The Engineer Ought To Be A Man Of Business

B R Dickson
Department of Chemical & Process Engineering,
University of Strathclyde, Glasgow, Scotland, UK.

1. Introduction

During the first decade of the ***20th* century**, Dr Alex C. Humphreys, the President of the Stevens Institute of Technology, gave an address on '*Business training for the engineer*' in which he began with an axiom:

> "*Self-evident should be the truth of the proposition that the engineer ought to be a man of business, or at least informed of, and prepared to conform to, business conditions and business methods. Businessmen bankers, and manufacturers not infrequently refuse their confidence to engineers and experts as a class, because, under trial, some individuals have demonstrated their incapacity to meet business conditions; from the standpoint of the man of business, their reports, advice, conclusions have required interpretation and readjustment or amendment*."[1]

This paper shows how the University of Strathclyde's Chemical and Process Engineering uses business management material at both undergraduate and Master level to assist students in:

- Understanding how business decisions are made.
- How the role of engineers fit into companies.
- Promoting cross-functional business skills.
- Understanding the language of other business professionals.

and seeks to demonstrate that these activities provide additional skills to students graduating into employment.

It will also show that this course design meets a number of the requirements set out in the Quality Assurance Agency for Higher Education (QAA) Subject Benchmarks[2] (see Appendix 1 for the remit of QAA) suggesting that the following areas should be addressed:

- Business and management techniques.
- External constraints.
- Impact of engineering on society.

Finally lessons are drawn on how this approach can have wider consequences in teaching and learning.

2. Background

The University of Strathclyde, Department of Chemical and Process Engineering is the UK's largest teaching department by virtue of its intake of full and part time students into *Batchelor/Masters* programs. Part of that provision includes the only part time distance-learning course in *BEng in Chemical Engineering* and a *Masters in Process Technology and Management.* This latter programme developed in 1997, provides "a technical MBA" for engineers and scientists working in the UK's process industries and is increasing developing a worldwide audience. Our full course portfolio covers:

- *BEng in Chemical Engineering* for school leavers taught on a full time basis.
- *BEng in Chemical Engineering* for industry-based students taught by distance learning on a part time basis.
- *MEng in Chemical Engineering* for school leavers taught on a full time basis.
- *MEng in Chemical Engineering* for industry-based students taught by distance learning on a part time basis.
- *MSc in Chemical Processing* taught on a full time basis as part of the Faculty of Engineering's programme in Sustainable Engineering.
- *MSc in Process Technology & Management* for industry-based students taught by distance learning on a part time basis.
- *MSc in Chemical Technology & Management* for industry-based students taught by distance learning on a part time basis.

The MEng course is a first-degree course extended to provide depth beyond BEng level and requires a higher level of qualifications at entry from school leavers. The MSc courses are post-graduate level and normally require a good first degree for entry. It is the strength of this post-graduate Masters programme in terms of its industrial contacts, development of relevant and new course material bound in industrial practice that has had a significant impact on our undergraduate teaching programme.

The existing BEng & MEng course material has always provided underlining teaching and the development of Core Skills in:

- Communication and Presentation.
- Analysis and Numeracy.
- Information Technology.
- Planning and organization.
- Teamwork and Collaboration.
- Innovation and Creativity.

These are represented in the core Mathematics, Science and Chemical Engineering subjects through years 1-5, with a "business outlook" covered with a full module in *Process Economics* and attempts to bring in "commercial judgments" made in

Engineering Design Projects. (see Appendix 2 for a mapping of core skills to course modules)

Following the introduction of Engineering Council UK(UK-SPEC),formerly SARTOR regulations (see Appendix 1) in 2002, which developed new standards for "the professional engineer", the full time programme was extended to MEng level to allow the meeting of corporate membership requirements of IChemE. This programme provides additional "depth and breadth" of taught materials as well as further project design teaching. As part of that extension in curriculum, use is made of advanced chemical engineering modules from the existing postgraduate MSc in Process Technology & Management programme to meet that additional demand for "depth", and as result, MEng students receive current industry specific technical subject material in their programme.

However, as part of ongoing course review procedures, three factors influenced a further change of course delivery:

- Recognition that school leavers have an incomplete view of how a course in chemical engineering will lead to a career in the process industries.
- Feedback from graduating students on their performance at job interviews.
- End-of-year course assessment suggesting limited choices of optional modules in year five.

As a result of this process, two new modules have been introduced into the degree programme

- A second year class in "Business Management Practices".
- A fifth year (for MEng students) class in "General and Strategic Management".

These further reviews of the programme having centered on the "breadth" of the programs and providing the full time degree program with topics that will provide students with opportunities to be "job ready".

3. Module Descriptions and Teaching Practices

3.1 Introduction

It is worthwhile saying at the outset that an underlying thought throughout the module design here, is based upon the author's experiences' of managing the distance-learning programme *MSc in Process Technology & Management*.

This programme is designed to meet the needs of the chemical and process industries and focuses on generic and core aspects of Process Technology, Management/Business and IT. It also aims to provide networking experiences, and transfer of technology, between the delegates. It is a part-time, modular, Master's level training program run as a partnership between businesses and universities, offering a wide range of highly adaptable, industrially relevant courses. These courses are structured so that they are easily tailored to individual needs and enhance the contribution of the individual 'delegates' to their companies. The overriding objective is to enable delegates to perform their jobs better by continuing their professional development. The courses are designed not only to impart relevant technical knowledge, but also the management skills necessary to make the most of that knowledge. (See http://www.strath.ac.uk/Departments/ChemEng/igds/main.html)

In reviews of student performance in the management modules in these MSc programs (which are equivalent to MBA business topics), particularly the Major project, which integrates teaching across the three subject areas of Process Technology, IT & Management, there was a demonstrated weakness in some individuals who had graduated from other universities and who were often in their second promoted level of post in their company. Many still seemed to fail to link the importance of the firm's technology drivers with its overall business objectives and a view looking towards customer needs.
This weakness in students from other universities represented an opportunity to make an early impact in these business subject areas with our own graduating students and the main driver was seen as way of making sure that "our outputs" were meeting that "job ready" requirement and perhaps ahead of the competition from other universities.

3.2 Business Management Practices (2nd year)

This module looks at

- How Firms Operate
- Business Functions within the firm
- An 'Engineers' Role in the Firm
- Business Ethics
- Managing People
- Finance Management
- Marketing Management
- Operations and Distribution

The teaching practice here, is based on the use of an Open Learning text book with defined weekly readings and a corresponding one hour lecture that translates general principles into concepts that are embedded in the process engineering sector.

Typical examples might be

1. A reading on "Leadership Styles" matched with a video interview of Richard Branson from the Virgin Group and an article on John Brown, CEO of BP – the students then write a essay comparing all three aspects.
2. A review of Corporate Mission Statements from an internet search and then a review of corporate responsibilities using published material from the Chemical Industries Association.

A significant feature the interactive nature of the module, is the use of recent graduates for the MSc course, who by this point in their career will be in their 2nd or 3rd posting – and in their presentations, they relate their career exposure to relevant business functions and the lecturer links this back to course text. This adds "live" industrial relevance to the teaching and develops career models for the students to reflect on. Again assessment here is a further reflective essay on lessons learnt that students would take forward in their future career.

The final major exercise is a group communications presentation for the *Exxon sponsored Prize.* Students are briefed that

1. They must make a group presentation on a marketing topic (generally industry related).
2. There is a prize of $350 for the best group.
3. They must form their own teams reflecting that large teams provide more resources but smaller teams achieve greater individual shares from any win.

An interesting outcome on this activity is that males will tend to form small groups of 2/3, females will settle on 4 members and mixed groups are generally 5/6 individuals, and to date no small all-male group has won.

This activity brings together all the elements of industry specific research, business and technology issues and are brought together in the core skills of:

Communication & Presentation	Analysis & Numeracy	Information Technology	Planning & Organization	Teamwork & Collaboration	Innovation/ Creativity

What do the students learn? (1): In their own words-

> *"Chemical engineering is an extremely diverse discipline and therefore it should come as no surprise that the chemical engineer requires an extremely wide range of skills. A thorough knowledge of chemical behavior, the problem solving nature of designing a fully functional, industrial sized plant and the ability to work safely and efficiently are but a few important examples of this. The purpose of this article is to deal simply with the skills the chemical engineer requires to successfully contribute to business performance. It will refer specifically to recent presentations given in class on "Business Development", "Managing Chemical Engineering Projects" and "Chemical Engineering in the North Sea" and finish by suggesting one key skill stressed in all three presentations as being vital for chemical engineers in their contribution to business performance… it is essential that teamwork and communication are placed with the highest value."*
>
> Christopher Traynor

> *"Chemical engineers, as with most employees, will tend to have a broad knowledge of various aspects of the company; standard knowledge such as its background– its track record, how it is perceived, the resources it has available and the employees – as well as the culture of the organization and how adaptable it is to change and innovative projects. They are involved in technical roles and so will have a good working knowledge of the products and services the company provides, its strengths and weaknesses in these areas, and also about the limitations the company will face in producing these products and new products. Being from a technical background means that they will be aware of the available resources and how they are utilized, and also of the experience of the company and its employees in different projects/processes."*
>
> Susan Love

3.3 General & Strategic Management (5th Year)

This main theme of this module is one of *Business Policy & Approaches to Strategy*. It looks at business ideas, the mission of the organization and environmental and industry analysis. It then uses models of internal assessment and traditional strategy models to review corporate direction and strategic choices.

This is done by a series of readings taken from the University of Strathclyde's Business School *MBA Programme* (again a module replicated from the *MSc in Process Technology & Management*) which is then applied to a Business Simulation taken over a period of 3 days. Here groups of students act as a company management team and their performance is measured in two ways:

1. Justification of their decision-making and use of strategic models.
2. The company's reported share price.

Assessment is a group mark (which is partially competitive) and then an individual reflective essay of how the group performed as a team and its use of strategic decision-making models.

What do <u>the students</u> learn? (2)

The use of a Strategy analysis case study provides to the students:

1. A replica of the assessment process that they will experience at graduate recruitment.
2. A realization of the balance that companies need to achieve when making in investment decisions
3. That a company's first objective is that of keeping cost under control

The student feedback here is set out above in a review session at the end of the workshop and a measure reported as

> "*A 46% improvement in their understanding of how to run a business*"

and a particular lesson,

> "That R&D and Marketing decisions can only be made from a sound profit base"

<u>3.4 Conclusion from students feedback and module reviews- i.e. what do we learn?</u>

Our immediate conclusions are based on questionnaires issued at the end of each teaching session and give clear answers suggesting:

1. That school leavers are a very uncertain of what awaits them in their career choices
2. That by exposing 2nd year students to views on their future potential role in industry gives them more confidence in their course choice
3. That traditional degree programs are tied in processes rather their industries applications

4. Graduate engineers with high numeral and analytical skills can also make sound business managers if given scope to experience the role.
5. We can successfully integrate MBA material into mainstream engineering programs.
6. The practices shown here are good examples of the Kolb[3] Learning cycle, in that presenting students with experiences and making the assessment a reflective exercise, leads to a greater understanding of the required core skills they will display as technical managers in the future.

4. Concepts in Module Design

The opportunity to reflect on what is achieved in the delivery of course material and how it matches with the original development module material is paramount in course management. A useful tool to consider in this evaluation is the taxonomy developed by **Bloom**[4]. He suggests that six levels of learning exist, covering a range from *Factual Learning*, through to *Evaluating Information.*

Table 1: Bloom's Taxonomy of Learning

Level	Definition	Possible evidence
Knowledge	Student remembers or recognizes information/ ideas/ events in the approximate order and form in which they were learned	Student quotes from the text, copies a relevant diagram, refers to an author, encloses relevant documentation, writes a list
Comprehension	Student translates, interprets information, grasps the meaning, identifies key points	Student summarizes events, writes a précis of the text, paraphrases, explains
Application	Student selects, transfers and uses ideas in situations that are new, unfamiliar or have a new slant	Student uses course ideas to explain events, judge the effects of actions or interpret the causes of events,
Analysis	Student breaks the material down into its component parts and relates assumptions, evidence, events to structure	Student uses course ideas to structure events or situations in the workplace, uses annotated diagrams, compares and contrasts, points out differences
Synthesis	Student combines ideas in a new way	Student makes links between two or more course ideas, redesigns diagrams to better fit a real situation, makes recommendations for action, develops a plan or makes suggests changes to an existing way of working
Evaluation	Student appraises, assesses or judges the value	Student identifies what they have learned about themselves, others or the organization as a result of the analysis, shows understanding of the relative importance of an idea and its components, criticizes theory or supports it

It could be suggested that to be successful in course design, there is a need to achieve recognizable levels of attainment to the levels of "analysis-evaluation", since that demonstrates application of course learning. If this does occur, that will begin to address the three initial objectives for our course changes set out previously, of being able to act as "business orientated" engineers.

Ultimately most of our graduates go into industry and therefore a measure of our own success could be how we match the requirements of industry. Our best graduates find jobs easily in the main but the 2nd / 3rd quartile met more competition from other universities and the key to our own graduates success must be in fitting the recruiting companies requirements. These requirements are often difficult to quantify and match directly back to degree programs. Close questioning of graduate recruiters directed the author back to their company web-sites, which gave typical examples of the output that "*we(they) would expect to see in potential recruits*",

> **EXXON**
> *A high level of academic achievement. The desire to contribute, realize your potential and exceed your expectations. A high level of personal ethics, innovation and creativity. Intelligence, tenacity and sound judgment. A track record of demonstrating leadership and teamwork capabilities. Sound analytical skills and an eye for detail.*
>
> **ICI**
> *We are looking for driven candidates who can think strategically. You must have excellent interpersonal skills, as you will be expected to deal with internal contacts from Senior Managers to shop floor. You will be an excellent team builder and team player with the ability to work under pressure.*
>
> **GSK**
> *Alongside sound technical ability, we are looking for good interpersonal skills - an ability to work effectively with others at all levels, to operate as part of a team, to challenge existing practice and be prepared to take a leading role to get things done.*

What seems to be common across all of these recruitment requirements are skills in:

1. Judgment.
2. Innovation.
3. Teamwork.
4. Interpersonal.

In linking these skills back to the theme in this paper and how the can be linked to module outcomes, it could be appropriate to mirror them in Bloom's taxonomies as:

Analysis- student uses course ideas to structure events or situations in the workplace

Synthesis- makes recommendations for action, develops a plan or makes suggests changes to an existing way of working

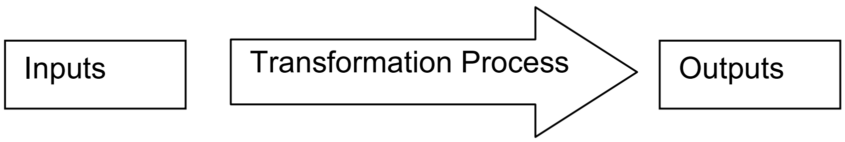
Evaluation- student identifies what they have learned about themselves, others or the organization as a result of the analysis

A conclusion here might be that the Module Learning Outcomes set out in the original design could be taken as direct comparisons with these industry demands, if we use the Bloom taxonomy as the comparative tool.

5. Is There a Final Lesson Here?

The author is happy to put forward a view not perhaps shared by all his colleagues, since it seems to cross over traditional aspects of who is the customer in the academic market place. The argument suggested goes beyond the view that the student is the customer and towards a view that the student is "**the product**".

Why might this be the case? As academics, we carry out a process of transformation



i.e. take in raw material, add knowledge and produce graduate engineers for the customer, i.e. industry.

That final product has:

- Quality mark- degree award
- Specification- degree subjects
- Brand image- University name
- Price- starting income

i.e. The conventional 4 Ps from marketing of *Product, Place, Price & Promotion*.

Can we therefore say that in fact we serve three customers?

- **The student**
- **Industry**
- **The university**

and by "*satisfying*" the first two, we maintain the prominence of our "manufacturing facility (*faculty?*) and its eminence in the market place.

Conclusions- What do we learn? (2)

1. Chemical Engineering courses can be fun too
2. That mapping Blooms taxonomy against module outputs may be viable and a consistent approach to module design.
3. We might be closer to the "holy grail" of satisfying industries' perceived demands than we think by taking the approach of developing:

"*The Engineer Ought To Be A Man Of Business*"

References

(1) Taken from J.IRWIN "Early 20th Century Advance to Young American Engineers": Engineering Science and Education Journal – December 2001
Source: Addresses to Engineering Students (Waddell and Harrington, Consulting Engineers, Kansas City, Missouri, USA, 1911)

(2) http://www.qaa.ac.uk/public/srhbook/contents.htm

(3) KOLB DA (1984) Experiential Learning: experience as the source of learning and development, New Jersey: Prentice Hall

(4) For an overview of BLOOM's taxonomy and its application, see
D'ANDREA V. (2003) "Organising teaching & Learning: Outcomes-based Planning" in FRY H. et al "A Handbook for Teaching and Learning in Higher Education: Enhancing Academic Practice (2^{nd} Ed), London: Kogan Page
or
BLOOM B.S. (Ed) (1956) Taxonomy of Educational Objectives: The Classification of Educational Goals: Handbook 1, Cognitive Domain. New York and Toronto: Longman Green

Appendix 1: UK-SPEC & QAA Definitions

(a) Engineering Council UK

The engineering profession in the United Kingdom is regulated by the Engineering Council UK(ECUK) through 35 engineering Institutions (Licensed Members) who are licensed to place suitably qualified members on the ECUK's Register of Engineers. The Register has three sections: Chartered Engineer, Incorporated Engineer and Engineering Technician.

UK-SPEC is the standard for recognition of professional engineers and engineering technicians in the UK. The standard is published by ECUK on behalf of the engineering profession.

Formal education is the usual, though not the only, way of demonstrating the underpinning knowledge and understanding for professional competence.

The following qualifications exemplify the required knowledge and understanding required of a Chartered Engineer

an accredited integrated MEng degree.

or

an accredited Bachelors degree with honours in engineering or technology, plus either an appropriate Masters degree accredited or approved by a professional engineering institution, or appropriate further learning to Masters level

see: http://www.ukspec.org.uk/files/CE_IE.pdf

The ECUK is the UK signatory to the Washington Accord - an agreement which provides a mechanism for mutual recognition between signatory bodies of Engineering education accreditation processes. Each member of the group of eight countries involved has expressed its confidence in the Quality Assurance processes of the other seven countries. By extension this leads to the effective mutual recognition of accredited Engineering Degree courses, and, generally, to exemption from the education requirement for practicing in each of the signatory countries.

The ECUK fellow signatories include:

- The Accreditation Board for Engineering & Technology (ABET),

(b) The Quality Assurance Agency

The Quality Assurance Agency for Higher Education's (QAA) mission is to safeguard the public interest in sound standards of higher education qualifications and to encourage continuous improvement in the management of the quality of higher education.
They were established in 1997 and are an independent body funded by subscriptions from universities and colleges of higher education, and through contracts with the main higher education funding bodies.

To achieve its mission, the Agency works in partnership with the providers and funders of higher education, the staff and students in higher education, employers and other stakeholders, to:

- Safeguard the student and wider public interest in the maintenance of standards of academic awards and the quality of higher education
- Communicate information on academic standards and quality to inform student choice and employer understanding, and to underpin public policy making
- Enhance the assurance and management of standards and quality in higher education and promote a wider understanding of the value of well-assured standards and quality
- Promote a wider understanding of the nature of standards and quality in higher education, including maintenance of common reference points, drawing on uk, other european, and international practice

see: http://www.qaa.ac.uk/aboutqaa/aboutqaa.htm

Appendix 2: Current BEng/MEng Course Profile Skill mapping

	Communication & Presentation	Analysis & Numeracy	Information Technology	Planning & Organization	Teamwork & Collaboration	Innovation/ Creativity
1st Year						
Core Engineering Mathematics 1		*				
Vectors, Matrices and Numerical Methods		*				
Foundation Chemistry		*				
Physical and Organic Chemistry		*				
Basic Principles in Chemical Engineering	*	*			*	
Intro to Chemical and Process Engineering		*			*	
IT and Graphical Communications	*	*	*			
2nd Year						
Algebra and Calculus 3		*				
Algebra and Calculus 4		*				
Foundation Engineering Mechanics		*				
Process Thermodynamics		*				
Process Analysis 1		*			*	
Process Heat Transfer		*				
Process Fluid Flow		*				*
Chemical Engineering Practice	*	*	*	*	*	
Business Management Practices	*	*	*	*	*	*
Introduction to Process Biotechnology		*				

3rd Year						
Biochemical Engineering		*		*	*	
Process Analysis 2		*				
Safety and Loss Prevention	*	*			*	
Reactors		*				
Computer Applications	*	*	*			
Separation Processes 1		*			*	
Separation Processes 2		*				
Food Process Engineering		*			*	
Plant and Process Design	*	*	*	*	*	*
Chemical Engineering Practice	*	*	*	*	*	
4th Year						
Chemical Engineering Design	*	*	*	*	*	*
Chemical Engineering Project	*	*	*	*		*
Air Pollution Control		*				
Water Pollution Control		*				
Process Analysis 3		*				
Process Control and Instrumentation	*	*	*	*	*	*
Process Economics	*	*			*	
Transfer Processes 1		*				
Separation Processes 3		*			*	
5th Year						
Chemical Engineering Design	*	*	*	*	*	*
Safety and Loss Prevention 2		*				
Process Control and Instrumentation 2	*	*	*	*	*	*
Biochemical Engineering 2		*				

Membrane Technology	*	*	*	*	*	
Chemical Engineering Project	*	*	*	*		*

Appendix 3: Business Management Module Descriptors

Business Management Practice

Objectives

By the end of the course the student should: -

- understand how the chemical process industries work and are structured.
- understand how they operate within and are affected by market forces.

Contents

- How Firms Operate
- Business Functions
- An 'Engineers' Role in the Firm
- Business Ethics
- Managing People
- Finance Management
- Marketing Management
- Operations and Distribution

Syllabus

Nature, structure and scale of the process industries; raw materials, products and markets; competitive issues and drivers for innovation and development; human resources and their development; case studies.

Course text: *Business Functions*, Open Learning Foundation, Blackwell 1998, 0631201777

Assessment

Class work (50%) and Exam (50%).

General & Strategic Management

Objectives

To consider strategies adopted by organizations and to relate these to the processes that influence the way in which companies undertake problem solving and decision making that lead to competitive success. To explore ambiguity in the process of strategy making and organizational action under uncertainty.
To explore the practice of dealing with ambiguity in business decision-making and to develop skills to enhance effectiveness in an organizational context.

Outcomes

By the end of the module students will be able to:

- Realize that organizations can only be understood from a mix of disciplines. The course aims to enable students to action theoretical knowledge through inter-functional integration,
- Use tools and techniques available to the student for analyzing problems, issues and options, and conducting a process aimed at reaching conclusions through action in an organizational setting,
- Conduct business analysis and use appropriate presentational methods in discussions on strategy,
- Understand the dimensions of rational analysis and institutional intervention in creating successful organizations,
- View business problems from various different perspectives,
- Consider a variety of responses to business situations

Contents

Business Policy: Approaches to strategy. Business ideas and the mission of the organization. Environmental, and Industry analysis. Internal assessment. Traditional strategy models. Corporate direction. Strategic choice. Strategy analysis case study. Collection of cases studies.

Teaching and Learning Methods

Text-based self-study material. Case studies.

Assessment

Case Study Report 50%. Group Activity 50%.