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DESIGN PRACTICE IN THE UK CAR INDUSTRY: HOW COVENTRY UNIVERSITY IS ADDRESSING THE NEEDS

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This paper considers the needs of the UK car industry and identifies specific situations that have serious implications upon design practice. The response at Coventry University to these needs and how Design plays a major role in our programmes of study is discussed. The undergraduate course in Automotive Engineering Design is highlighted as an example of our approach to Design Education. We introduce our PAKTS model for Design Education. This model is a convenient means of expressing our aspirations and reflects our dedication to the development of professionally trained engineering designers. The model recognises the importance of the University and Industrial environments to the growth of the student and identifies five branches of growth: Processes, Attitudes, Knowledge, Tools and Skills.

INTRODUCTION

In the 1980's, Japanese automotive manufacturers enhanced their product development capability, reduced product age to an average of 2.1 years, doubled the number of new model ranges, successfully developed and marketed highly profitable niche products and in turn created a customer-led demand for 'technology' and 'modernity' [1]. More specifically, in the period 1982-1987, Japanese manufacturers produced 70 new models whilst those in the USA produced only 30 and those in Europe just 20.

The passenger car industry in the UK is a very mature industry. It has evolved over almost 90 years from small enterprises to today's large multi-national organisations operating in a very competitive environment.

The Needs

If the UK automotive industry is to successfully compete in future car markets, it is essential that it at least matches Japanese manufacturers' "vitality and continuous product recycle" [1]. The industry's design practice has had to change to match this evolution. In addition to embracing the new technological tools, there is now a structured approach to the management of design and an attention to workplace procedures (Design Science). The Total Quality culture is accepted as being beneficial. Concurrent Engineering is recognised as a necessary practice and there are attempts to bring some science into its operation.

Some of the situations that now have to be seriously addressed are:

- shortening concept-to-market lead time
- the need for the product to be manufactured 'right first time'
- an increasing emphasis on the whole life costs of the car, including an extended definition of the life.
- a greater focus on the customer who has higher expectations of product performance.

- the change in organisational philosophy with manufacturers focusing on core technologies and assembly and design responsibility being devolved to the component and sub-assembly suppliers.
- an enhanced capability of the supporting technologies, in particular CAD/CAM, materials and manufacturing.
- an increased awareness of Design as the driver of the product's success.
- multi-disciplinary teams requiring a team approach to design.

The response at Coventry University to these needs

Coventry University is one of the few educational establishments that has a School of Engineering and a School of Art and Design. Both schools have strong links with the automotive industry and this is reflected in the undergraduate and postgraduate courses each provides. Design plays a major role in these programmes of study. The research that the Coventry University Centre for Integrated Design undertakes is one response to bring the different cultures of design taught in each school closer together.

There is a range of courses and modules within courses. We have traditional Engineering Degree courses that provide the analytical specialist to support the product's development. Students on these courses are schooled in Design as a compulsory part of their curriculum so that they can appreciate the Designer's role and have a basic skill of their own in Design. In a mirroring sense, we also have specialist Design courses which give the opposite balance of major abilities in Design and a sound basic capability in the Engineering Sciences. These Design courses are themselves divided into one addressing Engineering Design with a base level ability in aesthetic aspects, and one with the reverse balance of Industrial Design alongside a foundation of Engineering. The BEng degree in Automotive Engineering Design has been targeted towards the automotive industry and is considered in more detail below.

In view of the wide acceptance now of the key role of Design in the product introduction process, it is surprising that such specialist courses are not more widely available. This shortage is certainly true in the UK and probably so for Europe and the rest of the World.

THE BEng DEGREE IN AUTOMOTIVE ENGINEERING DESIGN

The BEng degree in Automotive Engineering Design has been running at Coventry University since 1989. Since then, over 100 students have graduated from the course and currently the total number of students enrolled on the course is over 180. The course aims to:

> Produce graduates who have the potential to become leaders of mechanical engineering design, having a specific focus of expertise on the products of the automotive industry. They must be aware of the workings of the industry and be able to develop competence in using the processes involved with the creation and production of technically and commercially viable products. They will in addition be able and motivated to continue learning throughout their careers to meet the challenge of a changing world

To help achieve the aims the course has a detailed set of learning objectives. These define the range of personal qualities, skills and knowledge that we expect graduate engineering designers to develop. More specifically, the list defines the mental characteristics, attitudes and values, personality characteristics, mental skills, information skills, action skills, social skills, factual knowledge and experiential knowledge they must acquire. Griffiths has described previously the structure of the course and the range of the assessment methods we use [2,3, 4].

Figure1: The PAKTS model for Design Education

A MODEL FOR DESIGN EDUCATION

At Coventry University, we have devised the "PAKTS" model of Design Education. The acronym PAKTS refers to the **P**ersonal **A**ttribute **K**ernel **T**ree **S**ystem (Figure.1) on which we base our teaching approach. As you can see, the tree-like structure of the PAKTS model embraces the total educational needs of the professional designer. We find this model a particularly convenient way of expressing our design education aspirations and one that reflects our dedication to the development of professionally trained engineering designers.

For the Automotive Engineering Design course, we recognised that the quality of the University Environment is key to successful development of the student. We provide dedicated studios for the second and final-year student groups. We encourage teamwork and the use of artifacts in our teaching. Importantly, we have adopted a problem-based approach to learning. This approach encourages students to learn through the experience of solving engineering problems. It provides a deep understanding of engineering design whilst developing competence, confidence, personal skills and attitudes. We choose design tasks that are relevant to the automotive industry and encourage the participation of industry based personnel in our project work. We also encourage students to undertake industrial training by taking a work placement prior to final year. In this way, we believe we are giving the graduate designer the best possible preparation for the Industrial Environment in which he will grow to full maturity.

The synonym PAKTS is also representative of the five major branches of growth that we wish to see in a mature engineering designer. These are:

- **P**rocesses
- **A**ttitudes
- **K**nowledge
- **T**ools
- **S**kills

Processes

We prefer to consider Design a general problem solving activity. We discuss various models of the process and follow them as appropriate, but we do not necessarily encourage a rigorous adherence to any one approach. We prefer students to develop a model of Design for themselves. The student will fashion this model from their own experiences of the iterative nature of problem solving and it will reflect their maturity as a designer. As a reflection upon the automotive industry, the student must appreciate the management of design in a concurrent engineering environment. This necessitates working in a team of people distributed across many organizations.

We have adopted this approach because it helps students develop a professional attitude towards Design. Students tend to value their model of Design more highly than those devised by others because the model will embody the processes in which they have developed competence and confidence. Also, the comprehensive understanding of the Design process that a personal model provides enables a student to achieve a total product realization quickly and effectively.

Attitudes

The unique feature of the course is its emphasis on the development of the attitudes and qualities of the individual. We demand a professional approach to all work. This requires the student to form an "ownership" of the problem and to adopt an overall responsibility for the preparation of a suitable solution and its presentation to all parties.

Additionally, we recognise that design in the automotive industry involves working with many other people. We, therefore, demand that students to work in groups to enable them to develop team playing skills. Group work develops good discipline and a professional attitude to work which allows students from the course to integrate into industrial work placements very quickly indeed.

Students also develop self-reliance and a life-long attitude to self-learning and recognise that they must often seek new information and knowledge to solve a problem. We expect them to develop an ability to assess their own capabilities and knowledge and those of others. This is an essential attribute because designers must recognise their own limitations and seek assistance where necessary. Importantly, the designer must be able to evaluate the worthiness of the information being received from others.

Knowledge

We recognise that we are unable to identify the full range of knowledge individuals will require in their lifetime**.** Therefore, we focus upon the fundamental principles of engineering science and business. The generalist technology education we provide gives the student a framework for the continuous development of knowledge throughout their career

Similarly, the extent of the depth, breadth and level of knowledge provided by an undergraduate course is always open to debate. . We require students to acquire sufficient knowledge to allow them to evaluate the performance of engineering design concepts and to verify the fulfillment of specified targets. We can test the ability of a student to acquire depth of knowledge by setting specific tasks which require research into a narrow range of knowledge. This knowledge might be product specific and reflects the way the designer tends to develop in the industrial environment.

Tools

The Design Science of tools provides efficient techniques for the support of the design process, e.g. CAD, QFD, FMEA, DFA, MA, Taguchi. The automotive industry, in particular, has appreciated the suitability of these tools and techniques to the design of their products. Therefore, it is only appropriate that a course that is preparing engineering designers for the automotive sector should include these design methods.

Tools embody good design practices that have been established from rigorous research in Design Science. Consequently, they enable students to realise professional quality solutions at an early stage of their development. Many of these tools provide a process for design evaluation which in turn provides a quantified measure of product performance. Quantification of performance reduces the subjectivity of the choice a designer must make between different candidate solutions and lessens the assessment of commercial risk.

We have seen that design tools often allow students to demonstrate significant improvements in the overall design of a product. The gains they make would be smaller if they used only the scientific analysis tools that more traditional courses emphasize. By this approach,

students are more likely to suggest “step” changes in product design rather than “incremental” changes.

Finally, there is now a greater emphasis to create tools that bring the technology of Engineering Science closer to the designer. Specialist knowledge is embedded in these tools which enables the designer the operate as an expert without necessarily comprehending the mechanics of how the tools are operating. However, it is essential the designer appreciates the fundamental principles of these tools and recognises the limitations of their application.

Skills

We recognise that the ability of an individual to be a successful designer will depend very much upon his level of skills. These skills, for example, include the ability to organize, analyze, evaluate, synthesize, acquire information, communicate, plan, visualize, co-operate with others, lead others and justify actions. These skills are developed by practice and the problem-led approach to learning allows plenty of opportunity to acquire these essential characteristics.

CONCLUSIONS

In this paper, we have considered the needs of the UK automotive design industry. We have discussed the approach we have adopted at Coventry to the development of engineering designers for that industrial sector. In particular we have described one specific course that aims to produce graduates who have the potential to become leaders of engineering design in the automotive industry.

Finally, we have introduced our PAKTS model for Design Education. We believe that this model provides a thorough description of the approach that we take to developing young engineering designers. It includes five major branches of growth which we consider are essential in a mature designer, especially one who is being prepared for a life long career in the UK automotive industry.

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