SURVEY ON THE RELEVANCE OF MECHANICAL ENGINEERING COURSE CURRICULA TO THE PROFESSIONAL MECHANICAL ENGINEERS

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To my children, Bahauddin and Ibtehal
to my mother,
and to the spirit of my father

SUMMARY

A number of mechanical engineering courses in the British Isles were reviewed and the literature was scanned for the different views and criticism of the available teaching systems A survey of the opinions of engineers in Ireland about the academic engineering education which they had received was carried out by using a mail questionnaire formulated to obtain information about the industrial training component of the education process and the relevance of the ancillary and basic subjects 425 IEI members returned back the questionnaire, of which 282 member were mechanical engineers, and 70 I Mech E have also responded This makes up 28% response rate The respondents were from different age groups, courses backgrounds and occupying different jobs The majority of the respondents were satisfied with the education they received in general and they believe that it helped them in performing current duties However, a large proportion of the respondents (49%) expressed their views on some weaknesses in the education process, among the important were 1) Some of the Subjects were not entirely relevant, 2) Absence of adequate industrial training schemes The technical knowledge acquired by the engineers during their courses was the most important aspect they have gained from the university and decision making abilities and skills were of secondary importance in the courses of study The responses of the sample population to the enquiries about the relevance and importance of the different subjects they learned at the university to their current duties indicated a significantly high degree of importance of computing, design and strength of materials among all of the groups surveyed However, other subjects were rated differently by the various generations of engineers Those who graduated within last 25 years gave usually a slightly higher rating to all the subjects than other groups, the only significant exception was ergonomic subject which received a very low rating from the older generation Though few respondents were graduated from sandwich courses, the sample population was strongly in favour of cooperative education

DECLARATION

I declare that this thesis has not previously been submitted as an exercise for any degree at Dublin City University or any other university, and I further declare that the work embodied in it is my own except where duly acknowledged in the text. I agree that this thesis may be lent or copied at the discretion of the Librarian, DCU, Dublin.

signed:

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Date: **AUGUST 1995**

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ABBREVIATIONS

C I	Confidence interval
IEI	The Institution of Engineers of Ireland
IMechE	Institution of Mechanical Engineers (Irish Branch)
n	sample size
P	Population proportion or probability of success of null hypothesis
q	1-*P* , Probability of failure of the null hypothesis
r	Linear correlation coefficient
SD	Standard deviation
SE	Standard error of proportion
t	*t* -distribution
z	Units of the standard normal distribution upon which the z-statistic is based

CHAPTER I

INTRODUCTION AND LITERATURE REVIEW

1-1 Objectives.

1-2 The goals of engineering education.

1-3 Problems of engineering education.

1-4 Task based engineering education.

Engineering to many people means the creation of successful systems and objects to meet the needs of the society However, it is difficult, sometimes, to know what one means by *engineer*

In this thesis, unless otherwise specified, ***engineers*** mean the graduates of the mechanical and manufacturing departments who work in industry, including those engineers who are working in research at different universities The research per se is seldom a component of engineering practice because researchers seek new knowledge, whereas practising engineers apply existing knowledge to problems in process and product design, production, and management However, the decision to regard researchers as professional engineers is highly justifiable because of their contributions to the profession and industry [(1)], and because they constitute the majority of the engineering teaching staff in the universities

1-1 Objectives:

The situation of mechanical engineering education in The United Kingdom and Republic of Ireland will be reviewed and evaluated with regard to the training components in the undergraduate teaching syllabi and the relevance of ancillary and basic subjects The idea of **task based education** would also be discussed, what is meant by it ?, is it needed to have a task based education? and why?

In other words, what are the problems of engineering education in the UK and Ireland that make people think that they have to introduce a new approach to their teaching goals and strategies ? and what the people in the industry think about engineering teaching systems in this part of the world ?

Such a work is highly justifiable because it has been proven that the continuous assessment of education and the co-operation of the universities and employers in this process would always benefit both sides by producing a better teaching system leading to a better performance in the industry

However the process of education is not simple and straightforward and the relationships between the different parts of this process is indeed more complicated than one might imagine The following diagram may show some components of these relationships

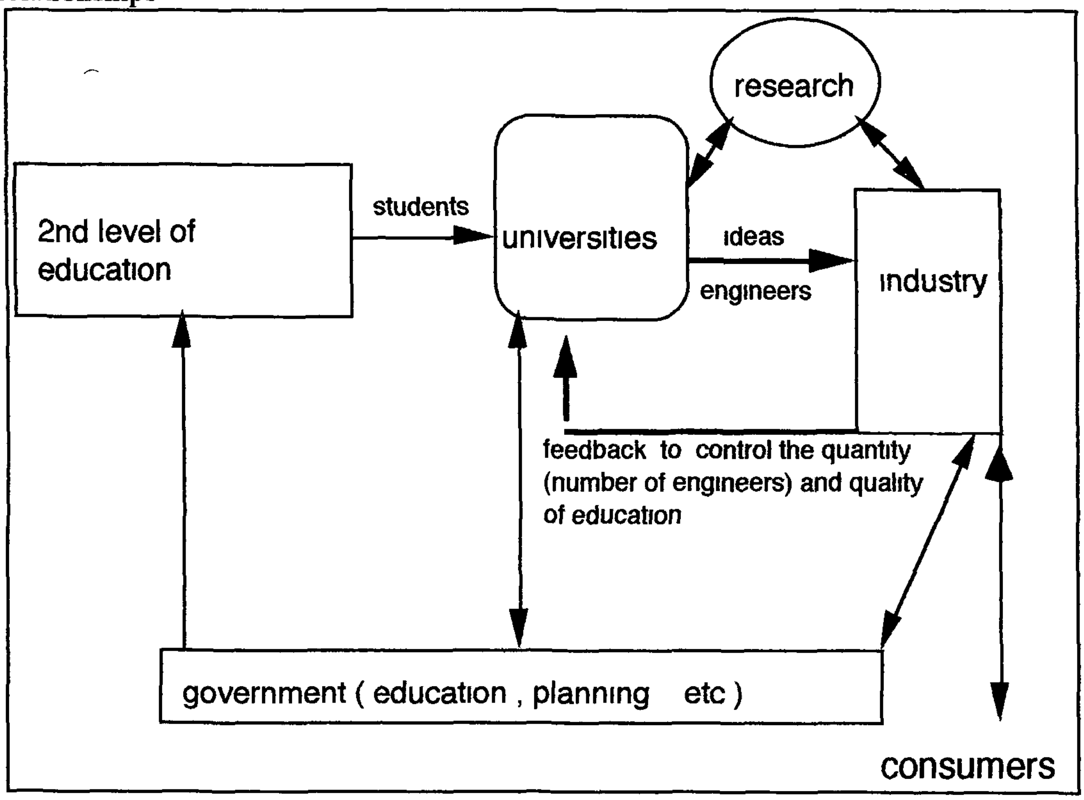


Figure 1-1 The relationships between universities, industry and government

Before one can evaluate the situation of engineering education in the UK and Ireland the following should be done

1-The goals of engineering education should be clear, specific and classified

2- The details of the teaching activities in the area should be obtained

To deal with question 1 a theoretical discussion of the goals of mechanical engineering education and the critics of the situation of the British and Irish engineering education will be reviewed from the literature hereafter Chapter 2 is devoted to answer question 2

1-2 The goals of engineering education:

There are approximately 61 schools of mechanical engineering in the UK and 6 in the Republic of Ireland and typical objectives of these schools have been stated as "to provide the students with the opportunity to specialise in mechanical, manufacturing and materials engineering " (2)

"to provide students with a broad knowledge of engineering principles, combined with a sound grasp of analysis and design methods in mechanical engineering " (3)

" to give an integrated treatment of mechanical engineering science , design and manufacture " (4)

These are the objectives , of course , of any school of engineering However, one has to be more specific in defining the goals of teaching students to become engineers and in particular mechanical engineers, therefore what some of these schools mean by mechanical engineer should be studied first

" the mech engineer is the key figure in manufacturing industry He is the designer of vehicles, domestic equipment and many components used in industry like pumps, machine tools and robots He also builds and operates giant power stations, as well as plants manufacturing a host of products from tyres to synthetic diamonds Mechanical engineers need a knowledge of the latest advances in new materials , they must be able to use computers in analysis and design and must understand the work of electronic engineers to be able to incorporate it into their products and processes They also need to understand the human factor in industry so they study the problems of planning and controlling the effort of large group of workers "

" Mechanical engineering graduates are employed in manufacturing and process industries , as engineers and as managers, as well as in related area such as accountancy and business consultancy " (2)

Most of the schools (departments) give similar description to the profession of mechanical engineering and all state its importance to the economy However, mechanical engineering is a very broad discipline and because of this a general definition to the profession is usually difficult to formulate

In 1983 a DES/CNAA project (5), conducted by Leicester polytechnic, to investigate what engineers think the goals of engineering education should be , the findings of this project are summarised below

The goals of engineering are grouped in two major groups , group "A" which refers to the technical side of engineering and group "B" which refer to the engineer's personal development

A- to give the engineer

1- an adequate understanding of the wide range of activities which constitute engineering

2- the basic scientific principles and mathematics which are fundamental to engineering

3- a wide range of engineering knowledge and practice

4- a strong grasp of engineering theory and practice in the specific area of engineering practice for which he or she is being prepared

5- the ability to understand the interfaces between specialist engineering areas

6- an understanding of the importance of the documentation and the ability to translate ideas into drawings, written statements and specifications

7- the ability to estimate the scale of an engineering problem and the scale of the resources which its solution would require

8- to give the student engineer an appreciation of the problems that the practising engineer seeks to solve , many of which are not technical but social, economic and political

9- the ability to see engineering in a broad business context and an understanding of costing, company finance , marketing and industrial relations

10- the ability to see engineering in a broad social context For example, the conversion of energy and raw materials into goods and services may be achieved in a variety of ways and have a variety of impacts The engineer should be aware of his or her role in this process and of the responsibilities to The society, in his employment and to his profession The engineer should be equipped to recognise and make sound value judgements when these responsibilities conflict

B- to give the engineer the intellectual and social abilities which are important to his personal development , and these include

1- creative thinking

2- to be able to make critical , independent judgement

3- to be able to take account of , and modify, earlier decisions in the light of new information as it becomes available

4- to be able to recognise and define problems

5- to be able to analyse, to discern the interacting elements in an artefact, system or argument

6- to give the engineer the ability to synthesise , to take an overview of a problem, to determine which solutions are available and to decide on , and implement , appropriate solutions in the light of constraints such as people , money , machines , materials , time , technology and desirable long-term targets

7- to be able to cope with real conditions, i e to cope with indeterminacy and to tolerate imperfect information under conditions of multiple uncertainty and pressure of time

8- to be able to communicate clearly, concisely and persuasively, orally and in writing, using both words and numbers and other techniques as appropriate

9- to be able to conduct and participate in meetings, including those involving non-engineers

10- to be able to see the world from the points of view of people of different disciplines, backgrounds, interests and cultures

11- to be able to develop good working relationships

12- to have the ability and the courage to seek the changes should they seem desirable

13- to have the ability to seek and take responsibility and to delegate authority

14- to have the ability to assign priorities and organise work

1-3 Problems of engineering education:

The above points cause the educational institutions to face difficult decisions and a lot of questions to answer, for example,

- How much material from the basic science and mathematics is required to give the engineer the fundamental scientific background?
- What is the difference between the science and engineering ? and what is meant by engineering science ?
- How does one really prepare a student engineer in a specific area of engineering before specifically defining that particular area? For example, the mechanical engineering is a very broad area, is it necessary to divide it further into sub-disciplines ? Will this help in producing a very good specialist engineer ?
- How much should the mechanical engineer know about other engineering areas (e g electrical and industrial engineering)?
- Is it necessary to teach engineers psychology to develop their personal character? What about language and humanities subjects in the curriculum?

Do the universities want to produce an engineer who is very good at a particular task but has a poor performance on other jobs even if they are related to his/her job? or, to produce someone who is not specialist in any job but has an average performance in most of the them ?

Of course the best is a combination of the two , best in one job good at others , but unfortunately this is always difficult because of the nature of the education process , the time available, and the continuous change in the technical responsibilities of a given job because of the rapid change of technology

However, the universities usually prefer to produce the second type of engineers and leave the training to a particular job to the employer The need for a broad technical education is clearly felt by the British engineers [5], and one of the problems of engineering education in the UK is that the courses give much attention to specialisms and too little to the underlying fundamentals which are the only stable element in times of rapid technological change

The other problems of the British engineering education[5] are

1- Too much engineering science and too little on engineering as a process

2- Very little about business, commerce, costing, budgeting and marketing

3- Poor social and human skills e g participation in meetings

4- insufficient time is taken to complete a first degree in engineering

1-4 Task based engineering education

A graduate Marine engineer said when he saw the boiler room for the first time ' I opened the door and I couldn't believe my eyes ' [5] Another engineer said ' what they teach [in university] is so theoretical ,no reality is attached to it ' and an aeronautical engineer said ' Not until the third year did we draw a picture of an aeroplane '[5]

These statements and many others indicate some weakness in the engineering education , and this leads many researchers to question the relevancy of the curriculum and the aims of the educational institutions " Mathematics , basic science and fundamental engineering science must be rethought and made meaningful to students " states an American head of department [6] " students tell us that math and science are too sterile They lack the connection to the real world Why aren't these courses integrated? Why don't we teach math and science when it is needed to support engineering education? " ask some professors [7]

The problem of too much mathematics and science in the curriculum is not the only one that represents a challenge to our existing educational system , the design education is another difficult dilemma which deserves better attention , " There is a consensus that our engineering design curriculum does not fulfil its role as well as does the engineering science curriculum " [8] Another topic, which might be unsatisfactorily educated is information technology

In order to be able to develop its educational system any university should discuss thoroughly, within academia and with industry, and then declare its educational aims, the institute should know exactly what kind of people it is going to produce and accordingly the curriculum should be designed to avoid the problems mentioned above A good quality control system for engineers (graduates) would guarantee further improvement of the educational system This is what may be called a **Task based education:** "adjusting the educational process to produce graduates able to fulfil the declared objectives "

<u>History of task based education</u>

The idea of co-operative education can be attributed to the initiative of the Dean of engineering of Cincinnati University in the USA in 1906 [9] However, the major developments in this system occurred in the 1950's and later Canada adopted the same programmes initially at the university of Waterloo [10] In the UK, the Sandwich courses claimed to be originated in the university of Glasgow in 1840 [11] However the credit is generally given to Sunderland Technical College in 1903 The major developments occurred in 1950's and 1960's [12] In other countries, the training programmes which are incorporated into undergraduate education neither fit the requirements for the structure of the course nor feasible for supervision by the educational institutions According to this definition the majority of the Irish institutes are lacking a co-operative system in their mechanical engineering schools with an important exception of NIHE/University Limerick

Advantages and disadvantages of task based education.

The **co-operative education** which can be defined as " a system that integrates a student's classroom instruction and career interests with work experiences in public and private organisations This enhances the understanding and application of academic knowledge and motivates the students to further their education and improve personal skills" (13) This on-the-job education is obviously a task based educational system However, it should be clear that the aim of the university is to produce a good engineer and not a technician and if the co-operative education turns to be on-the-job training only, then the objectives of the university are not achieved some other practical problems of co-op education include

- prolonged date to graduation
- problems in course sequencing
- the students may be moving to a different geographic location during their employment

The introduction of the sandwich pattern in the 1950's and 1960's provided a sensible solution However, this system still regarded as unsatisfactory because training and academic learning are independent of each other making the integration of theory and practice unsuccessful (17) The integration of academia and industry should provide a better method of training if the training schemes are carefully planned Most of the sandwich schemes require the student to spend a year in industry, some require the student to spend a year in European or North American industrial institutions

Continuing education versus Task based education.

Some researchers in the education system believe that continuing education after graduation is the answer to the decline in British and Irish manufacturing compared with the rest of Europe " the undergraduate courses are overloaded in the belief that students must know everything" said one Professor (14) He proposed that engineers should take a broadly based first degree and specialise at postgraduate level, followed by continuing education

The need for a good engineering educational system is urgent, and it is the responsibility of the universities and industries to improve the situation (15) Training of the undergraduate engineers was and still is a great challenge facing academia and industry

In this thesis, chapter 2 describes the details of teaching activities in the mechanical engineering institutions in the British isles The methods used to survey the professional engineers are described in chapter 3 The results are summarised in chapter 4, while chapter 5 contains the discussion of the most important findings of this survey, and the main conclusions, general comments of the respondents are summarised

CHAPTER II

COURSE SURVEY

2-1 Introduction.

2-2 Method.

2-3 The Courses.

2-4 Contents of the syllabi.

2-5 Discussion.

2-1 Introduction

In a rapid changing industrial environment, it is necessary for both academia and industry to combine their efforts to produce competent engineers. In order to do so, it is important to evaluate the existing educational and teaching systems and to assess the qualities of graduate engineers . In this study a survey was undertaken of 69 universities and polytechnics which provide courses leading to BEng and MEng degrees. The BSc courses are not covered in this survey as they are science oriented; some interdisciplinary courses have also been neglected because they are not Mechanical engineering biased.

2-2 Method

Information about the courses were intended to be obtained directly from the mechanical engineering schools and departments, as such 76 institutions in the UK and Ireland were contacted for the relevant information. Only 39 of them replied, i.e. 51% response rate. Most of the replies consisted of the university calendars and guides of 1993 and the schemes for mechanical engineering courses, and syllabus contents. As a result it was necessary to consult some other available references to cover a large number of the courses . The guide produced by the Institution of Mechanical Engineers " WHICH DEGREE 1993" [16] has been helpful in providing the needed information. Also, it was necessary to consult many university guides which are available in the library. This study is based on the information gained in 1992/1993 academic year on about 69 Mechanical Engineering institutions.

2-3 The Courses

The 69 universities and polytechnics in UK and Ireland which have been surveyed offer 127 Mechanical Engineering BEng/MEng courses. The duration of these courses range from 3 to 5 years. The types of courses are shown in Figure 2-1. and Figure 2-2.

The total Mechanical engineering courses without any particular combination with other disciplines are 82 of which 38 can be classed as sandwich courses. Mechanical engineering with some other disciplines or in special schemes are 45 of which 20 courses can be regarded as sandwich (see table 2-1). This makes 46% of all courses available as sandwich courses.

Table 2-1 Mechanical engineering with some other disciplines or in special schemes .

Mech. eng. with	courses
Manufacture	12
Electronics	5
Electrical	9
Management	3
European Studies	5
Computing	2
Materials	3
Others	6

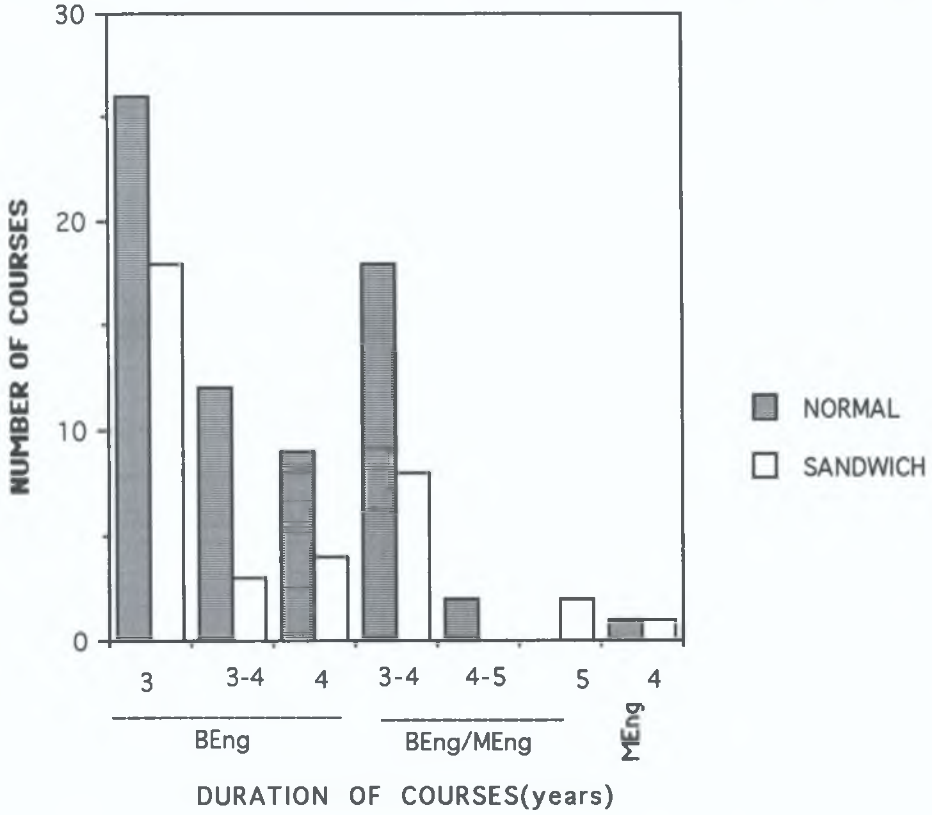


Figure 2-1
MECHANICAL ENGINEERING COURSES IN UK AND THE REPUBLIC OF IRELAND

Figure 2-1 Shows the distribution of Mechanical Engineering courses according to the duration of the course and the degree awarded. 3-4 years BEng means either the duration of the course is 3 year but a foundation year is necessary for some candidates without appropriate A levels, or the course could be completed in a maximum 4 years. 3-4 and 4-5 years BEng/MEng means that the BEng require 3 or 4 years respectively and the extra year is for MEng. For a sandwich course add one more year. These courses do not include interdisciplinary courses or any other special scheme and the degree awarded as Mechanical Engineering.

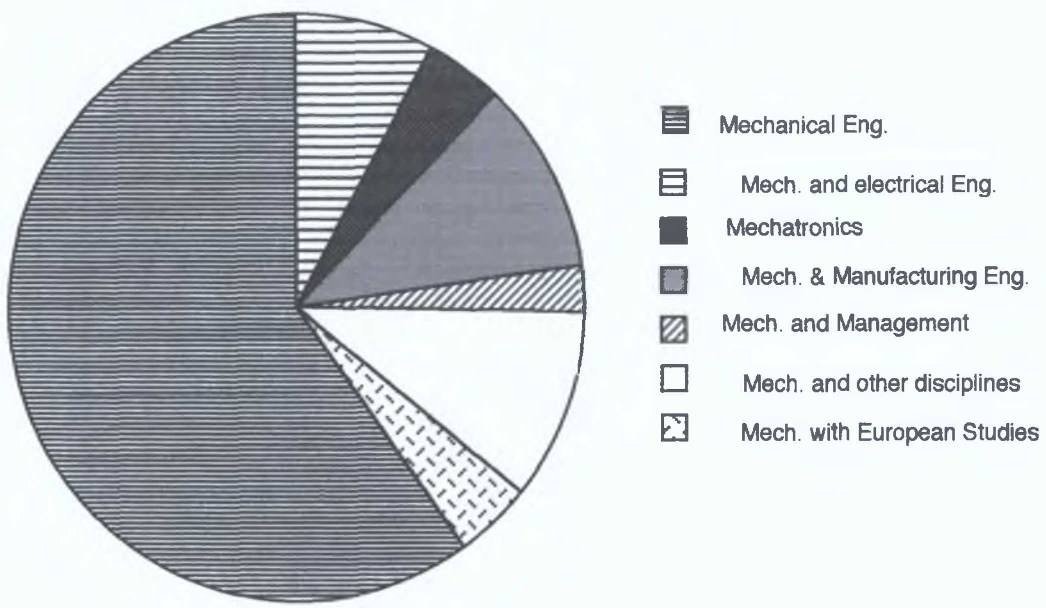


Figure 2-2

INTERDISCIPLINARY COURSES WITH BIAS TO MECHANICAL ENGINEERING

Figure 2-2 The courses which lead to degrees in Mechanical Engineering and Mechanical engineering with other disciplines are shown.

2-4 Contents of the syllabi

Courses with a duration of 3-years are taken here as an example of those degrees in Mechanical Engineering or Engineering (Mechanical), which is composed of three major groups of subjects:

1-Basics: such as mathematics, computing, engineering science and design.

2-Mechanical subjects: dynamics, automatic control, thermodynamics, heat transfer, fluid flow, properties of materials...etc.

3- Industrial and management: Business studies, industrial relations, marketing....etc.

In addition to these subjects Mechanical engineering courses cover other necessary subjects as electrical and electronic engineering. Finally there are a wide range of optional subjects (usually) in the third year to shape the knowledge gained through the course into a specified career. Table 2-2 shows the details of 5 courses selected across a range of 68 three-year BEng courses.

Four year courses are composed of the 3-years course plus an extra year which is either;

1-foundation year for those students who have not got appropriate A level, this year usually includes mathematics, physical sciences or chemistry plus options as engineering drawing, dynamics....etc.

or;

2- a year leading to MEng (in some cases a honour) degree, which is usually consists of special project work, professional studies, management and some other options.

Table 2-2 . Mechanical engineering 3-year course syllabus (Five courses selected at random are represented)

	course 1	course 2	course 3	course 4	course 5
First year					
mathematics	*	*	*	*	*
computing	*	*	*	*	*
electrical & electronic eng	*	*	*	*	*
design	*	*	*	*	*
thermodynamic	*	*	*	*	*
dynamics	*	*	*	*	*
materials	*	*	*	*	*
fluid(mech.)	*	*	*	*	*
eng. systems			*		*
laboratory	*	*	*	*	*
communicati-on skills	*	*			*
business		*	*	*	*
Second year					
design	*	*	*	*	*
mathematics	*	*	*	*	*
computing		*	*	*	*
dynamics	*	*	*	*	*
heat transfer	*	*	*	*	*
mechanics (solids, materials..)	*	*	*	*	*

manufacturingsystems		*	*	*	*
microprocessor				*	*
elecrtical eng.	*				*
business	*	*	*	*	*

Third year

project**	*	*	*	*	*
computing (advanced)				*	
design	*		*	*	*
business		*	*	*	*
thermofluid (advanced)		*			
stress analysis				*	
energy systems				*	
control				*	
optional courses	3 options from:	a choice of five	4 options from:	none	3 options from:
** individual or team project in a special problem.	automatic control	subjects in the areas of:	manufacturing eng		tribology
	computer aided eng.	eng. science	biomechanics		math.
Note Some subjects are overlapping each other and some	heat transfer	manufact-uring	heat transfer		Automobile eng.

subjects have a slightly different titles in different courses.	**materials** **polymer eng.** **internal combustion engine** **robotics** **noise** **microprocess-ors** **stress analysis** **turbomac-hinary**	**design** **aerospace** **tribology** **biomedical eng.** **vehicle eng.** **energy**	**math.** **control** **internal combustion engine** **robotics** **noise** **power systems** **computing** **turbomac-hinary** **polymer**		**fluid** **robotics** **thermo-dynamic** **noise** **machine dynamics** **solids mech.** **human factors** **French or German**

2-5 Discussion

The contents of the syllabi of different Mechanical engineering courses in the UK and Ireland are almost the same in the first and second year, but differs in the final year as more options are available and a bias towards a certain specialisation is obvious in the curriculum. There are some courses with a much greater specialisation (see table 2-1) and concentrate in a more interdisciplinary career, for example, Mechatronic courses cover a larger portion of electronics, circuits and digital technology than a typical mechanical engineering course does. However the title of the course is not an important issue as many Mech. Eng. courses contain a large number of options leading to specified career without having its indication in the title.

Computing subjects are covered in all the courses. Programming, computer systems and computational mathematics are important components of the courses. How successful is the teaching system of computing in British and Irish Mech. Eng. institutions is yet to be evaluated.

CHAPTER III

METHODOLOGY

3-1 Introduction.
3-2 The population.
3-3 The questionnaire.
3-4 Sources of errors.
3-5 Statistical analysis.

3-1 Introduction.

A postal questionnaire was designed to survey the professional mechanical engineers in Ireland with the following objectives in mind:

1- How do they evaluate their undergraduate courses ?.

2- Did the training component in the university prepare them for their current duties ?.

3- What subjects were redundant and what were deficient ?.

4- Evaluation of the continuing education programmes.

The choice between postal questionnaire and interviewing was discussed in the early stages of this project and although mail questionnaires is criticised because of the difficulty of securing an adequate response [18], It was selected for this survey mainly because it does not require manpower (interviewers) and for its practical and economic merits.

3-2 The population

The target population for this survey are those professional engineers who graduated from mechanical engineering departments and work in technical and managerial posts requiring them to perform mechanical and manufacturing engineering duties. These engineers are either members of Institution of Engineers of Ireland (IEI) or the Institution of Mechanical Engineers -Irish branch, (IMechE).

To reduce the sampling errors to insignificant value a copy of the questionnaire was sent to more than 90% of the members of IEI and I Mech E (exactly, 2980 IEI members and 479 I Mech E members) and when responses were obtained, those whose duties suggested that they meet the above definition were selected for analysis. Thus in this survey the target population equals the survey population. However, as many were expected not to reply, a non-response error would therefore is unavoidable.

3-3 The questionnaire

In order to use the returned information properly the questionnaire was designed to make it possible to classify the respondents into groups as shown in figure 3-1 and discussed below,

-Because of the rapid changing of technology and science, the teaching system and course syllabus are changing as well. To account for these changes, the population was classified into **different age groups (according to graduation date)** .

-The satisfaction with the training received at the university was expected to be affected by the **type of course. full time - part time - sandwich** which the respondents undertook.

- **Nature of duties. technical- managerial- academic** may also affect the judgement of the respondents on the relevance of the course syllabus.

A copy of the questionnaire is enclosed in this thesis (appendix 1) and it shows that all the questions asked can be grouped as the following:

1- Questions related to the quality of teaching and educational systems.

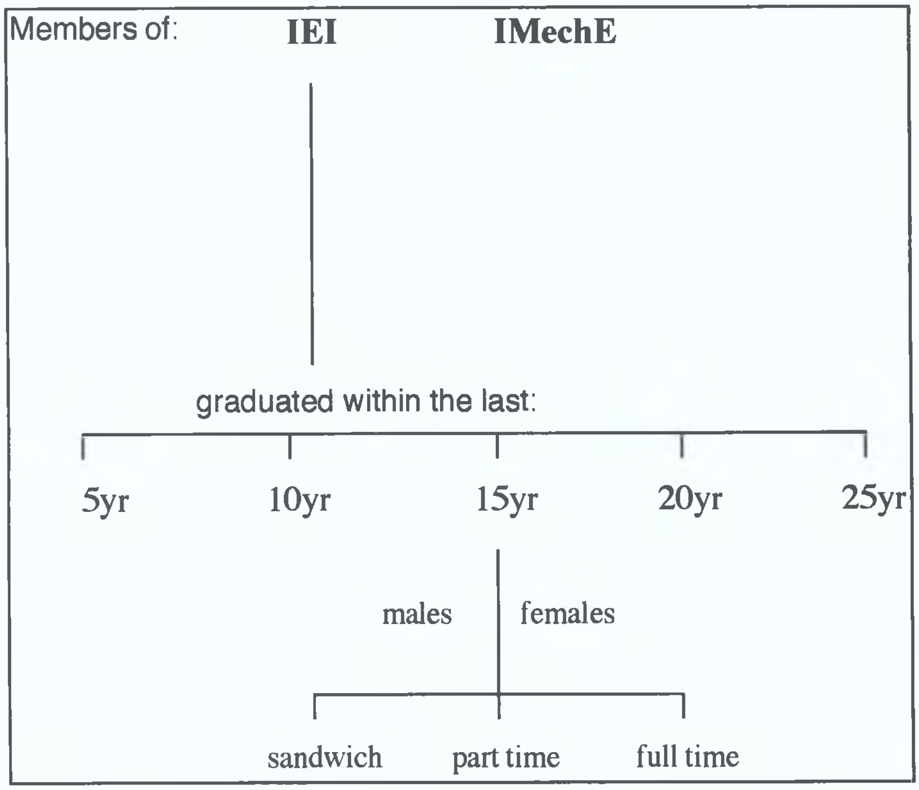


Figure 3-1 Scheme shows the different groups of the population.

2- Relevance of courses to the present duties of engineers.

3- Training and continuous education.

4- Questions were asked to help in describing the population under study.

A short pilot study was proposed and carried out in the school of mechanical and manufacturing engineering at DCU, by sending a copy of the draft questionnaire to 10 engineers to clear some ambiguous questions and to classify some answers.

Open ended questions were avoided as much as possible but some were included. The questions and answers were not pre-coded but they were given numbers and were coded by adding the question number to the answer selected as in the following example:

13-B- How do you think the education you received at the university prepared you for Membership of I E I?				
very well	**fairly well**	**just satisfactory**	**not very well**	**unsatisfactory**
1☐	2☐	3☐	4 ☐	5 ☐

Coding system: if answer 3 was selected the code for this entry will be 13-B-3.

The coded answers then were entered into a collecting sheet (see appendix 2) and eventually the important data were put into a computer statistical package (StatView 512+ for the Macintosh) for analysis, storage and production of graphical information.

The questionnaire was sent together with another short questionnaire belonging to the IEI without a prepaid reply envelop (for financial reasons). Instead, a prize of £500 was declared to be won by one of the respondents.

3-4 Sources of errors

Errors in this kind of survey are of three types:

1- non-response error.

2- sampling errors.

3- response errors

The **non-response errors** is the difficult one to deal with, as no follow up letters were sent to the non-respondents, the non-response rate was expected to be high even though the questionnaire was sent to almost every member of the described population of interest. The fact that the questionnaire was long and contained some difficult questions to answer may have put some engineers off. In addition to this, the absence of a prepaid reply envelope was really a drawback. Nevertheless, the population was expected to reply better because we thought that the results of this survey is important to them. If this is not the case, the non-respondents here may constitute a different sub population and any speculation about their opinions would be questionable. However, for practical reasons the non-response errors would be a part of **sampling error**, which can be estimated easily given the fact that every element (Engineer) has the same probability of appearing in the sample (*epsem* sampling)[(19)]. For *epsem* sampling, the proportions and averages calculated from the sample provide estimates of the population values.

The response errors may be caused by, misreading handwriting, lapses of memory, failure to understand the question, tendency to agree or disagree with politically-correct issues (e.g. co-operative education is a good thing)...etc. Errors may be resulted also during the entry and analysis of data. These errors can be minimised with a little more effort during collection and entering of data.

3-5 Statistical analysis.

Confidence intervals rather than statistical significance were used where appropriate because they provide a range of possibilities for the population value and convey more useful information [20]. However, the actual *P* value where also used for its familiarity to denote statistical significance.

Pearson product-moment correlation coefficients (r) were determined for the correlation between the time of graduation of respondents (x) and their rating to some undergraduate subjects (y). The significance of the correlation coefficient (r) of the relationship between x and y was tested by Student's t - test.

Unless otherwise stated the numerical data are expressed as (arithmetic mean ± standard deviation) and the Z- test (two-tailed) was used to reject the null hypothesis at $P < 0.05$ significance level.

The Z test :

The Z test (statistic)-for two independent proportions in two random samples, n_1 and n_2 from two populations (e.g. sandwich graduates *vs.* full time graduates) in one category of the variable (e.g. opinion towards academic training)- was calculated as the following:

The null hypothesis states that the proportions π_1 and π_2 of the two populations are equal. The Z test is applied:

$$Z = \frac{p_1 - p_2}{\sqrt{pq(1/n_1 + 1/n_2)}}$$

The obtained value for Z was then compared to the critical value Zc of the normal distribution at .05 probability of success of the null hypothesis.

Now if $Z \geq Zc$ or $Z \leq -Zc$ the null hypothesis is rejected (i.e. the differences between the two proportions are significant).

Confidence interval and Standard error of the proportion:

The standard error of the observed proportion in sample size of n were calculated as :

$$SE = \sqrt{p(1-p)/n}$$

The confidence limits (errors) for the population was calculated as:

$$p \pm (N_{1-\alpha/2} \times SE)$$

Where $N_{1-\alpha/2}$ is the appropriate value for the standard normal distribution. It is 1.96 at 95% confidence level and 2.576 at 99% (Geigy Scientific tables,1982)[21].

CHAPTER IV

RESULTS

4-1 Response rate.

4-2 Description of Respondents.

4-3 Managerial and computing skills.

4-4 How did they rate education in general?.

4-5 Training element and Continuing education.

4-6 Relevance of Basic Science and ancillary subjects.

4-1 Response rate

425 IEI members returned back the questionnaire, of which 282 member were mechanical engineers, and 70 I Mech E have also responded. This makes up 28% response rate. Although this rate is obviously low, it represent 28% of the whole population of mechanical engineers in Ireland who are either members of IEI or IMechE. Therefore the results showed here are representative. Though the argument that the non-respondents may constituted a different group, from the respondents, is not resolved.

4-2 Description of respondents

The respondents were from different age groups, course backgrounds and occupying different jobs as described in tables 4-1, 4-2 and 4-3.

Table 4-1 Classification of the respondents according to their graduation time (graduated within the last (n) years).

	IEI					IMechE				
	5yr	10yr	15yr	20yr	25yr	5yr	10yr	15yr	20yr	25yr
male	74	54	38	26	82	24	5	5	3	29
female	5	2	1	-	-	4	-	-	-	-

Table 4-2 Classification of the respondents according to the type of undergraduate course

	IEI					IMechE				
	5yr	10yr	15yr	20yr	25yr	5yr	10yr	15yr	20yr	25yr
Sand-wich	3	3	1	-	2	5	1	-	1	5
full time	74	51	39	25	80	19	4	4	2	21
part time	2	2	-	1	-	4	-	-	-	3

Table 4-3 Classification of the respondents according to the type of undergraduate educational institution.

	IEI					IMechE				
	5yr	10yr	15yr	20yr	25yr	5yr	10yr	15yr	20yr	25yr
Unive-rsity	59	53	53	26	77	24	4	3	3	17
Polyte-chnic	7	1	-	-	5	4	1	2	-	11
others	13	2	3	-	-	-	-	-	-	1

The striking feature of table 4-1 is the low number of female engineers respondents. This is most likely a reflection of their low enrolment in mechanical engineering schools. Tables 4-2 and 4-3 Show that the majority of the respondents (>90%) received a full time course rather than a sandwich or part time course and they graduated from universities. It was found that insignificant number graduated from non-Irish institutes. Figure 4-1 shows the different titles of courses received by the respondents.

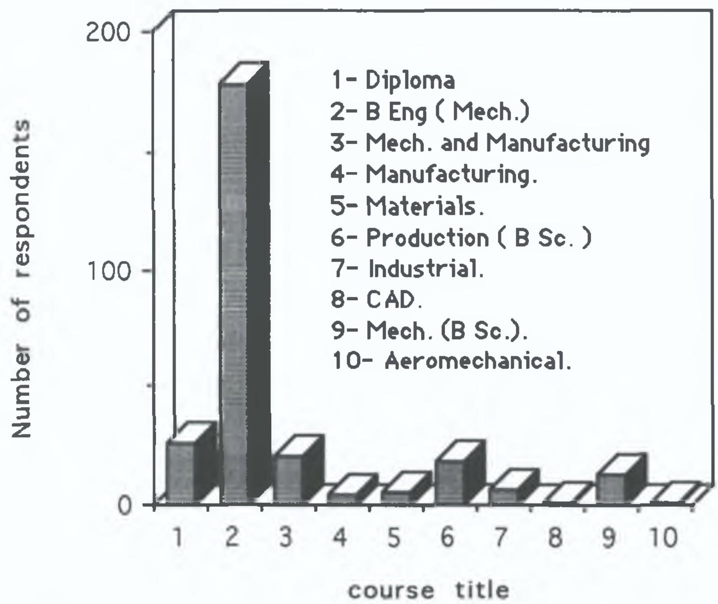


Figure 4-1 Classification of the respondents according to the title of the awarded degree.

The engineers who were surveyed, occupy different positions in academia and industry. Table (4-4) describe these positions.

Table 4-4 description of positions occupied by the respondents.

Position	Number of engineers (n=350)
Research and academia	32
Quality/shift charge eng.	58
Project engineers	40
Manufacturing (process) eng.	22
Maintenance	8
Managers and sales	72
Mech. (function) engineers	23
Operations/Production/Design	24
Others (self-employed, retired...etc.)	71

4-3 Managerial and computing skills.

To describe the respondents more accurately some questions were formulated to assess their skill in two important criteria of modern engineers, computer literacy and managerial skills. The findings are shown in 4-2, 4-3, 4-4, 4-5 and 4-6.

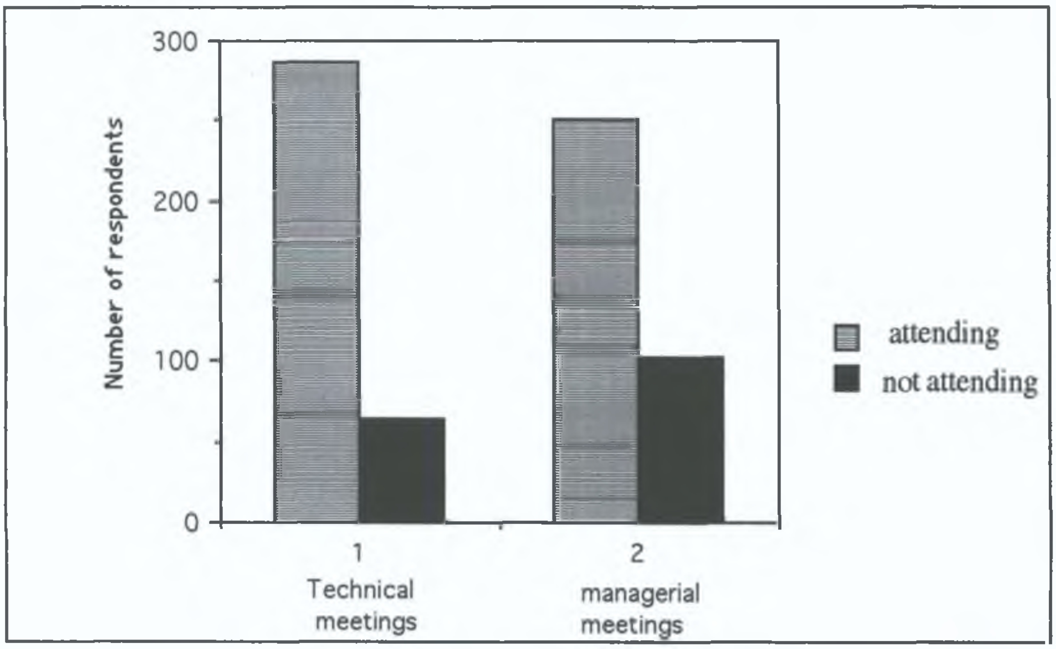


Figure 4-2 showing the respondents attending to higher level tasks: 1- technical meetings;. 2- managerial meetings.

The attendance of managerial meetings (70% ± 2.4 SE, confidence limits at 99% C.I. was 66 to 76%) was significantly lower, P=.008, than that of technical meetings (80% ± 2.1 SE, confidence limits at 99% C.I. was 76 to 84%).

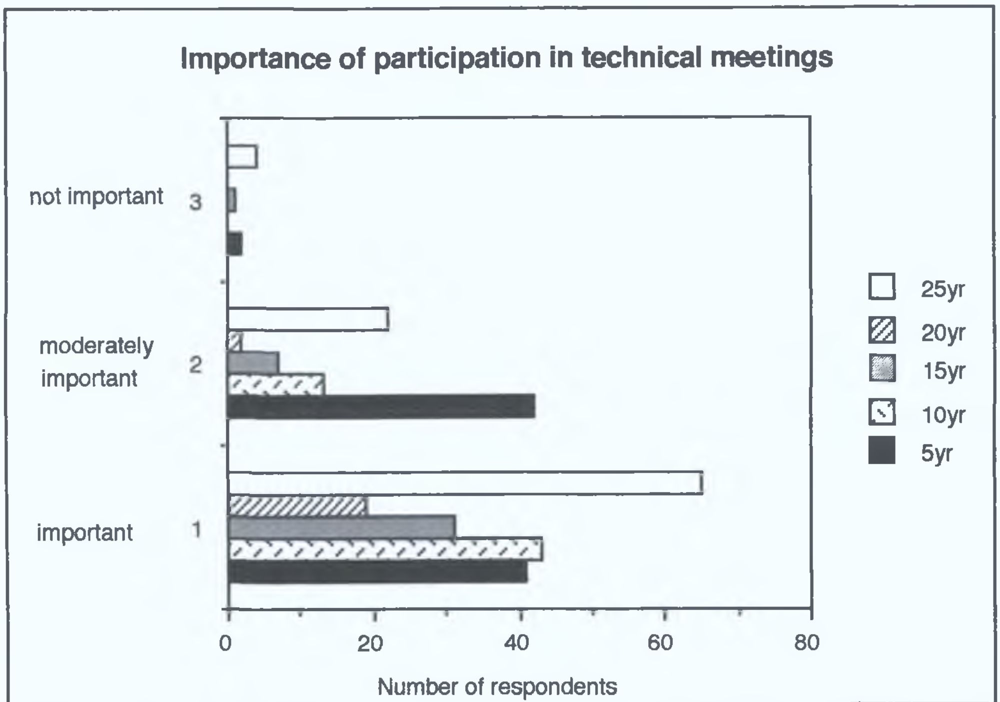


Figure 4-3 How the respondents perceive their participation in technical meetings. The difference between 5yr and 25yr groups were significant, P=.02 (compare with figure 4-4)

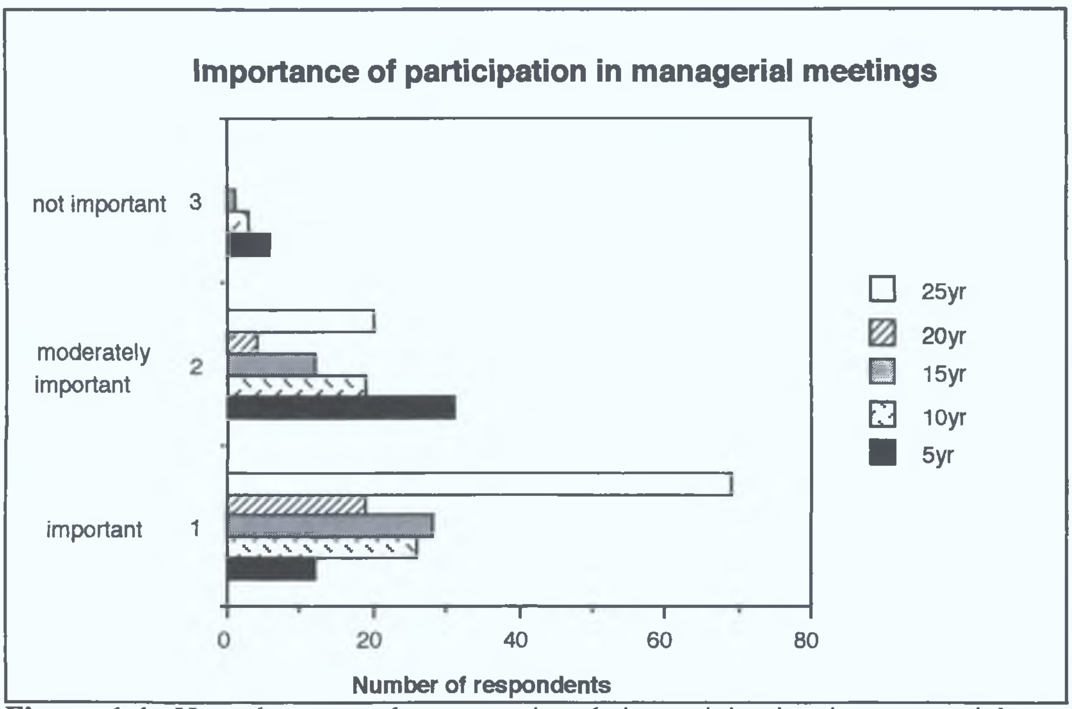


Figure 4-4 How the respondents perceive their participation in managerial meetings. The difference between 5yr and 25yr groups were significant, P=.02 (compare with figure 4-3)

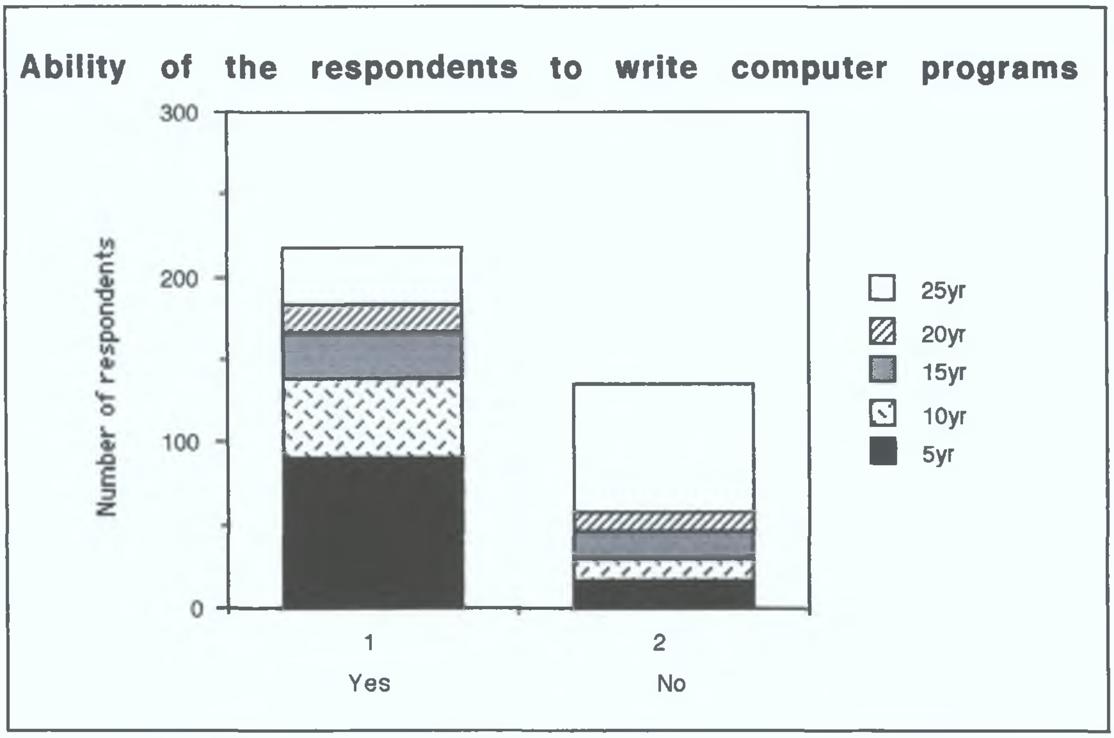


Figure 4-5 Showing the degree of computer literacy in the respondents population as a whole and according to their graduation periods. The differences between 5yr and 25yr groups were significant, P <.05 (z-test).

The number of respondents who know at least one programming language is higher in the recent graduate than in older ones as shown graphically above. These differences were found to be statistically significant and it is obviously attributed to the developmental history of computers in the last decade. The most learned languages were BASIC and FORTRAN and about 22% learned other languages (Lisp, Pascal, UNIX, C++,....etc.) and Used more than one language. This group of respondents consisted mostly of new graduates.

To see whether academia is aware of the greater demand of computer literacy the respondents were asked: where did they learn programming properly and the answers which are shown in figure 4-6 indicate that the majority of the recent graduates learned their computing skills at the university while, logically, the older generation did so in the job.

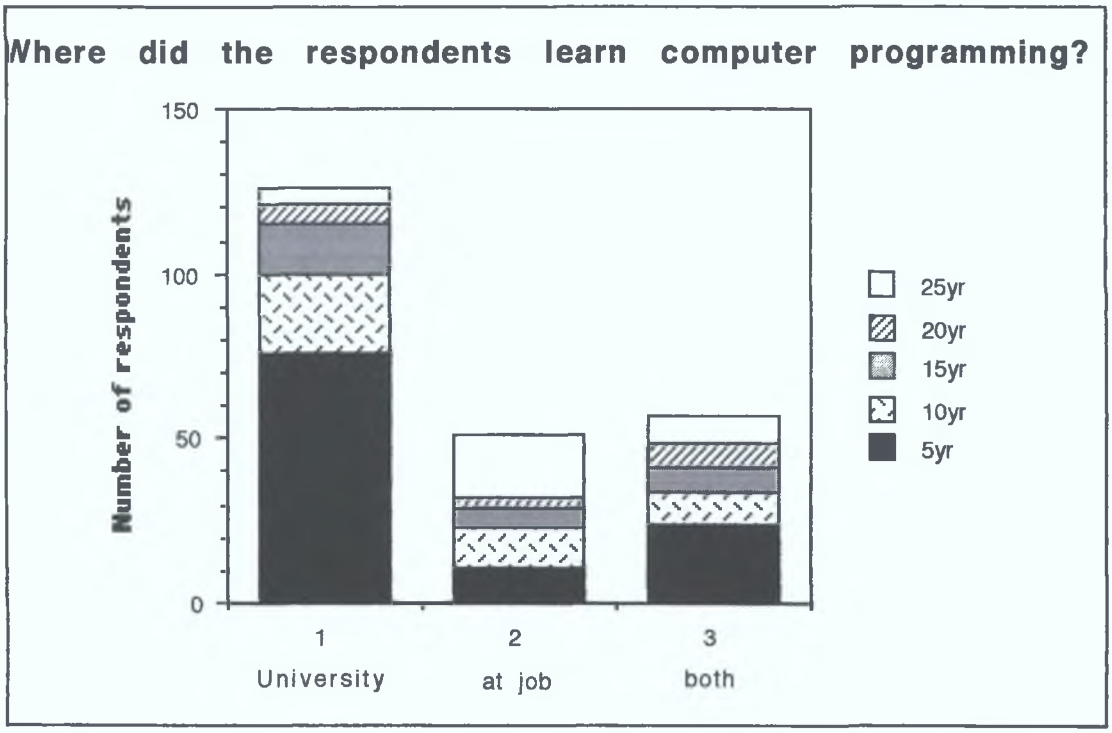
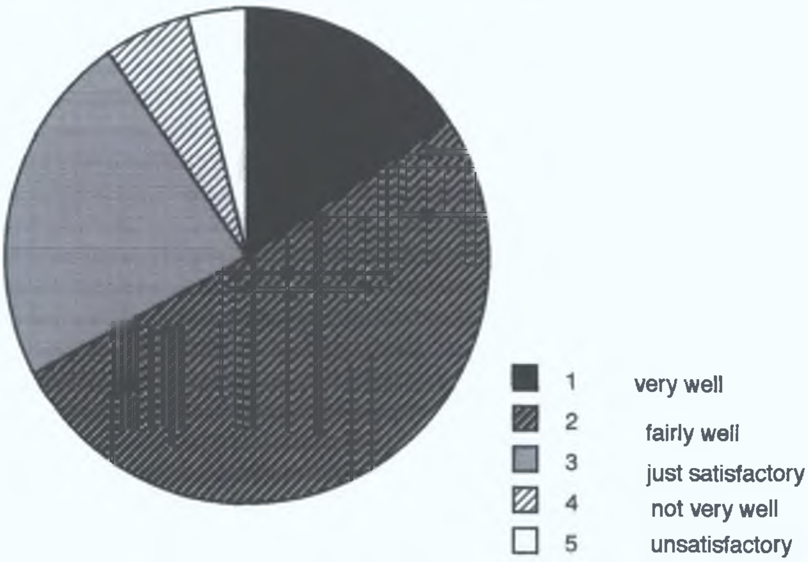


Figure 4-6 Showing where the respondents, initially, learn their computer skills. The differences between 5yr and 25yr groups were significant, P <.05 (z-test).

4-4 How did they rate education in general ?

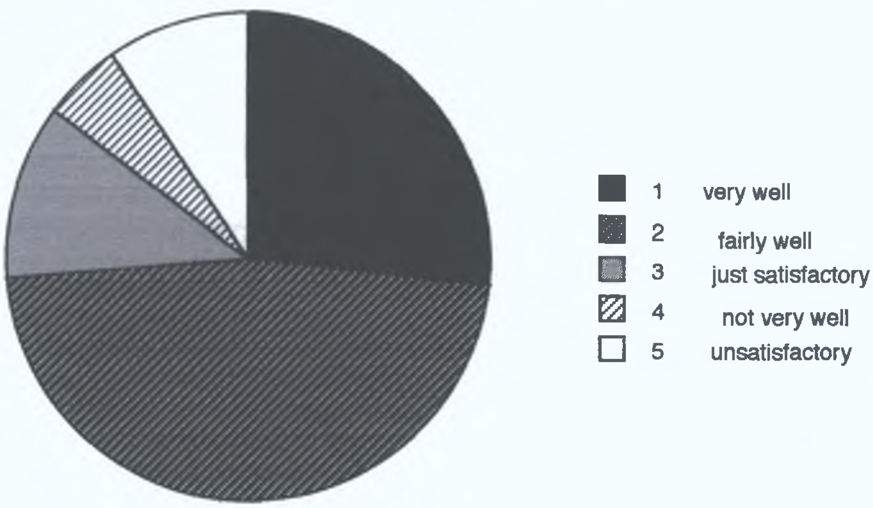
Several questions were asked to know the opinion of the engineers towards their education in general. The responses are summarised in figures 4-7; 4-8 and 4-9.

Figure 4-7 Pie chart showing the answers to the question: How do you think the education you received at the university prepared you for your current job ?



n=350

Figure 4-8 Showing the answers to the question: How do you think the education you received at the university prepared you for Membership of I E I or I Mech E.?



number of respondents=335

It is clear from the figures above that the majority of the respondents were satisfied with the education they received in general and they believe that it helped them in performing current duties. However, a large proportion of the respondents (49%) expressed their views on some weaknesses in the education process, among the important were:

-Some of the Subjects were not entirely relevant.

-Absence of adequate industrial training schemes .

-Poor teaching methods.

When the respondents were asked explicitly for their approval of the teaching methods in the class, only 12% said they were not satisfied with them and the rest expressed different degrees of satisfaction, the majority being fairly satisfied.

Respondents rating of the teaching of different subjects was based on their evaluation of quality of lectures, tutorials, lab and contact with teaching staff. The values which are presented as means in figure (4-9 a) should be critically interpreted because some subjects which have no laboratory or workshop part may be underestimated. This is quite true for ergonomics, management and mathematics. Corrected data are presented in figure 4-9 b.

Most of the respondents (>90%) agreed that the objectives of mechanical engineering education, which were put for them in the questionnaire (see appendix I) are to make the graduates:

-competent to design engineering systems.

-capable of analysing complex systems.

-have a full knowledge of materials.

-competent in written and oral communication including engineering drawing.

However, 10% disagreed that the responsibility of the education is to make graduates aware of environmental and social implications of industry, or to make them familiar with aspects of management, economics, accounting and law in relation to companies.

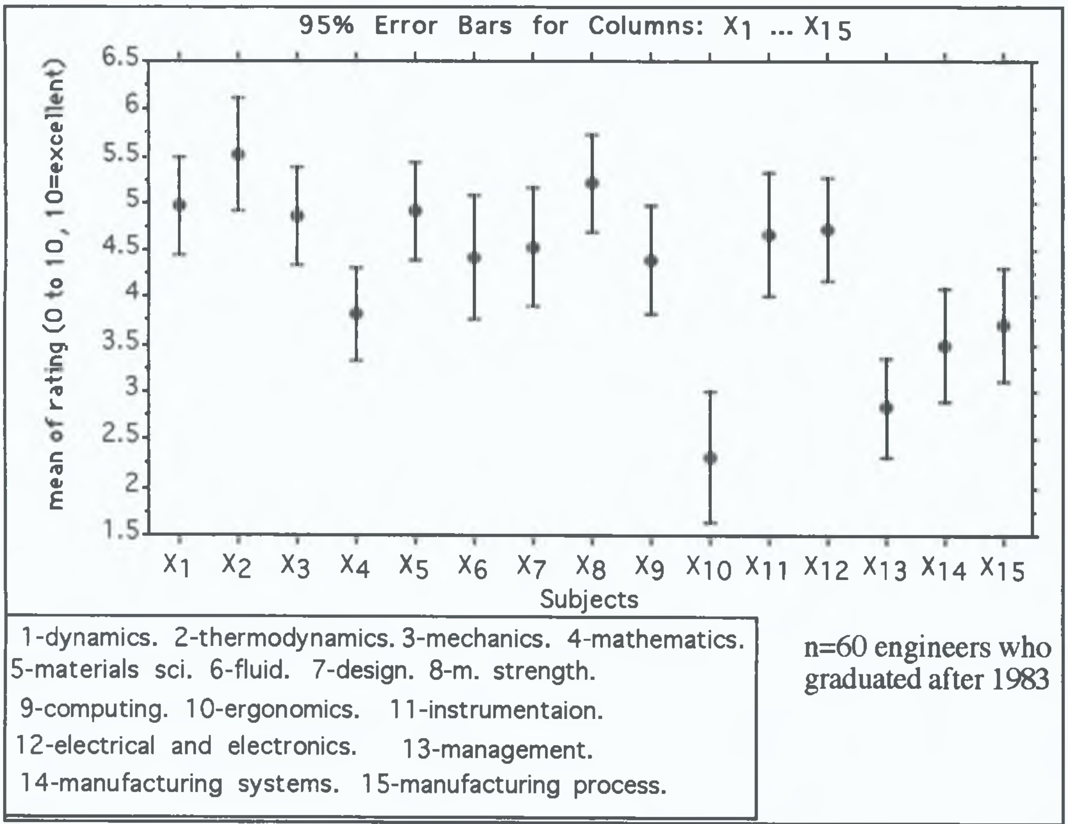


Figure 4-9 a Respondents' rating of the teaching of different subjects based on their evaluation of quality of lectures, tutorials, lab and contact with teaching staff.

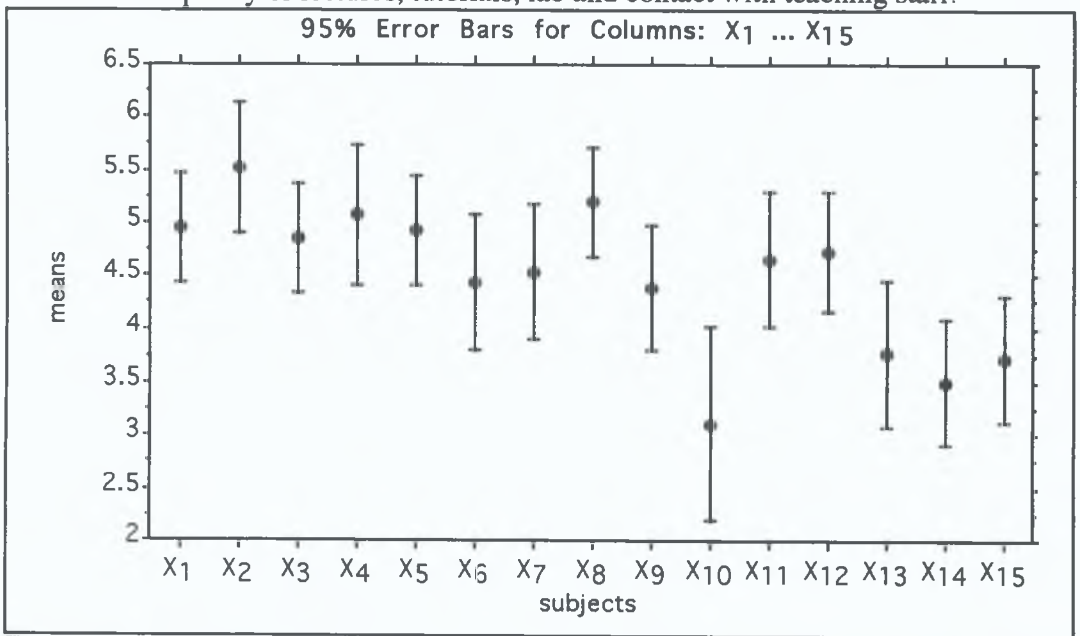


Figure 4-9 b Same data as in figure 4-9 a after correcting the values of x4 (mathematics), x10 (ergonomics) and x13 (management), by subtracting the values which were given to the Laboratory section (see text).

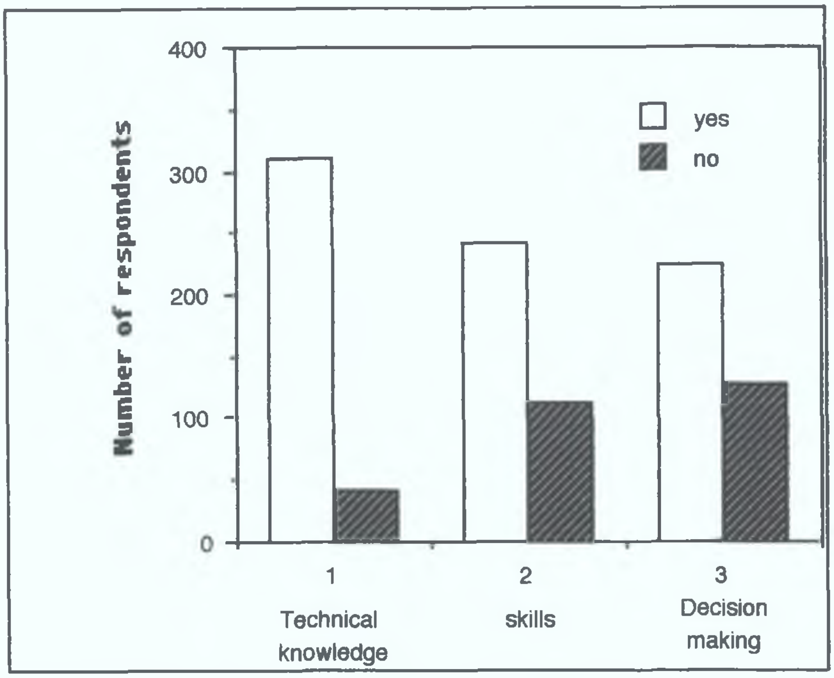


Figure 4-10 showing how the respondents think that the knowledge they have obtained at the university was helpful to compete in the changing environment of the job by improving their: 1- technical knowledge, 2- skills, 3- decision making. (differences between 1 and 2, 1 and 3 were significant, $P < .01$, and between 2 and 3 were insignificant, $P=.2$).

Figure 4-10 shows that the technical knowledge acquired by the engineers during their courses was the most important aspect they have gained from the university and decision making abilities and skills were of secondary importance in the courses of study.

4-4 Training element and continuing education:

Because of the importance of the training to the engineer and the fast progress of engineering the questionnaire addressed the efficiency of the training programmes during both the undergraduate and postgraduate periods of the engineer's career.

Figure 4-11 shows the responses of the population of engineers who graduated within the last 5 to 10 years when asked to rate the training components of the syllabus of some subjects.

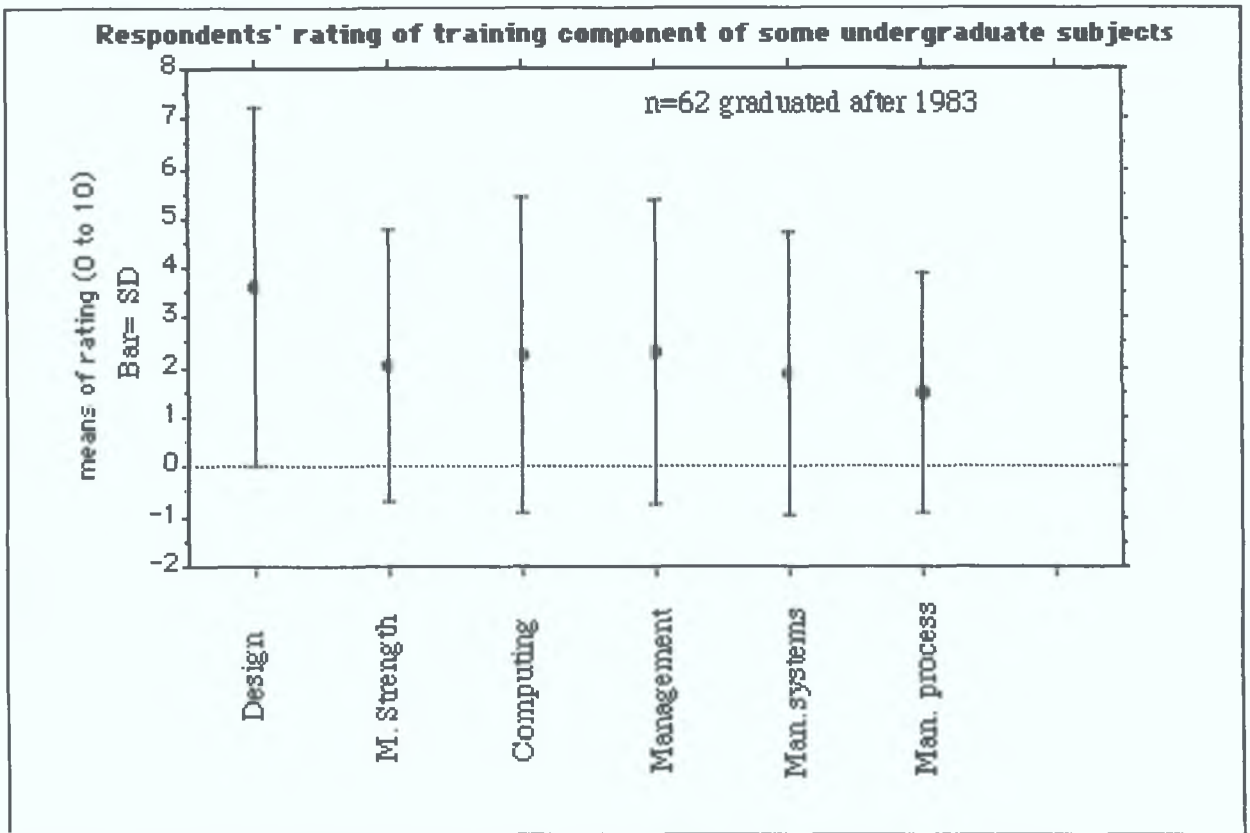


Figure 4-11 Respondents' rating to some subjects' training programmes.

All the training programmes which were presented in the above figure were rated below 40% indicating that most engineers were unsatisfied with the training they had received at university. However the large standard deviation shows that the respondents responded differently to this question. In figure 4-11 engineers who graduated before 1983 were excluded because of the lack of responses to the questions concerned.

One of the questions asked was : did the respondents receive any special education programme (foundation or additional subjects)? The answers are shown in figure 4-12. Figure 4-13 shows that most of the respondents (> 80)were satisfied by the academic training. Although few Sandwich course graduates were among the respondents, comparison between them and the population in general were attempted in figure 4-14 and figure 4-15 where their opinions towards co-operative education are illustrated

Was academic training enough for the engineers to pursue their professional career without the need of other special training programmes? Figure 4-16 and table 4-6 show those who attended any other training programme, for how long they needed it, and number of the respondents availing to continuing education programmes in IEI & IMechE?

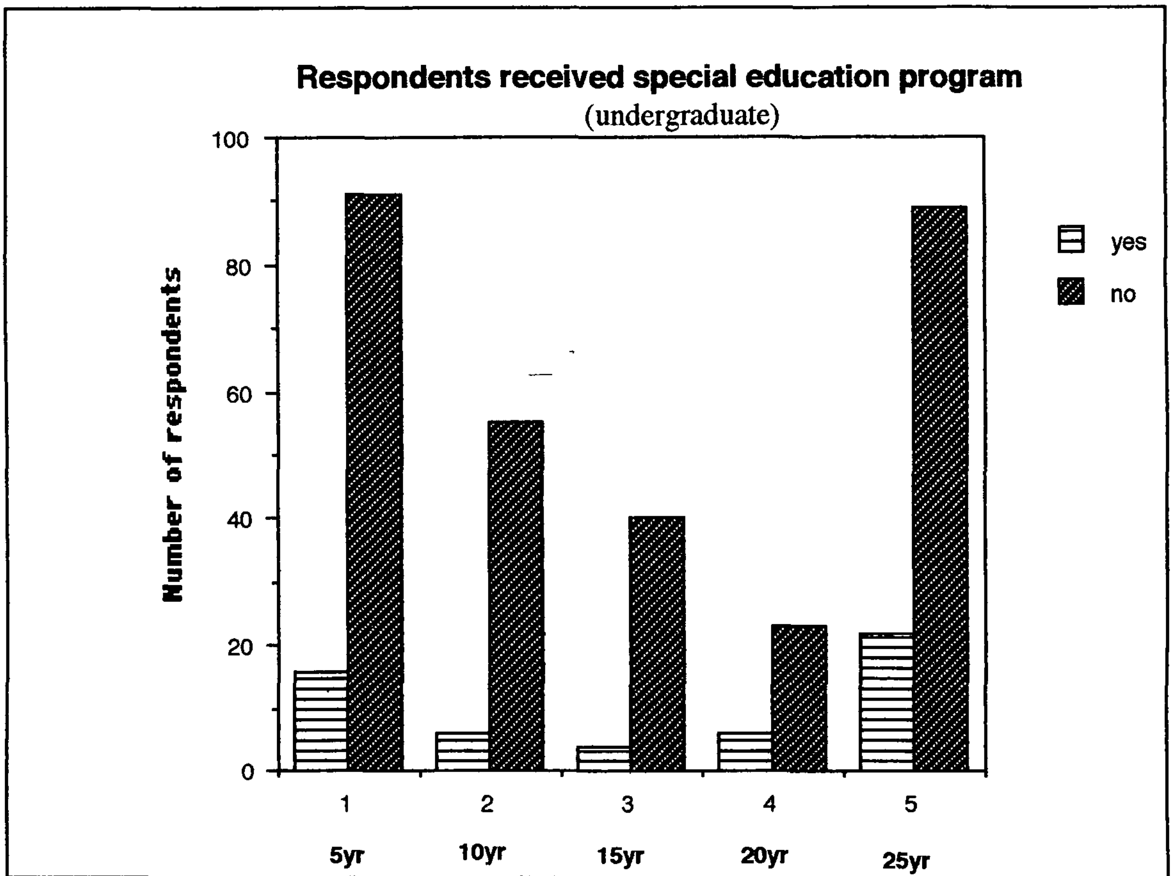


Figure 4-12 Undergraduate foundation year or additional subjects received by the survey population

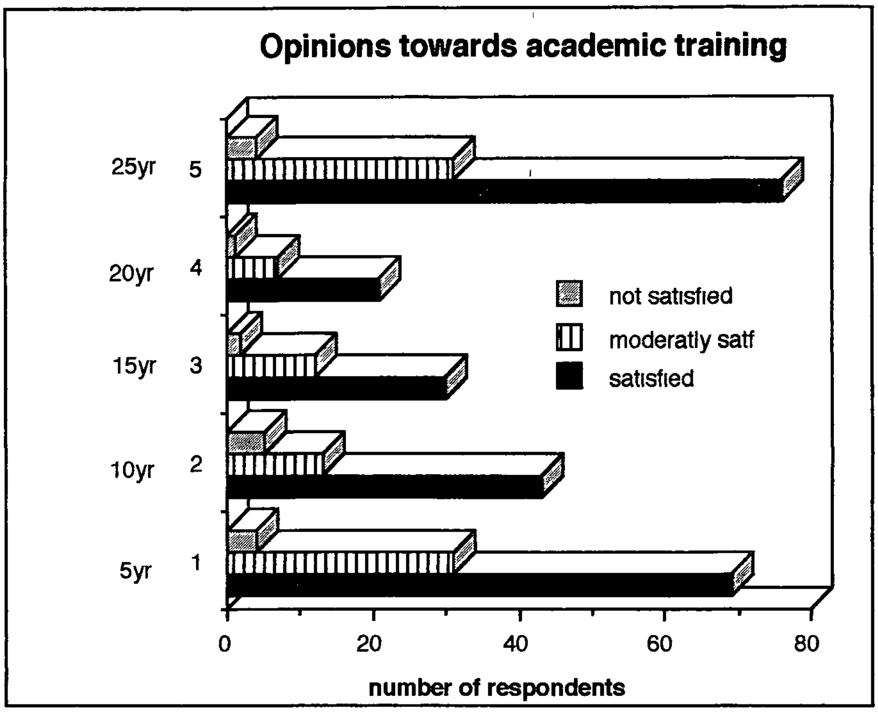


Figure 4-13 showing opinions towards academic training A high degree of satisfaction is expressed by all groups of the population

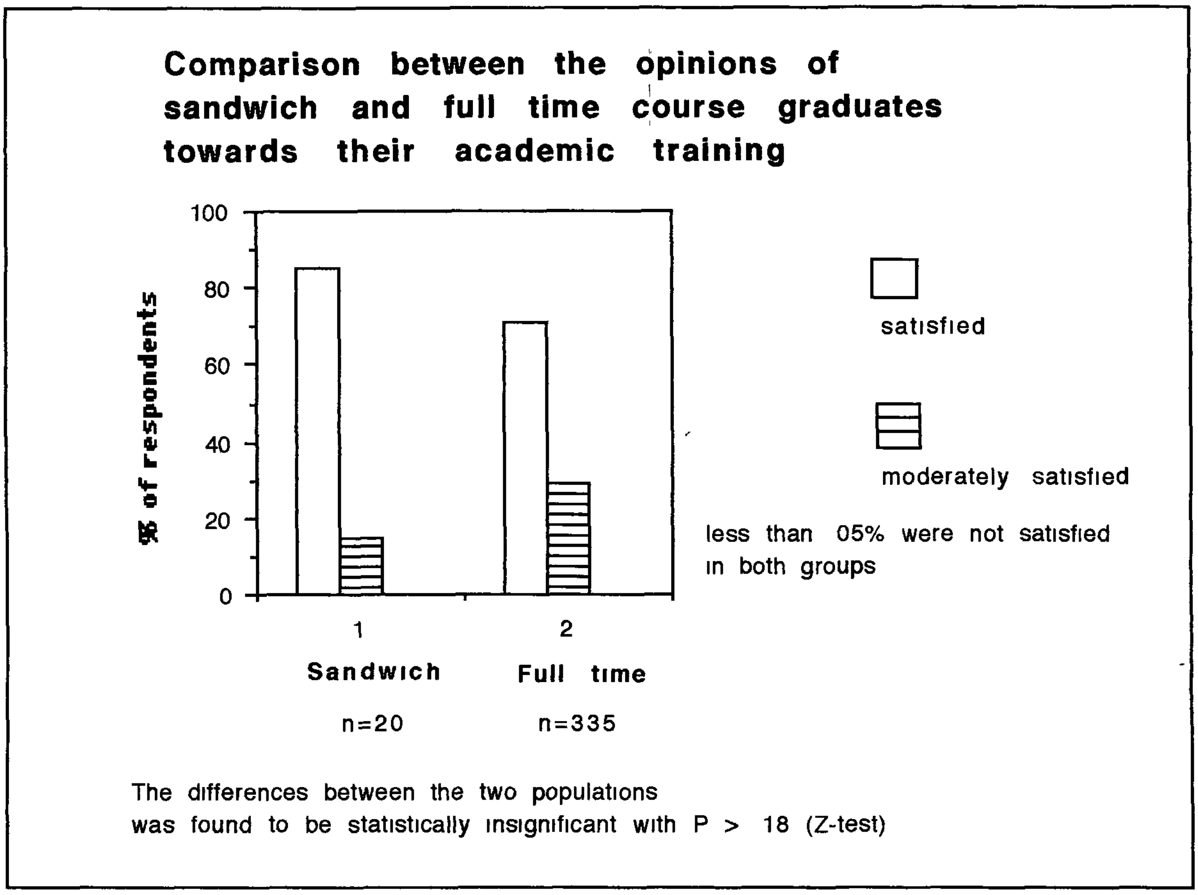


Figure 4-14 When the sandwich course graduates' opinions towards academic training was compared with that of full timers, no significant differences were found However, the low number of sandwich graduates and the ambiguity of the term " academic training" should be taken in account before any inference from this finding is considered

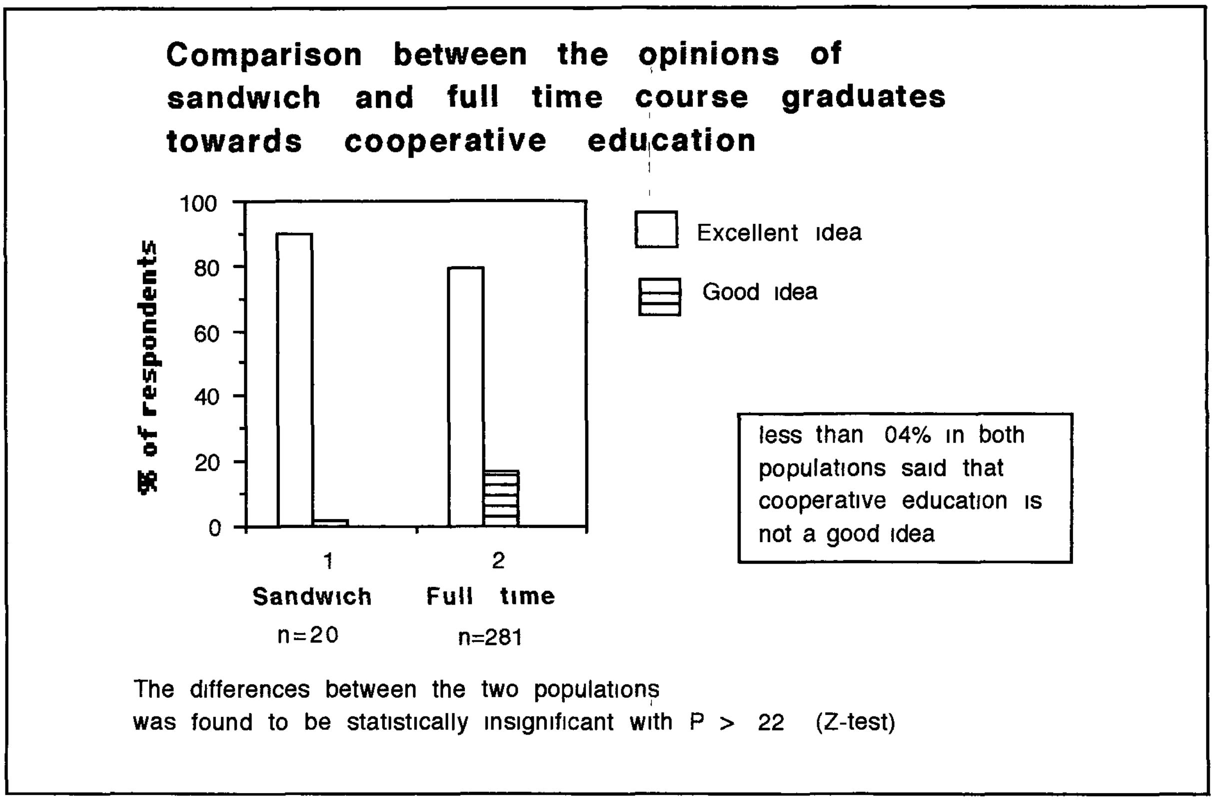


Figure 4-15 Both the sandwich course graduates' and full timers appreciate the cooperative education Though the full timers had not participated in cooperative education programmes, no significant differences were found between these two groups

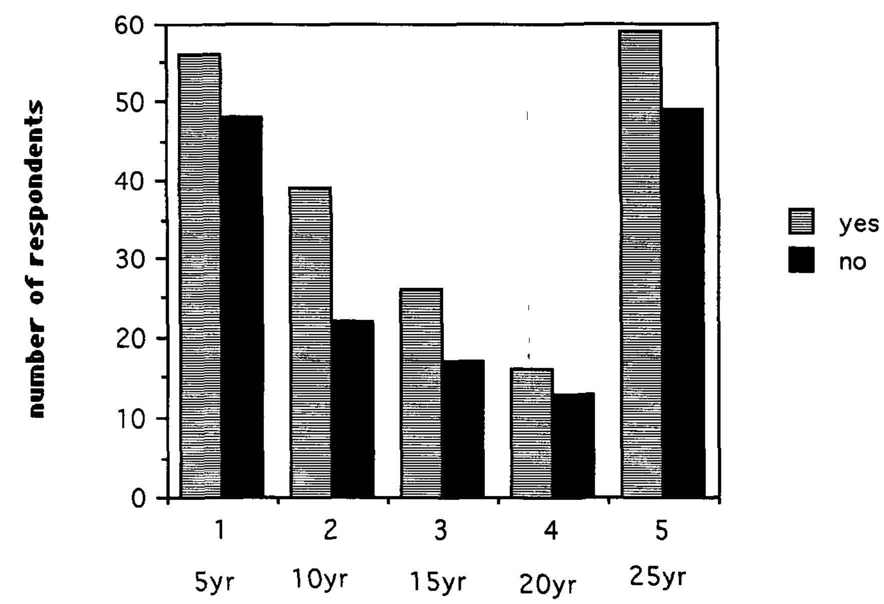


Figure 4-16

Respondents received (postgraduation) special training programme

Figure 4-16 More than 50% of the respondents in all groups received special training programme relevant to their current jobs

Table 4-5 Length of post graduation training courses which were taken by the respondents?

length	5yr	10yr	15yr	20yr	25yr
on going*	26	11	10	14	18
1-2 week	7	5	2	0	6
1-2month	5	8	4	1	4
3-6months	11	6	5	1	8
1-2yr	7	9	5	0	12

* Short duration (1-2 days) continuous special courses

Table 4-6 shows the respondents availing of continuing education programmes organised by the IEI & IMechE:

	IEI					IMechE				
	5yr	10yr	15yr	20yr	25yr	5yr	10yr	15yr	20yr	25yr
yes	10	2	8	9	18	2	0	0	0	2
no	69	54	31	17	64	26	5	5	3	27

From table 4-6 it is clear that most of the respondents (86%) did not take any education programme run either by the IEI or IMechE The reasons which were given by the respondents for not attending any of these programmes can be categorised as follows

a- Relevance of the programme

[31%] respondents say that, most of the programmes were irrelevant or belong to other engineering topics (civil)

b- The place

[20%] of them were living or working far away from the venue of the programme

c-programmes were not interesting

[16%] of members were not interested in or didn't need such programmes

d- Availability

[10%] said that, the programmes were not available while they were needing them

e-The time factor

[8%] respondents were busy and didn't have enough time for such programmes

f- New members

[7%] respondents are still new members; some of them said the access to these programmes was a problem for them.

g- Do not know about them:

[4%] didn't know or hear about these programmes.

f- Expensive:

[4%] said such programmes are very expensive for them.

4-5 Relevance of Basic Science and ancillary subjects.

The responses of the sample population to the enquiries about the relevance and importance of the different subjects they learned at the university to their current duties indicated a significant importance of computing, design and strength of materials (Figure 4-17) among all of the groups surveyed, senior and junior engineers. However, other subjects were rated differently by the various generations of engineers. Those who graduated within last 25 years gave usually a slightly higher rating to all the subjects than other groups, the only significant exception was ergonomic subject which received a very low rating from the older generation (Figure 4-18). Other subjects' ratings are shown in figures 4-19, 4-20 and 4-21. These figures show that management and mathematics are highly rated by older generation of graduate engineers and the rating decreases as the age of the respondent decreases. However, dynamics rating regression equation showed a very poor linearity.

Figure 4-22 shows the relevance of the level of mathematics and science syllabus in undergraduate courses. When the respondents were asked about the importance of their first year subjects to their career (but could have been important to follow courses in 2nd, 3rd or 4th years), 46% of the them said that these subjects were not important and only 37% of the population said that they were important. Those who said that first year subjects were essential, were asked about the extent of importance of these subjects, 47% of them said that the subjects were more than 60% essential to their careers Some subjects which were considered by some respondents as not essential at all, are the following

Chemistry (17% of the respondents said it was not important to their careers), mathematics (7%), physics (7%), electrical (2 5%) and dynamics, mechanics and drawing (3%)

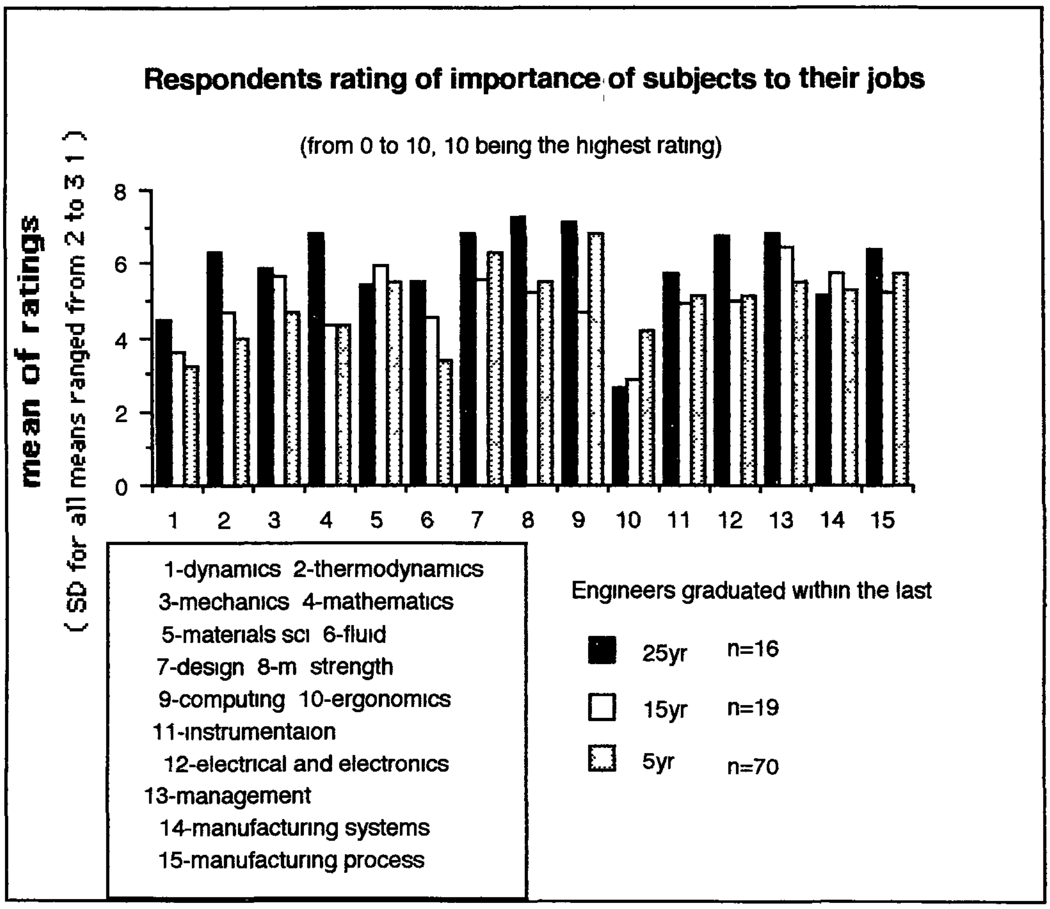


Figure 4-17 Importance of subjects to the respondents' career as professional engineers

These responses indicate that the senior engineers (25yr group) were inclined to give higher rating to most of the subjects than the other groups of engineers did

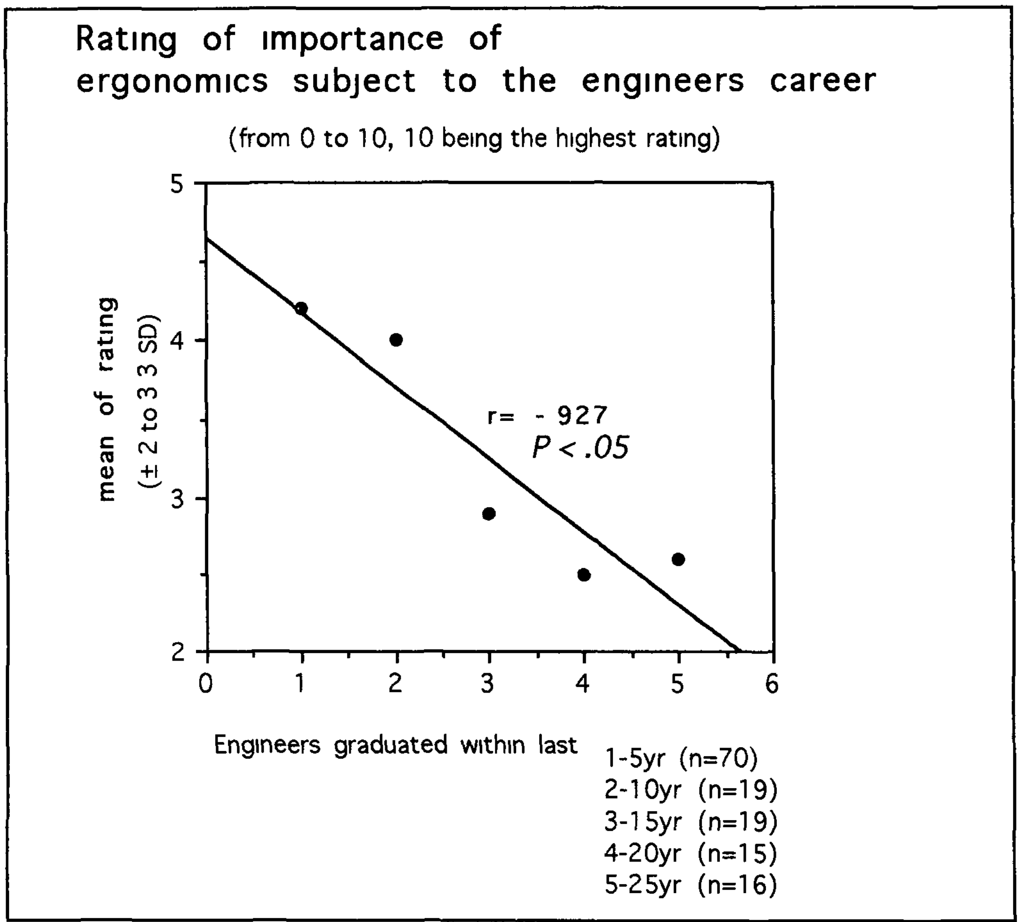


Figure 4-18 Respondents' Ratıng of Ergonomıcs ımportance to the engıneer's career shows a sıgnıfıcant lınearıty wıth tıme of graduatıon

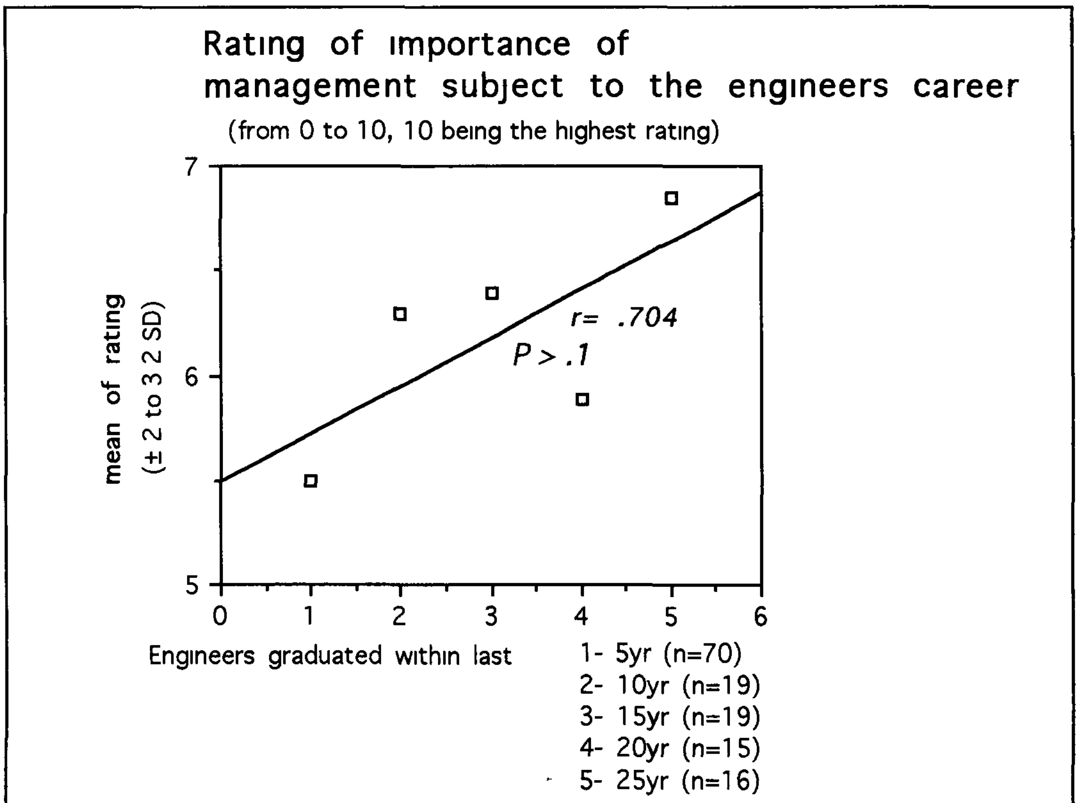


Figure 4-19 Respondents' Rating of management subject importance to the engineer's career shows a good but insignifcant linearity with time of graduation

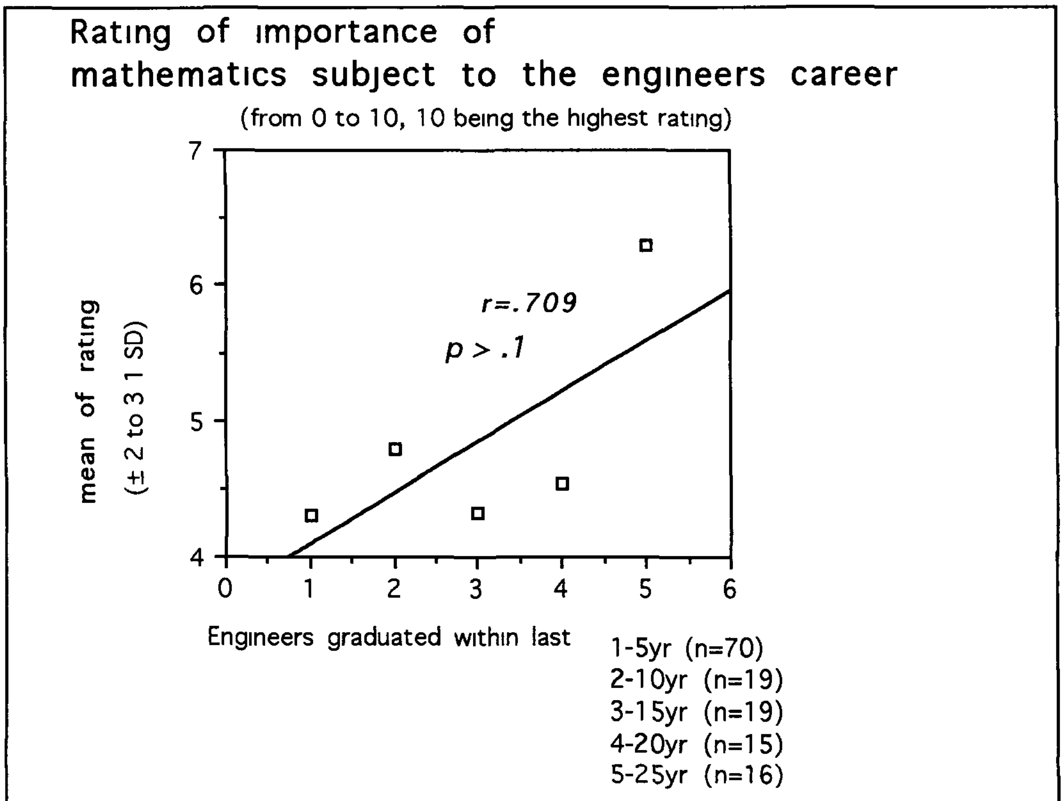


Figure 4-20 Respondents' Rating of Mathematics importance to the engineer's career shows a good but insignifcant linearity with time of graduation

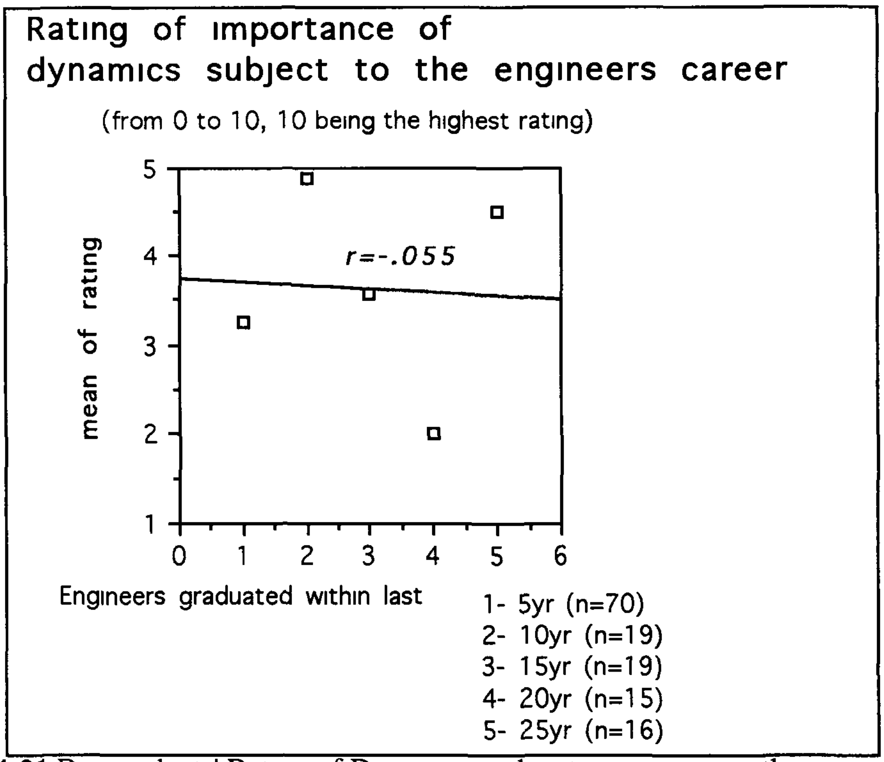


Figure 4-21 Respondents' Rating of Dynamics subject importance to the engineer's career shows very poor linearity with time of graduation

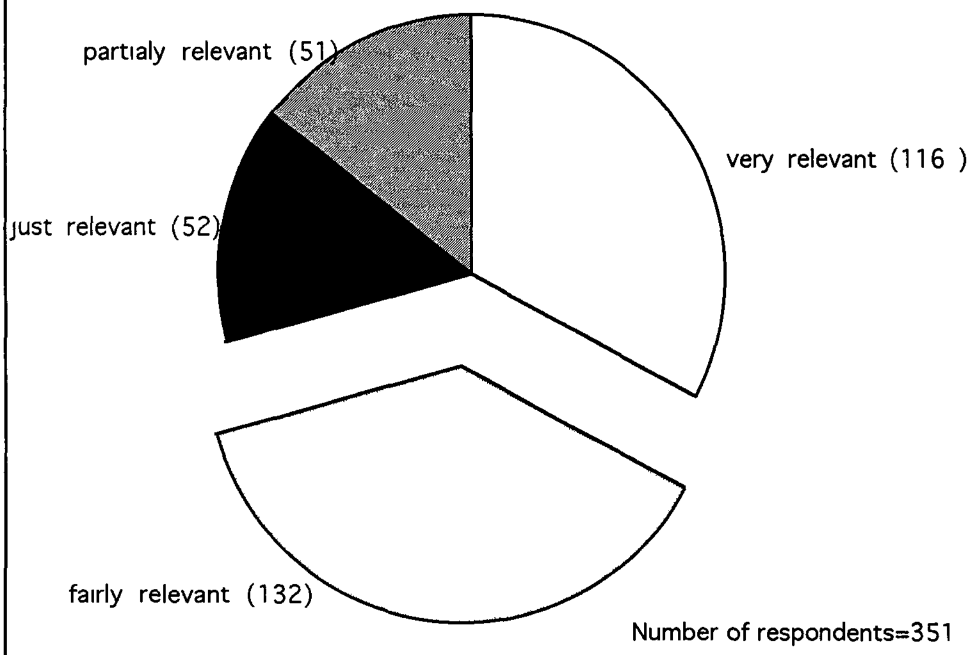


Figure 4-22 **Relevance of the level of mathematics and science syllabus to the engineers career.**

Figure 4-22 Shows the responses of the population when were asked to evaluate the relevance of the level of mathematics and science syllabus in their courses Compare with figure 4-20

CHAPTER V

DISCUSSION AND CONCLUSIONS

5-1 Evaluation of teaching methods.

5-2 The training element.

5-3 Management and Ergonomics.

5-4 Computing.

5-5 Relevance of basic science subjects.

5-6 Engineers recommendations.

In this survey, effort was made to obtain the opinions of the professional engineers concerning the industrial training component of the education process and the relevance of the ancillary and basic subjects in mechanical engineering undergraduate courses in Ireland Responses of the population to general questions revealed a degree of satisfaction towards the education process and teaching quality, but, specific questions generated different responses which are dealt with below

5-1 Evaluation of teaching methods.

Evaluating university teaching is one of the major issues in academic institutions Though, students' questionnaires is the predominant method of gathering data on evaluating teaching methods, there is no unique methodology for measuring teaching effectiveness [31] The Engineers' questionnaire, which was used in this study, is based on the assumption that engineers are more qualified than students to judge and report on the effectiveness of the education process

The questions asked about the teaching systems were unambiguous but they were generalised By asking different questions about the same issue and, moreover, asking the respondents to comment freely, it can be concluded from the responses that the teaching methods in mechanical engineering departments are reasonably good, but they should be improved

The results of this survey indicated that the majority of the respondents were fairly satisfied with the teaching system during their undergraduate studies, with a larger degree of satisfaction towards the quality of lectures, while tutorials, laboratory and training components scored markedly low ratings The arithmetic means of rating of the undergraduate subjects never exceeded 5 5 out of 10 Such moderate ratings may be due to the perceived mismatch between the topic taught, and the long term requirements of the engineering graduate [32] Engineers do not generally solve problems in the way that engineering students solve problems [33] An engineer does not simply sit down and solve mathematics problems He does a lot of work trying and testing new things A lot of engineering consists of responding to situations where engineers have never been before

Therefore, the engineering curricula should address a wider set of problems with less obvious solutions than the current engineering courses' problems This is closer to reality and also will allow an engineering-oriented viewpoint to be brought to bear in complex problems

5-2 The training element.

The respondents showed a high degree of satisfaction towards academic training, but when asked specifically to rate the training component of the subjects which they received at university, they tended to give low rating of most of these subjects These differences in responses may be due to the ambiguity of the term "academic training" which may be interpreted differently by each respondent

The general comments of the respondents and their responses to the questions about co-operative education, indicated that they are not entirely satisfied with the training programmes during their undergraduate studies Also, a large proportion of the respondents indicated that they received special training programmes after graduation to facilitate their skills in their jobs Thus, it can be concluded that the training component of mechanical engineering courses is indeed deficient and the link between industry and academia should be strengthened How to improve the training programmes in universities and the appropriate role of industry in this endeavour has been and still is a topic of controversy and debate There are currently two points of view, the first, strongly, supports the idea of long incorporated schemes involving industrial sojourns as part of the requirements for the engineering degree These schemes have been variously called sandwich courses, co-operative education, in-plant training etc [40,41,42] The second point of view, simply, states that universities should concentrate on teaching the theory, and leaving the completion of engineer's education to industry [14, 43]

The fact that the majority of the respondents were full timers and not sandwich graduates may lead one to think that the dissatisfaction of the population is because of the lack of co-operative education which is highly appreciated in the UK, USA and Australia [22] However, it is not possible here to confirm that there is a significant difference in the opinions towards training between the full timers and sandwich graduates

In some universities in Ireland, there is a formal industrial placement element included within the period of the degree courses [34] The effectiveness of such programmes should be investigated

5-3 Management and Ergonomics.

Participation in managerial meetings was regarded as important as participation in technical meetings by older generations of respondents (figure 4-3 and 4-5), while the recently graduated engineers under-rated the importance of managerial meetings This finding was supported by the fact that the older generations of the respondents rated the management syllabus more strongly than the younger engineers did (Figure 4-17) This is understandable because the older engineers are at the top of the job scale (managers, executives etc), in which the managerial skills are as important to the engineer as the technical skills

It can be recommended that the management syllabus should be appreciated more during the degree courses This agrees with the recommendation of many engineering education experts [23, 37,38], which stated that management is, and should be, an essential part of the training of both graduate engineers and engineering students In a recent survey of 100 engineers, 90 said that management courses were necessary for their professional success [35]

In addition to management, communication skills should be an essential part of any university engineering training Most engineering work requires communication, not only with peers, but, with organisational level both above and below the engineer in both technical and non-technical fields Ability to communicate, was considered the most appropriate characteristic the professional engineer should posses in order to succeed [35]

In contrast to management, the importance of ergonomic syllabus to engineering career showed a linear correlation with the time of graduation in the opposite direction (Figure 4-18), i e the more recent the graduation the higher the rating of the importance ergonomics This was not expected because it has been assumed that the older generation of engineers may be more aware of the importance of human factors in industrial mechanisms Anyway, this generation gap may be due to the following reasons

- realisation of the importance of human element in industry is the product of the recent changes in socio-political attitudes, industrial process and social implications of industry which resulted in new teaching approach

- over-mechanisation and computerisation of the manufacturing process marginalised the importance of human participation at the lower scale of the process and this was felt more by the older generation because of their experience and positions in industry

5-4 Computing.

More than 60% of the respondents claimed to have written computer programs in at least one language This agrees with the finding of Kalyanvala [24] who found that 65% of graduate engineers over a period of 12 years were able to write computer programs It was found also in our survey that the recently graduated engineers are more familiar with programming than the older generations and that university was the place where they learned to do so properly

The programming skill was taken, here, only as an indicator of high computer proficiency, it should not be, however, overestimated as computing does not mean programming only [25] Some respondents expressed concern over the other computing skills (familiarity with different packages, computer simulation, ability to run and control computerised machinery and operations etc) These concerns are not peculiar to Irish engineers as an American survey defined a sample population of aerospace engineering faculty and students as "information naive" who tend not to make use of information products and services oriented to them [36] The teaching of computing therefore should provide a broader, more scientifically oriented foundation which takes into consideration the different aspects of today's computing

Computing as an undergraduate subject was highly rated by all generations of the respondents Though, not studied in this survey, the use of computers in teaching (e g multimedia) was recommended by some respondents and several authors [26, 27, 28, 29,39,47]

5-5 Relevance of basic science subjects.

All of the basic science subjects were considered to be important to the engineers' jobs These were rated above 5 out of 10, by senior engineers with the exception of Dynamics which scored less than 5 Mathematics was given 7 by 25 years group and < 5 by all others (Figure 4-20) 33% of the population said that the level of mathematics and science syllabus was very relevant to the engineers career, and 38% said it was fairly relevant (Figure 4-22) These results do not indicate that the graduates are fully aware of the basic science subjects, or they believe that they were not wasting time studying them The younger generation of the graduates feel less strongly about these subjects than the senior engineers do If mathematics is considered irrelevant and inappropriate by younger generation of engineers, this would be a reflection of the ways of teaching mathematics and science (see the poor rating of mathematics' teaching in figure 4-9a &b) Mathematics and science teaching objectives and methods are always a source of debate [45] These should not be taught with the aim to produce mathematicians but to produce professional engineers capable of using mathematics and science as tools to solve problems [30] One of the objectives of the universities is " An Engineer should have a thorough understanding of the mathematics/scientific base" [44] On the other hand, the engineering schools should teach more applied and realisation-oriented syllabus and teach basic sciences only as far as immediately needed [46] The balance between these two goals is critical and challenging, but, once they are clearly defined they become achievable

5-6 Engineers recommendations.

As the respondents were given the chance to comment freely on the ways to improve the mechanical engineering teaching, we are obliged here to present their recommendations in this section The most frequent comments are presented below

" lectures and practicals need to complement each other"

" please use co-operative system in all colleges"

" some methods should be found to bridge the gap between a classroom and an industrial situation e g videos "

" survey the students to achieve feedback on relevant topics"

" use open book exam that will eliminate people learning by heart "

" avoid out of date engineering practice"

" inclusion of computers in relevant subjects"

" more practicals "

" more emphasis on team building, decision making, business and management skills "

" communications and writing skills and technical meetings should be integral"

" get the student involved in useful work and not just to see how the job is done "

" no engineers should qualify without at least 6-12 months industrial experience "

" it should be helpful if the training was organised between the university and IEI and IMechE "

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APPENDIX 1

THE QUESTIONNAIRE

Name (optional):
- Grade of I E I membership:
Fellow ☐ **Member** ☐ **Associate Member** ☐ Others...............

1-Sex: **male** ☐ **female** ☐ Age....................

2-Graduated within last: **5 years** ☐ **10 years** ☐

15 years ☐ **20 years** ☐ **25years** ☐

3-Degree Awarding Body: **university** ☐ **polytechnic** ☐

others..

4-Name of the university / polytechnic: (optional)

5-Title of the course :

6-Type of the course.

Sandwich ☐
Full Time ☐
Part Time ☐

7- How satisfied were you with the academic training during your study?

satisfied ☐ **moderately satisfied** ☐ **not satisfied** ☐

8-Do You agree that the objectives of Mechanical engineering education are to make graduates :

	agree	moderately agree	disagree
1- Competent of design of engineering components/systems	☐	☐	☐
2 - Capable of analysing complex systems for stress, stability, durability, instrumentation and control	☐	☐	☐
3- Have full Knowledge of various engineering Materials and thier useasbility	☐	☐	☐

4- Familiar with aspects of structure, management, economics, accounting and law in relation to companies	☐	☐	☐
5-Aware of environmental and social implications of industry	☐	☐	☐
6-Competent in written and oral communication including engineering drawing	☐	☐	☐

9-Your current position in your company is.

10-Is this your first job after graduation ? Yes ☐ No ☐
if not what were the previous jobs ? (write the last two).
1-
2-

11-Briefly describe your current duties and responsibilities ?

12-Did you receive any special training relevent to your current job ?
Yes ☐ No ☐

If yes for how long ?

was the training · In house ☐ External ☐

13-A- How do you think the education you received at the university prepared you for your current job ?

very well	fairly well	just satisfactroy	not very well	unsatisfactory
1☐	2☐	3☐	4 ☐	5 ☐

13-B- How do you think the education you received at the university prepared you for Membership of I E I.?

very well	fairly well	just satisfactroy	not very well	unsatisfactory
1☐	2☐	3☐	4 ☐	5 ☐

If the answer to question (13-A or B) is 3, 4 or 5 , why do you think the university failed to prepare you for your job :

Some of the Subjects were not entirely relevant ☐

Absense of adequate industrial training schemes ☐

Poor teaching methods ☐

other reasons..

14-Generally, were you satisfied with the methods of teaching in your classes ?

very satisfied	fairly satisfied	just satisfied	dissatisfied	very dissatisfied
1☐	2☐	3☐	4 ☐	5 ☐

15-What additional subject(s) if any, you had to learn after your degree course in order to perform your present duties?

Did you avail of any I E I run continuing education programme ?

yes☐ no☐

If NO, why not?

16-Are all the first year subjects and their syllabus contents which you have had at college essential to your current career ?

yes☐ no☐ don't know☐

If yes , to what extent it is essential (tick the appropriate percentage box below,the higher the percentage the more essential it is **) to your present job?**

20 to 40% ☐ 40 to 60%☐ **60 to 80%**☐ more than 80%☐

If no, which subjects, were not essential:
1-
2-
3-

17-How do you rate the relevance of the level of mathematics and science syllabus in your course ?

very relevant ☐
fairly relevant ☐
just relevant ☐
partially relevant ☐

18-How do you rate the teaching system which you have had of the subjects below? (express your rating in degrees from 0 to 10, 10 is the highest rating i. e very good)

	lectures	Tutorials	Laboratory	Industrial training	contact with staff
- Dynamics	☐	☐	☐	☐	☐
- Thermodynamics	☐	☐	☐	☐	☐
-Mechanics	☐	☐	☐	☐	☐
- Mathematics	☐	☐	☐	☐	☐
- Material science	☐	☐	☐	☐	☐
- Fluid Mechanics	☐	☐	☐	☐	☐
- Design	☐	☐	☐	☐	☐
- Strength of Materials	☐	☐	☐	☐	☐
- Computing	☐	☐	☐	☐	☐

- Ergonomics	☐	☐	☐	☐	☐
-Instrumentation & control	☐	☐	☐	☐	☐
- Electrical Eng. & electronics	☐	☐	☐	☐	☐
- Industrial manag -ement	☐	☐	☐	☐	☐
- Manufacturing systems	☐	☐	☐	☐	☐
- Manufacturing process	☐	☐	☐	☐	☐
- others (specify)					
-................................	☐	☐	☐	☐	☐
-................................	☐	☐	☐	☐	☐

19-Did you recieve any special education program (e.g. foundation or additional subjects?

20-What is your opinion towards cooperative education (on-the-job education, Sandwich Training) and its relevance to I E I Membership?

21-In your opinion how well did your lecturers relate their topics with practical examples?

22-Are you able to write computer programs? Yes ☐ No ☐

in what language?
Basic ☐
Fortran ☐
others .

where did you learn to do so properly?
at the university ☐
on the job ☐

23-In your current job or any other job you have had, indicate

i- for the following subjects the knowledge of which you have applied, substantially **by**
answering yes or no in colomn 1

ii-how relevant the subject is to your job **by**
answering 1 for (very relevant) 2 for (sufficiently relevant) 3 for (not so relevant) in colomn 2

iii-whether you had to take any additional course of the subject to be able to apply it in your job **by**
answering yes or no in colomn 3

iv-whether you had to consult your university lecture notes in order to perform your duties, **by**

answering 1 for (usually) 2 for (sometimes) 3 for (never) in colomn 4

v- the degree of importance of the subjects below to your job, **by means of points from 0 to 10. (10 is the highest rating) in colomn 5**

	1	2	3	4	5
- Dynamics	☐	☐	☐	☐	☐
- Thermodynamics	☐	☐	☐	☐	☐
-Mechanics	☐	☐	☐	☐	☐
- Mathematics	☐	☐	☐	☐	☐
- Material science	☐	☐	☐	☐	☐
- Fluid Mechanics	☐	☐	☐	☐	☐
- Design	☐	☐	☐	☐	☐
-Strength of Materials	☐	☐	☐	☐	☐

- Computing	☐	☐	☐	☐	☐
- Ergonomics	☐	☐	☐	☐	☐
-Instrumentation & control	☐	☐	☐	☐	☐
- Electrical Eng. & electronics	☐	☐	☐	☐	☐
- Industrial manag -ement	☐	☐	☐	☐	☐
- Manufacturing systems	☐	☐	☐	☐	☐
- Manufacturing process	☐	☐	☐	☐	☐
- others (specify)					
-.................................	☐	☐	☐	☐	☐
-............	☐	☐	☐	☐	☐

24-Do you usually attend meetings at higher level in your job?

technical meetings. Yes ☐ No ☐

managerial meetings. Yes ☐ No ☐

How do you rate your participation in those meetings?

technical meetings.

important ☐ moderately important☐ not important☐

managerial meetings.

important ☐ moderately important☐ not important☐

25-Do you think the knowledge you have obtained at the university was helpful to compete in the changing environment of the job?

technical knowledge	Yes	☐	No	☐
skills	Yes	☐	No	☐
decision making	Yes	☐	No	☐

Any general comments and proposals that may help to improve mechanical engineering education and training:

Thank you for your cooperation.

APPENDIX 2

Codes The codes refer to the questions and parts of questions in the questionnaire

Elements The elements are the possible answers for any question, for example, the question about the sex could be answered by either male or female, and therefore it contains two elements 1 and 2 respectively

Quantitative data data which are expressed in values within a known range, for example, age or the rating of the relevance of a subject

Qualitative data statements or data which are not possible to classify them as elements, although it is possible later to do so, for example, job description

Missing data when no answer have been provided and no logical assumption can be made the data is considered missing and (_) is entered for example if no answer was given to the sex question, the sex can be deduced from the name If the name is not given the data would be considered missing

Data collecting sheet for those who graduated within the last ( ) years

OBS	SEX	AGE	UNIV OR POLY	NAME	COURSE TITLE	COURSE TYPE	ACADEM-TRAINING	OBJECTIVES OF MECHANICAL ENG EDUCATION						CURRENT POSITION	1st job		Duties
CODE	1	1a	3	4	5	6	7	81	82	83	84	85	86	9	10		11
ELMNT	2	QND	3	QLD	QLD	3	3	3	3	3	3	3	3	QLD	2		QLD

ELMNT = elements QND= quantitative data QLD= qualitative data

OBS	special training			How education prepared you for			classes	Additional subjects you had to learn?	CONTINUING EDUCATION		1ST YR SUBJECTS			math & science	
	yes no	length	place	job	IEI	why not			YES NO	WHY NOT	essential	what extent	not essential		
CODE	12	12a	12b	13a	13b	13c	14	15	15a	15b	16	16a	16b	17	
ELMNT	2	QND	2	5	5	4	5	QLD	2	QLD	3	4	QLD	4	

ELMNT = elements QND= quantitative data QLD= qualitative data

How do you rate the teaching which you have had of the subjects below(rating from 1to 10)?

Design	mean																					
	staff	18DE5																				
	training	18DE4																				
	lab	18DE3																				
	tutorials	18DE2																				
	lectures	18DE1																				
Fluid mechanics	mean																					
	staff	18FL5																				
	training	18FL4																				
	lab	18FL3																				
	tutorials	18FL2																				
	lectures	18FL1																				
Material science	mean																					
	staff	18MS5																				
	training	18MS4																				
	lab	18MS3																				
	tutorials	18MS2																				
	lectures	18MS1																				
Math	mean																					
	staff	18MA5																				
	training	18MA4																				
	lab	18MA3																				
	tutorials	18MA2																				
	lectures	18MA1																				
Mechanics	mean																					
	staff	18ME5																				
	training	18ME4																				
	lab	18ME3																				
	tutorials	18ME2																				
	lectures	18ME1																				
Thermodynamics	mean																					
	staff	18TH5																				
	training	18TH4																				
	lab	18TH3																				
	tutorials	18TH2																				
	lectures	18TH1																				
Dynamics	mean																					
	staff	18DY5																				
	training	18DY4																				
	lab	18DY3																				
	tutorials	18DY2																				
	lectures	18DY1																				
OBS		code																				

How do you rate the teaching which you have had of the subjects below(rating from 1to 10)?

OBS	Materials strength						Computing						Ergonomics						Instrumentation & control						Electrical & electronics						Management						Manufacturing systems					
	lectures	tutorials	lab	training	staff	mean	lectures	tutorials	lab	training	staff	mean	lectures	tutorials	lab	training	staff	mean	lectures	tutorials	lab	training	staff	mean	lectures	tutorials	lab	training	staff	mean	lectures	tutorials	lab	training	staff	mean	lectures	tutorials	lab	training	staff	mean
code	18SM1	18SM2	18SM3	18SM4	18SM5		18CO1	18CO2	18CO3	18CO4	18CO5		18ER1	18ER2	18ER3	18ER4	18ER5		18IN1	18IN2	18IN3	18IN4	18IN5		18EC1	18EC2	18EC3	18EC4	18EC5		18IM1	18IM2	18IM3	18IM4	18IM5		18MF1	18MF2	18MF3	18MF4	18MF5	

How do you rate the teaching which you have had of the subjects below(rating from 1to 10)?

OBS	MANUFACTURING PROCESS						OTHERS ( )					
	lectures	tutorials	lab	training	staff	mean	lectures	tutorials	lab	training	staff	mean
code	18MP1	18MP2	18MP3	18MP4	18MP5		18X1	18X2	18X3	18X4	18X5	

			writing computer programs		
special education	Cooperative education	practical examples	yes no	language	where did you learn?
19	20	21	22	22a	22b
2	QLD	3	2	3	3

In your job indicate for the following subjects
1)applied knowledge 2)relevance 3)need for additional course 4)consult notes 5)importance

OBS	Dynamics					
	1	2	3	4	5	
code	23DY1	23DY2	23DY3	23DY4	23DY5	

Thermodynamics					
1	2	3	4	5	
23TH1	23TH2	23TH3	23TH4	23TH5	

Mechanics					
1	2	3	4	5	
23ME1	23ME2	23ME3	23ME4	23ME5	

Math					
1	2	3	4	5	
23MA1	23MA2	23MA3	23MA4	23MA5	

Material science					
1	2	3	4	5	
23MS1	23MS2	23MS3	23MS4	23MS5	

Fluid mechanics					
1	2	3	4	5	
23FL1	23FL2	23FL3	23FL4	23FL5	

Design					
1	2	3	4	5	
23DE1	23DE2	23DE3	23DE4	23DE5	

In your job indicate for the following subjects
1)applied knowledge.2)relevance.3)need for additional course.4)consult notes. 5)importance.

OBS	Materials strength						Computing						Ergonomics						Instrumentation & control						Electrical & electronics						Management						Manufacturing systems					
	1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5	
code	23SM1	23SM2	23SM3	23SM4	23SM5		23CO1	23CO2	23CO3	23CO4	23CO5		23ER1	23ER2	23ER3	23ER4	23ER5		23IN1	23IN2	23IN3	23IN4	23IN5		23EC1	23EC2	23EC3	23EC4	23EC5		23IM1	23IM2	23IM3	23IM4	23IM5		23MF1	23MF2	23MF3	23MF4	23MF5	

In your job indicate for the following subjects 1)applied knowledge 2)relevance 3)need for additional course 4)consult notes 5)importance

OBS	MANUFACTURING PROCESS 1	2	3	4	5		OTHERS ( ) 1	2	3	4	5	
code	23MP1	23MP2	23MP3	23MP4	23MP5		23X1	23X2	23X3	23X4	23X5	

Do you attend? technical meetings	managerial meetings	How do you rate? technical meetings	managerial meetings	helpfull Knowledge from the university to technical	skills	decision making	General comments
24a	24b	24c	24d	25a	25b	25a	26
2	2	3	3				