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Original Citation

Gill, Harry and Unver, Ertu (2000) Innovation, design and CAE in new product development. In: Integrating design education beyond 2000: proceedings of the 22nd SEED Annual Design Conference and 7th National Conference on Product Design Education, 6-7 September 2000, University of Sussex, Brighton, UK. John Wiley and Sons Ltd, Brighton, UK. ISBN 9781860582653

INNOVATION, DESIGN AND CAE IN NEW PRODUCT DEVELOPMENT

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ABSTRACT

There seems to be a need for clarification on a number of issues that are seminal for the design community: for example, the constructs of invention, of creativity and of innovation (or innovative) appear to be used interchangeably. They are all a vital interest for design but they are different things. Furthermore there is a failure to distinguish between what design has a ***legitimate interest*** in or should ***contribute to*** and that which is its ***direct responsibility***.

The authors of this paper will seek to clarify these and other issues. One of these interests is the increasing demand for sustainable practice: design has a crucial role here and this paper will explore how computer aids can be a powerful tool in this area and also more generally in both design and manufacture.

INTRODUCTION

At its simplest innovation can be defined as:

> ***'the initiation and implementation of change'.***

Other definitions such as:

> ***'Innovation – the successful exploitation of new ideas – is essential for sustained competitiveness and wealth creation. A country aiming to keep ahead of its competitors needs companies which innovate'. (HMSO 1996)***

stress the business, economic, political and technological dimensions of a concern for innovation that can obscure the fact that

> ***'innovation is for everyone'.***

All spheres of human endeavour benefit from a steady flow of new ideas and their subsequent implementation. So innovation can of course be technological and much of the literature centres on technological innovation but it also has applications in social, political, educational and other programmes. Organisations have to develop a creative dynamic that permeates all levels of the enterprise rather than it be the responsibility of one or two 'gifted' individuals. To establish such an ambience within an organisation can be difficult but some very large companies, 3M Corporation, Sony and Unilever have formal structures for

'unlocking the potential of its people'. (DTI Winning Report 1996)

The word ***innovation*** is often confused with ***invention*** and ***creativity*** : ideas are described as being

Innovative or inventive or creative

It is now generally accepted – and certainly for the purposes of this work – that the term innovation is used to describe the process that

Begins with an idea (preferably inventive or creative) and takes it through to implementation or widespread diffusion.

Space does not allow for a fuller treatment of the innovation process other than what follows since the focus is to be in the role of design within the process.

1. THE INNOVATION PROCESS

Interest in innovation has grown steadily but especially over the past ten to fifteen years. More recently still the associated issue of entrepreneurship has been the focus of attention. Rothwell (1992) has described a growth in understanding of innovation from earlier notions of it being driven by 'Technology Push' – the market being a passive recipient of the products of the technological infrastructure through the 'Market-Pull' and 'coupling' model to what he calls the 'fifth generation' model. In this the process is pursued by teams who are networked electronically rather than physically and international (global) boundaries apply.

Other authors have prepared models as explanations of the process some of which can be used as operational guides. The comprehensive model (fig. 1) proposed by Gill (1999) is used here to give some idea of the complexity of the process, the major components, the principal players, the way the direct focus moves and to provide a structure for identifying where IT input can be beneficial (see section 4).

2. DESIGN AND NEW PRODUCT DEVELOPMENT

Many authors both in books and in learned papers have confused the design process with the innovation process: the example Wright (1998) is typical. In his book 'Design Methods in Engineering and Product Design' he illustrates ***'The Design Process'*** as including – 'The determination of customer requirements'. He also includes the model from Pugh (1990) 'Integrated Methods for Successful Product Engineering' in which the ***Design Process*** is seen to include ***Market Analysis.***

Market analysis is a part of the innovation process but if designers are analysing the market what are the marketers doing?

The confusion stems from failing to distinguish between the:

Legitimate concern for, contribution to, interest in the whole process including market analysis and indeed manufacture and

the direct responsibility for.

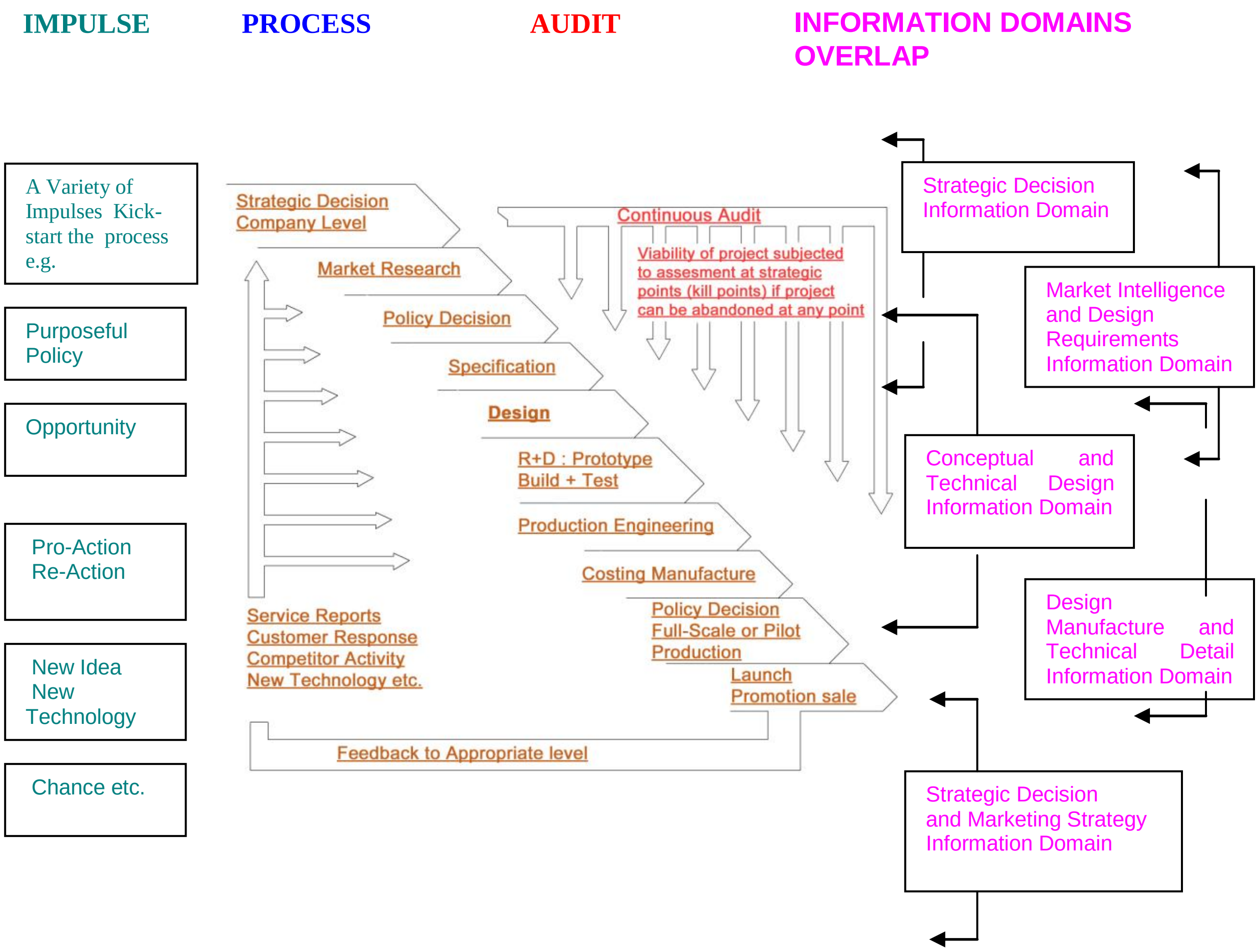
Various stages in the process of innovation require specialist input and although decision-making at various strategic points is collective, there comes a point – and design is one of these points – when the focus is on a particular activity: only the designers do the actual designing although the specification which guides the design input can be (and usually is) contributed to by other players. The same is true of manufacture and of marketing. It is a fact – not sufficiently emphasised in design education – that a lot of work has been done and very important decisions have usually been made before design input is engaged.

WHAT will be designed is often decided without recourse to design: Design is asked to concentrate on the ***HOW*** it will be designed.

Many in the UK see the flaws in this and seek to persuade companies to access design skills much earlier in the process and to use design much more as a strategic tool as opposed to a purely functional one. There is plenty of evidence e.g. Peter Drucker in a NEDO report (1978) writes of companies

'seeking to do better that which they shouldn't be doing at all'

i.e. striving to improve manufacturability and other features of products nobody wants.



Process characterised by concurrent activity and collective decision-making within project team and with continuous feed-back as new ideas emerge affecting either product or process.
The main focus moves as project progresses.

Principal players: marketing design, manufacture, other specialisms brought into teams as needed- including original equipment suppliers

Fig. 1

Hence the design community have to work at convincing business of the crucial importance of design but, to return to the confusion between design and innovation process, we will not do this successfully if we don't understand the nature and position of our input in the overall process of innovation. Design has an interest in – a concern for the whole process including user response etc., but its 'direct responsibility' is more circumscribed. Market analysis may precede and/or follow a strategic decision on ***what*** to design. There are some exceptions and the Sony Walkman is a case in point – 'gut-feel' (sensitivity to market possibilities) substitutes for market research – but in the vast majority of cases a rigorous study is needed to ***inform*** design. Design responds (hopefully creatively) to this and in turn ***informs*** manufacture. Project management structures determine the precise nature of the interaction between the players.

2.1 Conception to Consumption

2.1.1 Before Conception

There is an understanding proposed by some commentators that conception and consumption are the beginning and the end – the alpha and the omega! – of design. Consumption suggests a product (or service) in use and hence —depending on the product – can be a long way from the ***end*** of the design: manufacture, sale, etc., have been completed. But is not the ***end*** of the innovation process and this point is addressed in section (2.1.2)

The concept of the ***'concept'*** is clearly a well understood part of design: there is the 'concept design' stage; conceptual thinking is a recognised skill exhibited by the designer and concept designs are evaluated (preferably systematically) before one or more concepts are taken forward for development; French (1971) has written a book '…/ Design The Conceptual Stage'. But non of this is at the ***beginning*** even of the design process. Indeed the concept which follows an informed and rigorous challenge of the brief is the response to the ***concept*** – the original idea which is the ***basic prescription given*** to the designer – it is the raw material the designer has to work with. This challenge might question the whole notion of the product or maybe some aspect of it as ***prescribed*** by the brief. This is especially true if the brief is brought to the designer from a client who has not conducted any meaningful research.

The point is that very often (more often than not) a substantial effort has preceded the ***input*** to design. The conception – the idea – of ***what*** to design predates and is often decided remote from the design activity; it may even be past its sell-by date by the time it reaches design. It is crucial to a creative response from design to understand this reality

2.1.2 Beyond Consumption

Some of the issues that arise after the promotion and sale of a product: customer response; competitor activity; service reports and so on are part of the life-cycle of a product that can be extended by successive 'incremental improvements'. Indeed the vast bulk of innovative activity in the consumer products market is incremental and radical change is relatively rare. So consumption of the product can be sustained over a long period; choosing when to make a radical rather than an incremental change is a very difficult decision for businesses to make since the difference in investment between those choices can be enormous. Companies have folded because they have got this wrong.

But there is a growing challenge for design both in the life-time of the product in use and after this useful life is ended – in its retirement. These requirements have, of course, always been present but environmental pressures – ***the need for designs to be greener*** **-** is a growing pressure and it will have an influence on designs now and in the future much more so than in the past.

Life-cycle costing (LCC) has shown that it is in their use that products have their most serious environmental impacts. Hence it is we – the users – not the manufacturers who are the major polluters. But although this is an enormous challenge to the creativity/ingenuity of designers it is also, perhaps, the way in which businesses can be persuaded of the power of design.

Economy in use, longevity[*], ease of manufacture and ease of disassembly for recycling-re-use (retirement) can only be achieved by design. It is true that companies still mostly see environmental sensitivity as cost-incurring rather than cost-saving but there is a growing body of case material to demonstrate effectively that:

Greener Products are Better Products

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[*] There is a debate surrounding this issue. New products deplete resources so the longer they last the less the depletion. However more efficient technologies will emerge which the 'old' product does not exploit. Change might be environmentally beneficial.

Hoover's 'New Wave' washing machine was conceived, designed, developed and manufactured using a team approach to project management and life-cycle costing (albeit to a limited extent). It was the first to receive an eco-label for environmental performance and hence enabled Hoover to break into the German market for the first time.

Swedish Railways (SJ) adopted LCC in the procurement from suppliers of the X2000 tilting high speed train. Unlike the UK's own APT (advanced passenger train) which was a failure the X2000 is being evaluated by railways throughout the world. SJ accepted delays in the overall project time so that the commitment to LCC could be sustained. The result is a train far more reliable and up to 30% cheaper to maintain and run than its predecessors.

Increasingly there is pressure for companies to accept a buy-back approach and to be responsible for the products they sell from ***'cradle to grave'.*** Design has a central role to play in this process so it must project its thinking ***beyond consumption.***

3. THE DESIGN ACTIVITY

Design is often described as a

Problem-Solving Process or as

A response to a recognised need.

The need recognition – the problem identification – is often taken for granted.

But to fully comprehend design we need to recognise it as a –

problem-processing activity

rather than problem solving because as the design converges from concept to detail many sub-problems (lower-level problems) need first to be identified before they can be solved.

Problems not identified at the design stage identify themselves during manufacture, or worse, in use, with the attendant loss of goodwill.

If design is a problem-processing activity what do we need to know about:

- ***That which is processed – namely problems and***
- ***The processor – the designer. He/she may be the single most important variable in the 'equation'. A designer's personal value system can materially affect the outcome.***

Neither of these points is given due attention in the literature nor in design education.

Given due attention to the foregoing design can be seen as follows:

- There is an organising strategy that is inseparable from
- an accompanying mental process that assembles, organises and transforms the information required,
- there is a range of tools that can be deployed as appropriate and the designer has to be the master of these tools including an ever-growing array of IT tools
- there are a number of constraints that must be observed and which act to evaluate and filter decisions about solutions.

These four principal components of the activity interact in an indeterminable way to assemble, evaluate and convert information inputs to very specific outputs that are a prescription for

Manufacture, sales, operation, maintenance, and retirement of the product so described.

4. APPLICATION OF CAD IN THE DESIGN PROCESS

The University of Huddersfield has invested in CAD laboratories in which Alias WaveFront, Catia, Solidworks, CosmosWorks FEA software are all run on NT based Silicon Graphics machines. This development has brought us even closer to industry standards than before. CAD has empowered students with weak visualisation skills. The technology has improved these students understanding of their designs. Traditional drawing skills, which have been essential in the evolution of form through analysis and development of sketch visuals, have not yet been completely supplanted. However, the technological alternative has already removed the drawing board from the industrial setting and certainly will change the landscape in design education. Traditional studio teaching and assessment methods will also change if more CAD-based and the student is to be given equal access to staff advice during the development phase of their design projects. Jagger and Unver (2000)

Another significant development in CAD is the trend towards collaborative engineering. Industrial CAD users can produce innovative solutions to complex problems through the medium of the Internet. In the past, each user would require access to the same CAD system and connections to a local area network, to enable an effective collaboration.

4.1 CAD Modelling Techniques and Finite Element Analysis and Rapid Prototyping

Solidworks as our main 3D Design software can be categorised as Feature-based, Parametric Solid Modeling and CATIA as 3D Hybrid Solid Modelling and ALIAS as 3D Wireframe/Surface Modeling software.

Finite Element Analysis (FEA), as related to the mechanics of solids, is the solution of a finite set of algebraic matrix equations that approximate the relationships between load and deflection for static analysis as well as velocity, acceleration and time for dynamic analysis heat transfer, fluid flow, electrical and magnetic phenomena and acoustics. We use Solidworks to create the physical data necessary for analysis by creating a mesh of elements and CosmosWork FEA to analyse, FE Solvers and Post Processing.

Rapid prototyping is also a relatively new field that is gaining speed due to its accurate creation of three-dimensional models exact to the designers' CAD models. This has already started eroding the model-making profession, but it has given the designer more power and responsibility over the model making.

While CAD software is evolving, peripherals are changing too, with Virtual Reality (VR) and input devices. Some developments may not be as successful as CAD and this has been due to the constraints of the office environment, but this (the office) itself may also be challenged, changing the work environment for those in it. Product design has always needed a three dimensional form to give the manager, designer or client an idea of how the final production unit will look, feel or operate. Traditionally the task was carried out by a model-maker, who would receive initial plans and dimensions and make the prototype or visual model to the required finish. Gradually as time has progressed so too have the tools at the craftsman's disposal improving output and quality. This has developed from simple hand tools to more advanced items such as CNC lathes and milling machines and Stereolithography.

The Internet capabilities have already been added to most of High-End 3D Design software. In the future, collaboration over the Internet will be possible with manipulation and editing of live CAD models in peer-to-peer browser sessions. As the Internet and intranets improve in reliability, it may also be possible to execute more robust engineering design functions through a combination of browser and Java technologies. Enhancements in Java performance and security will also increase the client-based capabilities, as will continued extensions to Java, HTML, VRML, etc. As STEP matures, STEP-based browsers will emerge, breaking down the barriers between proprietary CAD systems while maintaining the intelligence within the models.

5. CONCLUSIONS

It is not mere pedantry to want to distinguish between Design and Innovation. Design is part (perhaps in many instances the most important part) of the innovation process but it is not the whole thing. ***Market intelligence is crucial input to inform design but it is not its direct responsibility; just as manufacture which is, in turn, informed by design is not its direct responsibility.*** In project management based on a matrix structure the boundaries are purposely made less distinct and concurrent decisions making pursues the team approach. This allows for more balanced decision making but designers are the only ones able to do the essential designing and the other players have their direct responsibilities in the same way.

If design is part of the process that precedes its direct input it will not have to spend time challenging the brief/specification. It can devote its creative energies to interpretation of the specification knowing its relevance to market needs.

This interpretation will increasingly take account of beyond consumption in pursuit of more environmentally responsive (and responsible) designs. A more precise understanding (for some, I think, a realisation) of its role in the innovation process and recognition of its ability to produce greener designs can be the way in which design finally convinces industry/business of its real value as a strategic tool. Design education has to make sure that these issues are part of their programmes. It is clear also and indeed already widely recognised that IT will play an increasingly significant part in both Design and the overall innovation process.

Product Design over the past 15 years has seen a tremendous change in the way in which the designer works, this is largely due to the increasing role that computers and software are playing. Not only have computers become cheaper, more reliable and faster, but CAD software has taken great leaps in development in this period making sophisticated 3D graphics available to most designers.

The future of product design is set to undergo an even more radical change than that of the CAD revolution that has affected the product design field in the last ten years. The software is set to become more accurate, faster, affordable and easier to use. The past implications of the advance in technology has been wide ranging, from the loss of draughtsmen and the arguable increase in freedom of the designer, through the decreased restraint of technical drawing. Manufacturing has also been evolving generally towards faster, more accurate machines (an example is injection moulding), whilst there has been a reduction of human reliant forming processes and an increase in automation and robotic assembly.

CAD, in principle, could be applied throughout the design process, but in practice its impact on the early stages, where very imprecise representations such as sketches are used extensively, has been limited. There are some new software programs currently available which are trying to fill this niche such as ALIAS Studio Paint. It remains to be seen how effective they will be and how widely they will be implemented. The advantages of CAD modelling as a result of its links with rapid prototyping technology will eventually have an effect on the model-making workshops of most Universities. At the present time, however, the cost of RP hardware is beyond the reach of most schools of design.

Finally computers can only enhance a good concept, and in a commercial environment, it can be expected that the CAD user has already developed a sound grasp of these basic conceptual skills. Using CAD will speed up the design process, help to visualise the product etc. but will not transform a bad designer to a good one.

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