USING PRODUCT DESIGN APPROACHES TO ENHANCE INNOVATION AND ENTREPRENEURSHIP IN ENGINEERING DESIGN EDUCATION

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ABSTRACT
The paper reports on the results from two surveys conducted following a lecture and workshop programme to improve engineering students' understanding of how product/industrial design approaches can help the development of successful products.

Keywords: product / industrial design, engineering design, entrepreneurial skills

1 INTRODUCTION
Driven by various European and UK national education strategies [1] relating to the development of skills to help students thrive in the global knowledge economy, the University of Bath is developing Enterprise Education through a number of initiatives. The university aims to develop students' entrepreneurial skills of tenacity, independence, innovation, imagination, risk-taking, creativity, intuition and leadership (see figure 1). Using the skills listed, it is possible to assess to what extent existing courses include activities that might enhance those skills in students.

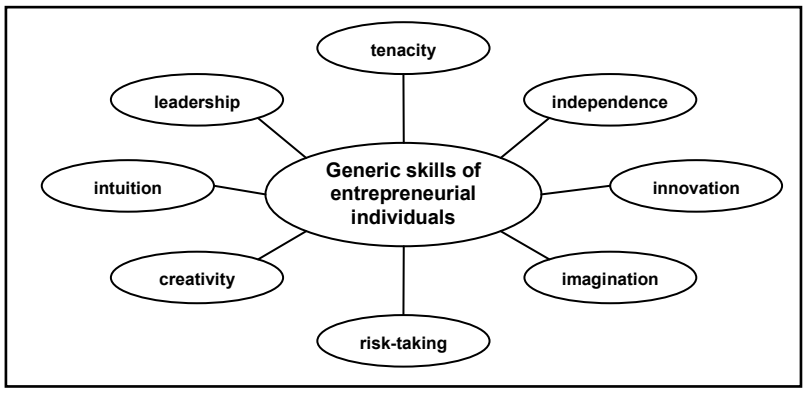

Figure 1: Generic skills of entrepreneurial individuals, after [2].

From a background in product/industrial design, the author observed some fundamental differences in the approaches to design teaching. Figure 2 shows how one guest lecturer summarised the differences in design approaches between engineering design and product/industrial design [3].

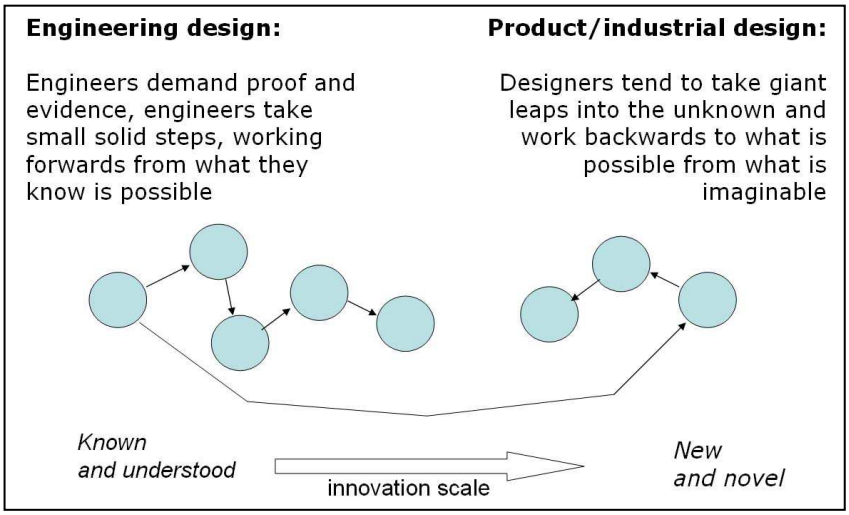

Figure 2: Differences in design approaches [3]

Engineering designers tend to work forwards from the brief, exploring constraints and delivering evidence for design decision making. Within this forwards process, there are several stages of divergent thinking (generating multiple creative solutions) and convergence (selecting the best solutions). This way of working fits with commonly adopted industrial models of New Product Development, such as 'stage-gate' development processes. Product/industrial designers on the other hand, tend to work backwards. Their first reaction to a brief is to generate imagined ideal solutions that might be rather futuristic and unattainable. They then work back from those concepts towards a final solution by exploring technologies available and applying constraints and data at later stages in their process. Jones [3] argues that this model shows how the product/industrial design approach might deliver more innovative solutions: their final solutions are likely to be situated further to the right on his innovation scale.

These two processes require different skills emphasis. For the engineering design approach the attributes of tenacity, independence and persistence are needed to achieve the most innovative results: to drive the design solution as far to the right on the innovation scale as possible. For the product/industrial design approach the attributes of imagination, intuition and risk-taking are needed to start the process from the idealistic, futuristic point. Both processes require creativity to achieve innovative solutions.

Within the Department of Mechanical Engineering there is support for new teaching activities to expose students to both these ways of designing. The Department has received funding for a two-year programme, brings practising product/industrial designers into the university to deliver a series of four lectures and workshops. The department worked with the UK Design Council and drew on their experiences and template lecture materials. The topics selected were design skills and activities not explicitly covered elsewhere in the engineering degree course: Generating and assessing ideas; User centred design; Branding and design; and New Product Development. The students were introduced to these topics through 'real' industrial examples in the lectures, and then applied specific design tools to their own projects during the workshops.

2 PROGRAMME CONTENT AND ACTIVITIES

The programme was open to third year Mechanical Engineering students, who were all participating in a group design and business (GDB) project, in which they work for three months full-time, in teams of six, on a design project that integrates business elements [4]. In total, 55 mechanical engineering students attended the programme summarised in table 1 below .

Table 1: Programme summary of lectures and workshop activities.

Lecture Topic:	Lecture content:	Workshops (2 hrs):
Generating and Assessing Ideas	Designer's own background, how to generate ideas (tools) and opportunities.	Short design problem set for all groups. Brainstorming techniques facilitated by the lecturer.
User-centred design	Commercial success of design, 'touch-points': physical, social, psychological and ideological	Introduced a tool, full example from industry, 'persona' tool applied to students' own projects.
Brand and Design	How companies use brand to create products. Linking tangible design features to brand values.	Talk on brand creation, interactive discussion good-bad brands, exercise based on groups' own projects.
New Product Development	Balancing design factors from ergonomics to aesthetics, design 'stories', successes and failures.	Group design tutorials with, pre-arranged times, 'next steps' advice.

The Generating Ideas workshop consisted of a design problem set by the Bath Institute of Medical Engineering (BIME) that allowed for various idea generating techniques - as introduced in the preceding lecture - to be practiced. This first workshop made it clear that the workshop activities would be more useful if directly applied to their GDB projects. The subsequent workshops were delivered with this in mind. The User Centred Design workshop consisted of an introduction to a user centred design tool, which was then applied to their design specification. The guest lecturer gave instant feedback, which included references to theory and the guest lecturer's industry experience. The Brand workshop started with a discussion about good and brand names then an exercise to create brand names and slogans for the groups' own projects. The New Product Development tutorials contained no 'formal content' but began with the students briefly explaining their projects. As a 'neutral outsider' to the project, the guest lecturer asked many 'obvious' questions and offered advice for next-steps.

3 RESULTS AND OUTCOMES

3.1 Survey results

Two surveys were conducted with the students, one conducted before the first lecture began and another completed at the end of the last workshop. The hypothesis was that students' skills and abilities relating to entrepreneurship would be increased after they had participated in the product/industrial design lectures and workshops.

Students were asked to rank their skills and abilities on a scale of 1 to 6 where 1 is poor and 6 is excellent. In table 2 the percentages of respondents rating their skills as good, very good or excellent (4, 5 or 6) are shown. (Note: 53 students completed a pre-test survey, where as 29 completed a post-test survey).

Table 2: The results from the pre-test and post-test surveys.

	Survey question- Rank your skill and ability to:	% Ranking Good to Excellent			Generic entrepreneurial skills needed
		Pre-test	Post-test	Change	
a	Recognise good ideas or opportunities	76.9 %	86.2 %	9.3%	Intuition, imagination
b	Design something novel and innovative	58.5 %	69.0 %	10.5 %	Innovation, creativity
c	Create a scenario in which to explore a problem	52.8 %	41.4 %	-11.5 %	Imagination, creativity
d	Identify who the users of your product and service are	83.0 %	75.9 %	-7.2%	Imagination, independence
e	Research the needs of your user	58.5 %	62.1 %	3.6%	Tenacity, independence
f	Incorporate user needs into the design of your product or service	66.0 %	65.5 %	-0.5%	Imagination, creativity
g	Communicate your idea visually	64.2 %	69.0 %	4.8%	Creativity, tenacity
h	Prototype your idea and test it	50.9 %	51.9 %	0.9%	Tenacity, creativity
i	Prepare a product design for manufacture	50.9 %	37.9 %	-13.0 %	Leadership tenacity
j	Develop a brand strategy for your business	35.8 %	58.6 %	22.8 %	Leadership, imagination
k	Understand the brand values for a business	35.8 %	65.5 %	29.7 %	Imagination

The biggest increases are those relating to branding and idea generation. These are the topics that are addressed least by other areas of the mechanical engineering degree, so we would expect to see the bigger increases in these areas. Some of the changes are a decrease rather than an increase. One explanation for this is that the students' perception of their skills may have been too high before the lectures began and as a result of learning through the lectures and workshops they are now more realistic about their own abilities. Another explanation might be that the programme did not provide enough practise time with the tools and techniques introduced.

The last column in the table shows an interpretation of how the skills and abilities ranked in the survey can be linked to the generic entrepreneurial skills of individuals. From these results it is possible to deduce that this programme has mostly bolstered the skills of imagination, leadership and intuition.

3.2 Qualitative results

Students were asked to say what learning they had gained from the design lectures and workshops that they had already applied to their GDB project and what learning they anticipated applying in the remainder of the project.

3.2.1 Generating Ideas

Students stated that brainstorming techniques to generate more creative ideas are useful. They felt that using them to become less restrictive in their thinking would lead to generating a larger quantity of ideas. One student commented that achieving a large quantity of ideas was actually more difficult than they were expecting. Students felt they had learnt the importance of 'not limiting thoughts however outrageous they may seem'. From these qualitative observations we can see that the students have been stimulated to improve their skills and abilities in imagination, risk-taking and intuition.

Although the existing engineering design curriculum includes phases of generating ideas, brainstorming techniques had not formally been taught. Brainstorming is often perceived as an informal skill that does not require practise. However, the rules of 'no criticism' and 'encouraging wild and exaggerated ideas' are difficult to adhere to. Better results emerge when brainstorming techniques are practised.

3.2.2 User Centred Design

Students used 'personas' created in the user centred design workshop to help them develop their group project and said that 'by considering a particular user and creating a persona we were able to come up with considerations for our design that otherwise may have been missed'. One student said that their group altered their specification 'due to increased user centred design knowledge'. In general, students commented on 'how user-focussed design affects the business performance of a product'.

3.2.3 Brand design

On brand design students were able to think about what characteristics should be displayed by the company and received by the customers. Developing a logo and slogan increased the professionalism of their presentation. Some students said that the branding knowledge would be useful to them as they wrote their business plan. Students also stated that they had learnt the 'importance of image and perception, not only to customer but to employers and suppliers' and specifically 'how to target a market and adapt a product design accordingly'.

3.2.4 New Product Development

The final key area of learning illustrates the product/industrial design approach described in section 1. The students were introduced to design 'stories' that started from ideal solutions and then worked backwards through stages of balancing design factors from ergonomics to aesthetics. From the 'stories' the students were encouraged to draw their own conclusions on what factors contributed to product success or failure. Students concluded that they would seek to keep their designs simple, consider the usability of the product and build physical models to help them with development - rather than relying entirely on using software packages. Students also said that they had learnt 'how important it is to think how ideas could be developed for the future even if

not possible at present'. They understood of the 'forward' and 'backward' approaches to design and the importance of imagination, intuition and risk-taking.

3 DISCUSSION AND FUTURE

All the design lectures, workshops and tutorials stressed the link between commercial success and the design topics covered. By using the pre- and post-test we are able to report an increase in the students' self-perception of their skills surrounding idea generation and branding. The workshop formats trialled were most successful and repeatable in subsequent years.

In the future, all students should be exposed to at least one 'futuristic design brief' during their course. This may mean introducing such an assignment in an earlier year. The engineering department can also foster more enterprise by helping students to generate their own final year projects that are both academically suitable graduation projects *and* promising business concepts.

Educational development in engineering design needs to look at the generic entrepreneurial skills (figure 1). Design activities within engineering department have the scope enhance these skills in our students by: exposing students to different design approaches such as product/industrial design 'backwards' approach; introducing specific new tools and techniques; and developing assignments that stimulate students to work in new ways.

The programme is part of a larger initiative to strengthen teaching in business and entrepreneurship in the department which includes: the appointment of an Enterprise Officer; and the development of a Business Activity Resource Centre. During the first year of this programme students have taken-up entrepreneurship mentoring and got involved in university initiatives such as: Business Plan Competition, the Student Enterprise Centre, Business link course, and a Student enterprise conference.

The department has observed that the students have been motivated to be more entrepreneurial, whether they aspire to start their own company or work as an in-house engineer. The design activities introduced build student confidence and broaden their view of the design process.

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