EXTENDED GROUP DESIGN ACTIVITIES FOR THE ENTERPRISE SOCIETY

Graham Outram[1], **Clive Stevens**[2] **and Stephen Culley**[1]
[1] Department of Mechanical Engineering, University of Bath
[2] Euronova Ltd

ABSTRACT

Design is commonly thought of as an activity to convert an idea into something tangible. Typically students are set a technical "design task". However in the modern world the business and enterprise dimensions of design are becoming increasingly important.
This paper sets out to describe design as an activity which is a combination of different strands working synchronously on both the technical and commercial aspects of a new product or system creation.
An effective, innovative design requires state-of-the-art knowledge from diverse sources including suppliers of materials and components, manufacturing techniques, customers, competitors and enterprise stakeholders. Knowledge must be collected from both the technical and commercial spaces associated with the particular project. This is difficult in the undergraduate situation, particularly that knowledge associated with the business side.
This paper describes an activity in which students can simulate such a total design project and can understand the importance of business and of communicating with others who may own different but relevant knowledge. The focus of the paper will be how the elements are brought together to produce a coherent design based 'Business Plan'.

Keywords: game, enterprise, business plan

1 INTRODUCTION

We intend to show that engineering design is an integral part of a dynamic system subject to many influences. Since such design is thought to be an essential activity in the knowledge economy [1], innovation will derive in large part from the agile smaller enterprises. Being part of these young enterprises, where the resources are limited, the design engineer will need to collect knowledge from a number of different domains in order to produce winning products.
It is our contention that such enterprises will demand commercially astute designers, if not entrepreneurs in their own right. We describe how we make the student aware of these many influences and impart such knowledge to the undergraduate mechanical engineer.

2 ENGINEERING DESIGN WITHIN AN ENTERPRISE

A product creating enterprise will need specific knowledge in a number of key domains if it is to both create commercially successful products and flourish (Figure 1).

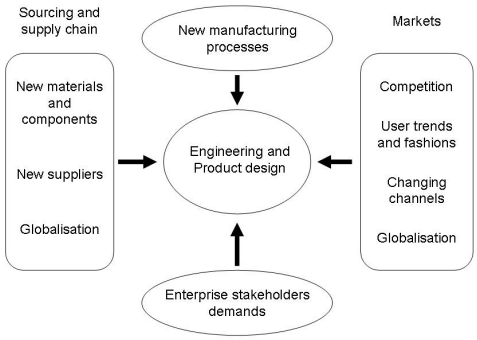

Figure 1 Knowledge Domains

Agility is essential to a successful enterprise. New opportunities will arise as others disappear. The introduction of new products by competitors and changing channels to market will require a response. Fashions and regulation will dictate modifications to the specification. Materials and components will affect the input costs and the product design will have to account for these changes. New technology will impact both the source of components and the manufacturing processes. Globalisation necessitates an awareness of opportunities and threats from all quarters.

Whereas many engineering courses include reference to Integrated Product Development [2] and a requirement for knowledge of markets and production, the astute engineer should have knowledge relating to all these domains in order to effectively change the products or process to meet every challenge, plus the demands of the enterprise stakeholders.

Here we describe how we make the student aware of these requirements and how to gather and use the knowledge of the different elements: sourcing and supply chain; manufacturing processes; markets and stakeholders' demands.

The process of gathering such knowledge together with its exercise and assessment is woven into a number of activities within Group Projects and described in subsequent sections.

3 STUDENT GROUP PROJECTS

The major focus of the group design activity is the technical design and this is briefly summarised below. Nevertheless the business aspects have been integrated in, arguably, a unique way, especially dealing with the group set up, the pump priming or introductory lectures, the "design/manufacture/trade" business game, the integrated business plan and the requirement for mentoring.

3.1 Group set up

Learning how to gather this knowledge is undertaken whilst participating in group activities, where, in addition, the students learn about team work and project

management. An element of this is the process of establishing well balanced and effective groups which is aided by the formal use of Belbin tests to make the overall experience effective [3]. All students complete a Belbin test which enables them to reflect on their perceived strengths and weaknesses. They will understand that the best performing teams will include a mix of profiles, and, so far as is practical, the teams, each comprising about 6 students, are selected to achieve an appropriate mix. Ideally a mixture including leaders, innovators, evaluators and finishers would be chosen, and in the current year of some 14 groups it was possible to achieve this with 8 of them. It is our intention to monitor the progress and attempt to correlate the team performance with the mix of profiles. To further support the team effectiveness some time is set aside for team building exercises. The groups are then assigned projects with very open briefs to allow a wide variety of solutions. Groups are provided with opportunities to reflect on their performance and are supported both to resolve issues and improve their overall effectiveness.

3.2 Technical Design

This is a brief introduction to the technical side of the project which has been described previously [4, 5] and there are a number of examples of other good practice in the area. What is key in this paper is the integration of the enterprise and business agenda.

A group project brief is deliberately broader than the student has been used to. For example "Company X which makes machines to pack frozen vegetables considers that there is a market for a machine to include varying portions of sauce into ready made meals. They would like to look into the feasibility of producing such a machine and recommend a design".

The team is expected to appoint a leader, who may be suggested on the basis of their Belbin profile. They have to then decide on the steps to be taken, which will include an analysis of the customer requirements and competitive products, and a definition of constraints due to manufacturing capability. The tasks are then divided between the members. Detailed market research is undertaken and customers consulted to inform the design of the machine or product. The patent databases are interrogated. It is expected that personas are defined to represent the profile of the user or customer for the product, and, if appropriate, corporate values - such as 'green-ness', 'ethical', 'traditional' etc - are identified and incorporated into the design or image of the product [6], and a feasibility report written. This is followed by a more detailed technical report from which the specification emerges and a recommended solution arrived at. Whereas students are expected to evaluate the performance of their final design against the initial requirements, experienced engineers talk to the students in detail about their solution and provide feedback. This activity is sponsored by the Smallpeice Trust.

3.3 The 'Business' Lectures

These group projects are introduced in the penultimate year of a four year Masters Degree course and lasts for a period of 15 weeks. At the start students attend some 25 hours of lectures interspersed with tutorials and interactive games. Most lectures are given by external practitioners drawn from lawyers, patent agents, accountants together with 'city' banks and entrepreneurs. Subjects include organisation, finance and accounts, marketing, law, intellectual property, enterprise, risk management and then the more directly applicable topics of user centred design, creativity, generation of new ideas and the importance of branding. The students are exposed to enterprise and it is

hoped that we ignite a latent entrepreneurial spark so that they may follow the example of others [7] or more simply apply the enterprise culture within the larger organisations.

3.4 The Business Game

This is a game that exercises the knowledge gained in the supporting business lectures and demonstrates decision making and financial control. It is a unique interactive game that combines business, manufacturing and supply chain issues. The detailed instructions are made available (Figure 1) and the Department is in the process of commercialising the game itself.

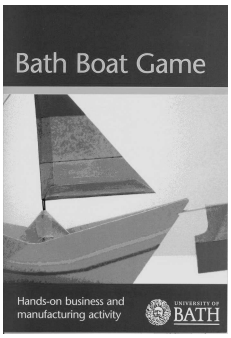

Figure 2 Bath Boat Game™

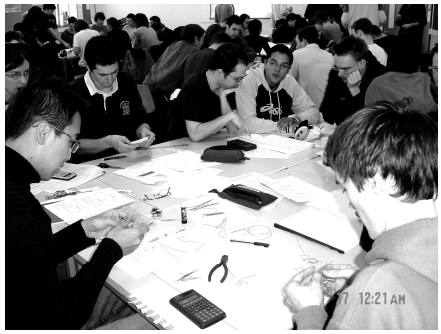

Figure 3 Participation in the Bath Boat Game™

Participants have to plan, manufacture, cost, trade and negotiate in a real time interactive environment. This is the closest that the students get to the real live complexities of modern business in the classroom.

The facilitator commissions the supply of paper sail boats from a number of reputable boat builders. These builders assemble boats using essential components: the hull, sail and rudder. They seek quotes from suppliers and negotiate terms of supply. Each of the manufacturers, both builders and suppliers, need to buy capital equipment and materials for production.

Each group of students represents a manufacturer. They are arranged as a company and appoint directors and production workers (Figure 3). Finance is provided by the issue of shares.

Details of salaries, equipment and material costs are provided to the companies. These are used to calculate unit costs for different quality of boat at various production rates. The calculations are then used in the sales/purchase negotiations. Once the contracts are secured manufacture commences. Materials and components are purchased and sales made throughout the supply chain. A minute represents a month and the game may be run over several "years". At the end of each year the financial director presents a full account of profit and loss for the period and a balance sheet. The game can be run under differing circumstances – a lead time may be included or not, the supply chain may be confined to certain suppliers (as in the defence industry) or not, the builders may provide competitive tenders etc. The game can be played with any multiple of 4 groups – from about 25 to 200 students – and is normally run over two 2 hr sessions. The most successful team will record the best gross margin and return on investment. This team will generally be the one where the members of the team have agreed an effective strategy between themselves before testing it against the competition.

In this exercise, the student gains knowledge relating to sourcing and the supply chain, the business of trading in the market, how to compute costs and margins and how capital, sales and costs are incorporated into reporting accounts.

3.5 Business plans

In parallel with the technical design each group set up a fictitious enterprise to make and sell what they are designing. In order to do this they set up business roles.

The *Business Manager* will chair the discussions about the business and ensure that the tasks are integrated and carried out satisfactorily by the due dates.

The Marketing Manager is responsible for market research and analysis - gathering information from the market place about what the customer wants, how to differentiate the product from existing offerings, define the profile and population of the potential customers and how much they are prepared to pay for the product or service.

Working closely with the Marketing Manager, the *Sales Manager* determines the channels to market, the selling strategy including advertising and promotion, the resources required and forecast the amount of sales over time.

Based on the customer requirements suggested by the Marketing Manager, the *Product Manager* describes the requirements of the product, the particular features and benefits that the product offers to potential customers, and provides estimates of the cost of the product, how it is to be delivered and, where applicable, the ongoing service requirements. This is linked closely to the detailed technical design which the group works on at the same time.

The *Operations manager* is responsible for describing how the product is to be manufactured or delivered. This includes the sourcing of components (in conjunction with the product manager), what facilities are required, including buildings and capital equipment, and the cost of the operation.

The *Finance Manager* draws on the information provided by the Sales Manager, Product Manager and Operations Manager to produce a cash flow forecast, estimated profit and loss accounts and balance sheets. They are expected to include an analysis of sensitivity to a number of risks. The Finance manager also determines how much funding will be required, in what form and what returns an investor can expect.

Each student concentrates on their task, and writes their own section to be incorporated into a combined Group Business Plan. It is a requirement that each individual section is written concisely, succinctly and comprehensibly. The style is lighter and aimed at the busy executive who is unfamiliar with the topic. Undergraduate engineering students are not used to writing in this style, and it is considered crucial to add such capability to their communications skills.

The Business Plan element of the Group Design Project enables the student to exercise what was learned in the preliminary lectures and discover how to integrate the product design into the wider context of an enterprise.

In addition to the formal report, each group is required to make a presentation as if to pitch for finance from banks and venture capitalists. In doing this they learn to distil the most important points from a larger body of data and to describe their proposition in a compelling and persuasive way. This is a very useful exercise for the engineer who may be used to thinking that the critical characteristics of their design is the elegance of the technical solution, and yet in reality, although this is a bonus, it is actually about how the solution fits the requirements of the marketplace and whether the complexities of manufacture and selling have been thought through. The student is encouraged to reflect on these issues and how they impact on their designs.

3.5.1 Business mentoring

This is difficult territory for students whose primary focus is technical. There are a lot of new and difficult concepts to assimilate: market share, team dynamics, routes to market, financial assessment strategies, controlling IPR and so on. To address this, the lectures, case studies and the engineering business game described above introduce the key concepts and start to make them come alive. But in addition a number of business mentoring activities are introduced at a group level so that the key elements listed above can be discussed and most importantly rationalized in the context of the *particular* project being undertaken. This is critical as all the projects will be different in terms of domain of activity, size and nature of the engineering design work being undertaken.

4 CONCLUSIONS

It is argued that business awareness and a spirit of enterprise are important aspects of engineering education and the enterprise agenda has been highly promoted. In addition the world is littered with products and systems that show a lack of awareness of the commercial element. In fact it has been stated on more than one occasion that "there are good designs and successful products and they are not the same thing"

The question is how do you incorporate the commercial element within an engineering design context. This paper describes the integration of these aspects with a long established design activity. However a number of critical elements have been introduced to build on the basic concepts. These are the use of a self contained business game that has a clear engineering (i.e. making and trading) dimension to it, and the requirement for a business plan that relates directly to the machine, product or system being designed.

REFERENCES

[1] Griffiths R. and Cater B., Design Education: Ensuring course content and delivery is relevant to the needs of industry. In Educating Designers for a Global Context, Hadleys Ltd 2006.

[2] Ottosson S, Integrated Product Development in Engineering Education. Product Development in Engineering Education, University of Limerick 1994.

[3] Morris L. and Wielkopolska J., Connecting Technolohy to the Marketplace. In Crossing Design Boundaries, Taylor and Francis 2005.

[4] Medland A.J., Culley S.J. The role of design within a 4 year MEng Programme. IEE Colloquium – The teaching of design concepts in higher education, March 1999, London.

[5] Culley S.J. and Mileham A.R., The integration of design and business issues in the engineering curriculum. Proc 24th SEED Annual Design Conference, and 9th National Conference on Product Design Education, pp37-42, Editors Evatt, M.A.C.; Broadhurst, E.K. Publishesr PEP Ltd. ISBN 1-86058 397 0 2002.

[6] Barber P., Developing and assessing group design work; a case study. In Crossing Design Boundaries, Taylor and Francis 2005.

[7] Hudson G. and Eason M., Supporting student enterprise and product commercialisation – a case study. In Crossing Design Boundaries, Taylor and Francis 2005.

Graham OUTRAM
University of Bath, Bath, BA2 7AY
r.g.outram@bath.ac.uk
+44 (0) 1225 386570