	2	1.0	3	1.5	5	2.5
9	50	100	3	8	2.7	9	3.0	17	5.7

10	49	0	6	16	2.0	2	0.3	18	2.3
11	456	n.d.	3	5	1.7	12	4.0	17	5.7
Total	2111	1123	71	-	-	-	-	-	-
Mean	192	112	4.8	9.5	1.8	9.0	1.9	21.1	3.9

[a] Calculated on a Session basis – i.e. one per week for a whole year is counted as 2 session hours

[b] Data provided by this campus combined lecture and tutorial teaching hours

Table II: Interest and experience of staff involved in teaching in mechanical engineering design: Proportion of course time taught by staff in the following categories for lectures and for tutorials

												Unweighted
University code:	1	2	3	4	5	6	7	8[a]	9	10	11[b]	Average
For Lectures	%	%	%	%	%	%	%	%	%	%	%	%
Full-time specialist academic design staff	-	50	-	70	60	80	67	-	-	70	n.d.	40
Full-time academic staff with design interests	80	50	20	20	-	-	23	100	100	-		39
Full-time academic staff with no design interest	20	-	-	-	-	20	10	-	-	-		4
Part-time design staff	-	-	-	10	-	-	-	-	-	30		4

Technical staff	-	-	-	-	-	-	-	-	-	-		0
Visiting designers from industry	-	-	80	-	40	-	-	-	-	-		12
Anyone with spare teaching hours	-	-	-	-	-	-	-	-	-	-		0
For Tutorials	%	%	%	%	%	%	%	%	%	%	%	
Full-time specialist academic design staff	-	33	-	60	30	20	30	-	-	-	n.d.	17
Full-time academic staff with design interests	100	33	20	10	-	-	30	100	100	-		39
Full-time academic staff with no design interest	-	-	-	-	-	20	-	-	-	-		2
Part-time design staff	-	-	-	10	-	-	-	-	-	100		11
Technical staff	-	-	-	-	30	10	-	-	-	-		4
Visiting designers from industry	-	-	50	-	-	-	-	-	-	-		5
Anyone with spare teaching hours	-	-	-	-	-	-	-	-	-	-		0
Postgraduate students (for	-	33	30	10	40	50	30	-	-	-		19

tutorials)											
Undergraduate students (for tutorials)	-	-	-	-	-	-	10	-	-	-		1

Notes: [a] Second year design subjects only [b] No data from this campus

Table III: Proportion of staff *lecturing* in mechanical engineering design subjects described in the following categories

Campus	Level of practical design experience			
Code	Extensive	Some	Little	None
	%	%	%	%
1	0	80	0	20
2	0	67	33	0
3	100	0	0	0
4	70	30	0	0
5	100	0	0	0
6	65	15	0	25
7	0	25	25	50
8	50	50	0	0
9	80	20	0	0
10	80	20	0	0
11	11	n.d.	n.d.	n.d.
Unweighted average	51	31	6	10

Table IV: Proportion of staff who *tutor* in mechanical engineering design subjects described in the following categories

Campus	Level of practical design experience			
Code	Extensive	Some	Little	None
	%	%	%	%
1	0	100	0	0
2	n.d.	n.d.	n.d.	n.d.
3	0	20	40	40
4	60	20	20	0
5	100	0	0	0
6	20	10	20	50
7	0	25	25	50
8	0	0	100	0
9	70	30	0	0
10	100	0	0	0
11	n.d.	n.d.	n.d.	n.d.
Unweighted average	39	23	23	16

Table V: Proportion of taught design course time regarded as being allocated to designated subject categories

												Unweighted
University code	1	2	3	4	5	6	7	8[a]	9	10	11	Average
	%	%	%	%	%	%	%	%	%	%	%	%
A purely theoretical machine-element subject	40	10	10	20	20	10	30	0	35	10	n.d.	19
A practical design subject focussed on established machine elements	50	20	50	60	40	60	50	70	35	20	n.d.	46
A creative-design subject	10	70	40	20	40	30	20	30	30	70	n.d.	36

Notes: [a] Second year design subjects only

Table VI: Proportion of taught design course time allocated to Project Management and to Solid Modelling

												Unweighted
University code	1	2	3	4	5	6	7	8[a]	9	10	11	Average
	%	%	%	%	%	%	%	%	%	%	%	%
Project Management	0[b]	n.d.	5	5	5	15	10	0	n.d.	0	n.d.	5
Solid Modelling	0[b]	n.d.	5	15	5	5	15	0	n.d.	0	n.d.	6

Notes: [a] Second year design subjects only **[b]** ‘Done elsewhere’

Table VII: Creative-design exercises incorporated in the course: hours and marks allocated [a]

												Unweighted
University code	1	2	3	4	5	6[b]	7	8[c]	9	10	11	Average
	%	%	%	%	%	%	%	%	%	%	%	
First Year												
Total course hours	-	-	-	3	-	-	6	-	-	-	-	5 hours
Marks allocated %	-	-	-	*10*	-	-	*20*	-	-	-	-	*15%*
Second Year (Warman competition)												
Total course hours	8	21	36	6	36	34	50	52	n.d.	54	-	33 hours
Marks allocated %	*25*	*33*	*32*	*25*	*50*	*15*	*25*	*n.d.*	*20*	*40*	-	*29%*
Second Year (other)												
Total course hours	-	-	-	3	12	150	-	8	n.d.	-	12	9 hours[d]
Marks allocated %	-	-	-	*10*	*15*	*35*	-	*10*	*25*	-	*5*	*17%*
Third Year												
Total course hours	10	78	48	-	9	260	56	-	-	54	32	41 hours[d]
Marks allocated %	*30*	*50*	*30*	-	*20*	*60*	*20*	-	-	*50*	*13*	*34%*
Fourth Year												

Total course hours	-	n.d.	n.d.	-	40	-	-	-	-	-	-	no est.
Marks allocated %	-	*n.d.*	*70*[e]	-	*100*[f]	-	-	-	-	-	-	*no est.*

Notes:

[a] As a percentage of the marks for the mechanical engineering design course for that year

[b] Includes private study time

[c] Second year design subjects only

[d] Average excludes university 6 which included private study time in course hours

[e] Level 4 design project

[f] Final year project