A visual metaphor representation of a design process model

Graham L Oakes, Amal Oraifige, Dr Anthony J Felton, Dr David Heesom
University of Wolverhampton
School of Engineering and the Built Environment
City Campus, Wulfruna Street, Wolverhampton, WV1 1SB
England UK
g.l.oakes@wlv.ac.uk
a.y.oraifige2@wlv.ac.uk
a.j.felton@wlv.ac.uk
d.heesom@wlv.ac.uk

Abstract - Engineering designers, industrial designers and architects have different design cultures in their approaches to solving design problems. Traditionally engineering and architectural designers have used a structured approach based upon a 'concept, embodiment, detail and prototype' model to design their product. However, industrial designers have tended to use a less structured approach based on 'intuitive' and 'creative' techniques, which can vary from one designer to another. This paper firstly deals with the various types of traditional design process models in terms of 'Descriptive', 'Prescriptive' and 'Industrial' categories. The paper then introduces a 2D design process model and then progresses to discuss the utilisation of 3D Virtual Reality software to provide an innovative visual metaphor representation of the development of a novel 3D design process model. The model includes consideration of development and analysis of the design brief, request for proposal, time compression technologies and virtual reality areas. The software prototype enables the design team to both visualise their progression through the design process model and allow the integration of engineering, industrial and architectural design methodologies. The model is in the advanced developmental stage and testing and validation is being performed with undergraduate and postgraduate students at the University and local companies.

Index terms – design process models, interaction, multi-disciplinary, virtual reality,

INTRODUCTION

The paper introduces descriptive, prescriptive and industrial design process models used by engineering, product, industrial designers and architects.

The paper then proceeds to explain how a 2D design process model, as detailed by Oakes [1], is utilised in solving design problem scenarios; this 2D model is then further developed into a conceptual Virtual Reality (VR) 3D design process model using a real-time self authoring tool kit software.

The new innovative 3D VR design process model can be utilised in both industrial and educational applications.

DESCRIPTIVE MODELS

In recent years there has been a number of attempts to provide models of the descriptive design process. The descriptive approach is where a model is provided that effectively describes the sequence of activities that typically occur when designing a product.

French [2] proposed a more detailed model, which considered the process to consist of four stages; analysis of problem, conceptual design, embodiment of schemes and finally detailing.

French [2] concluded that the analysis of the problem is a small but important part of the overall process and suggested that the analysis consists of three elements:

- i) Statement of the proper design problem.
- ii) Limitations placed upon the solution e.g. codes of practice, statutory requirements, customer's standards, date of completion.
- iii) Criteria of excellence to be worked to.

The activities that follow the above three elements are:

- iv) Concept design, where numerous conceptual designs should be considered, which places a great demand on the designer.
- v) Embodiment of schemes, where a final choice is made and a general arrangement drawing is produced.
- vi) Detailing, where a very large number of small but essential points are decided.

PRESCRIPTIVE MODELS

In addition to models that describe a more-or-less conventional heuristic approach to the design process there have been several attempts at building prescriptive design process models. Prescriptive models encourage the designer to adopt a different approach to designing products. They propose a more algorithmic, systematic procedure to follow, providing an approach termed a 'design methodology'. The basic idea of a prescriptive model is that more analytical work should precede the generation of conceptual design solutions.

Jones [3] proposed that this approach should basically consist of the following design process structure; Analysis – Synthesis – Evaluation, which are expanded upon below:

i) Analysis. All design requirements are listed and reduced to a set of logically related performance specifications.

ii) Synthesis. Possible solutions for each individual performance specification are used to build up complete designs with the least compromise.

iii) Evaluation. Evaluate the accuracy with which alternative designs fulfil performance requirements for operation, manufacture and sales before the final design is selected.

Archer [4] proposed a more detailed prescriptive model, within this proposal six types of activity were proposed:

i) Programming. To determine crucial issues and propose a course of action.

ii) Data collection. To collect, classify and store data.

iii) Analysis. Identify sub-problems, prepare performance or design specifications.

iv) Synthesis. Prepare outline design proposals.

v) Development. Develop prototype designs and prepare and execute validation studies.

vi) Communication. Prepare manufacturing documentation.

Pugh [5] proposed a systematic approach to the design process and proposed the sequential consideration of the following activities in a design core;

i) Marketing

ii) Specification

iii) Concept design

iv) Detail design

v) Manufacture

vi) Sell

The design team require the last topic to formally close the loop between selling and market user requirements in a satisfactory manner.

INDUSTRIAL DESIGN MODELS

Heskett [6] proposed that the industrial design process should be systemised. The requirement was that a rational analytical sequence should be used to identify the fundamental nature of a given design problem. This would enable a design solution to be devised to meet defined needs, rather than to provide aesthetic refinement or stylistic innovation.

For many industrial designers, rational analysis alone is considered to be too deterministic and impersonal. An intuitive synthesis and instinctive feeling for rightness in form is regarded as a requirement to ensure individuality of expression.

EVOLUTION OF 2D DESIGN PROCESS MODEL

The 2D design process model as shown in Figure 1 is the result of recent research undertaken at the University by the authors over the last three years. The model consists of six zones, as detailed on the right hand side of the figure, and requires the user to progress through the zones to enable the final design of the artefact to be approved. Each zone is briefly detailed as follows:

Zone 1. Questioning the existence of a design brief.

Not all product and components start their design life as a pre-determine design brief. Phillips [7] proposes that the design brief should not dictate how a designer will actually execute the design brief. Rather, the design brief describes the design problem and desired business outcomes of the design work. It is up to the designer to create the most effective and creative design solution to solve the problem, using the most effective techniques employed by the particular design discipline.

Zone 2. Evolution of a design brief.

Powell [8] observes that it is quite rare to find a really comprehensive design brief. Invariably clients work with the design team to help put the brief together. Bringing designers in early adds greater depth to a client's vision, unpacking what they have alongside what they think they could have. Nor is the brief ever a single coherent document – typically it is a file containing a record of all of the relevant factors and documents.

Zone 3. Initial response to design brief.

In this stage an initial response is required to be made regarding the approach that the designer and the new product development team should follow taking into account product requirements i.e. analytical or intuitive.

Zone 4. Combination of analytical and intuitive approach to design brief.

The proposed design process model allows any type of designer to move, to some extent, from the analytical approach to the intuitive approach and vice-versa.

Zone 5. Time compression zone.

In this area each design team would produce conceptual designs of their product culminating eventually with a computer-generated solid model, and a rapid prototype model.

Zone 6. Manufacture. Eventually, after consideration of all of the previous five zones, approval would be sought for the final design of the components and real manufacture would then commence.

The Key, at the top left hand corner defines the routes that University students would take through the model. Undergraduate degrees at this University are three years full-time and a route indicates a year on the degree. Year 1 students follow a formal route when solving design problems – the assignments and projects are very prescriptive. Year 2 students follow a transitional route when solving design problems – the assignments and projects are a mixture of prescriptive and open-ended case studies and projects. Finally, year 3 students follow an innovative route when solving design problems – their case studies and projects have open-ended design briefs.

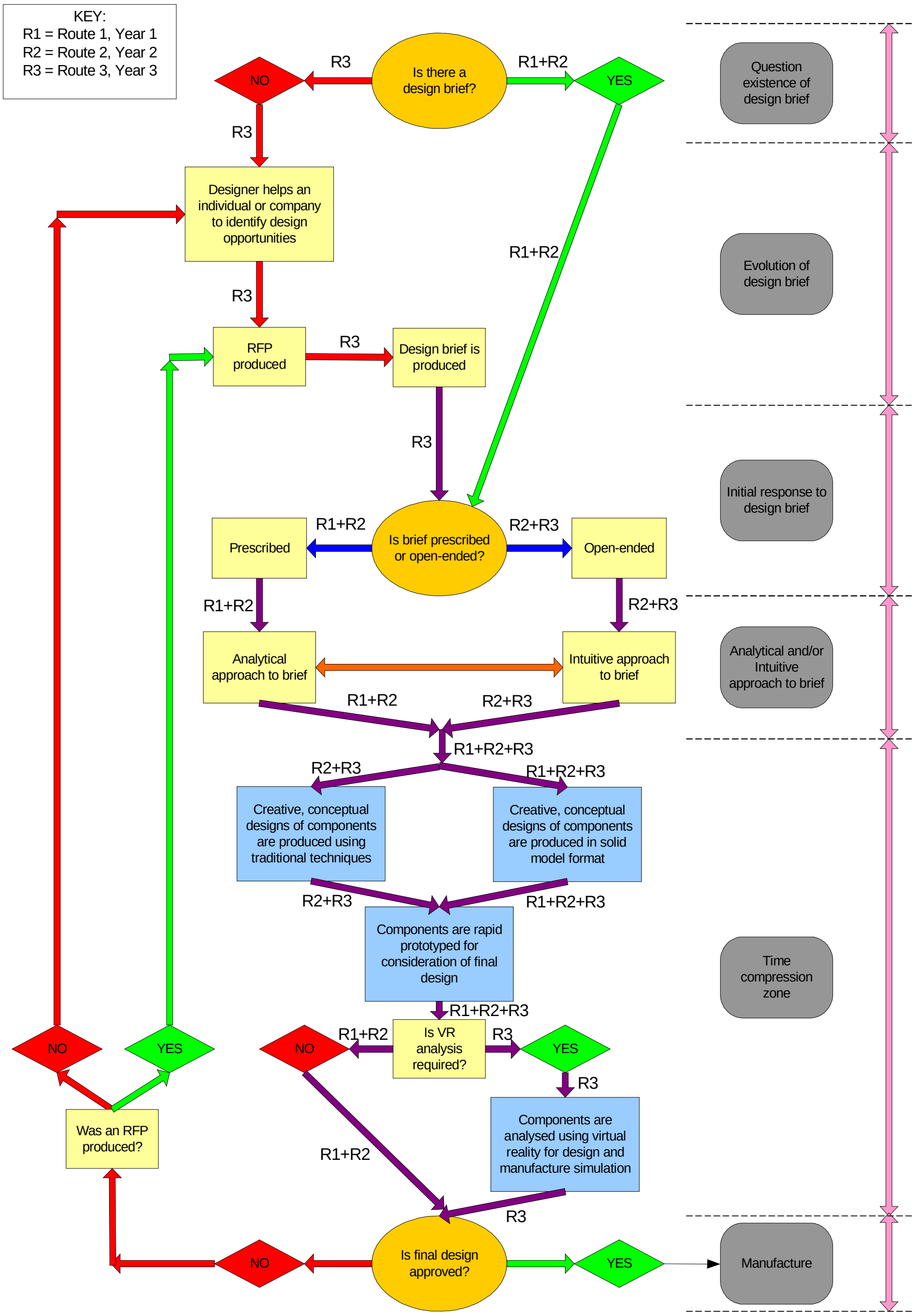

FIGURE 1
2D DESIGN PROCESS MODEL

EVOLUTION OF THE GENERIC FRAMEWORK INTO A 3D DESIGN PROCESS MODEL USING VIRTUAL REALITY

Continuing from Oakes [1], further research work has enabled the evolution of 3D VR design process model. The existing 2D format of the key elements of Figure 1 were utilised and built into a generic framework comprising of a 3D room using 3d Studio Max software as detailed in Figure 2. This model was then imported into Vizard self-authoring software where other aspects, including interactivity, were included. The Vizard 3D model provides the added benefit of real-time interaction using a Graphical User Interface (GUI) to enable the user to proceed through the model. There are two principal types of rooms within the model; Room type one is where the user is asked a question, for example 'Is there a design brief?' – the user has to answer this question with either a 'yes' or a 'no' before being allowed to proceed to the next room. Figure 3 is a typical example of a room of this type. Room type two is where the user has to complete a task, for example 'Design brief is produced', before being allowed to proceed to the next room. Since each user would have a different amount of knowledge and experience in design process models, each room type has a help facility to aid and assist them in either answering the question or completing the task. One such help facility is the web access tool. For example, Figure 4 shows an image from a screen contained within the model, which makes the statement 'Design brief is produced' – if the user did not know what a design brief was or required further help on this topic, by choosing the appropriate object within the room, a search engine web page e.g. Google, would be made available to allow the user to browse for information on design briefs.

Each room will eventually have this facility and, in addition, case study examples will be displayed in appropriate areas within the model to educate the users as they progress through the zones.

The model has been designed so that users do not always have to start at the beginning of the model. For example, a student could immediately proceed to the VR design room, if required, where general and specific information could be obtained on this topic for their education.

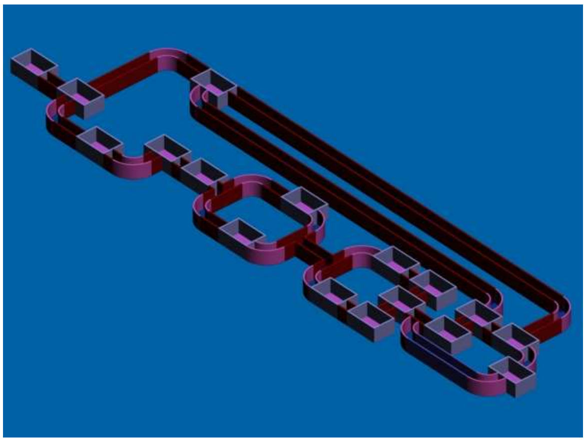

FIGURE 2
A VR SKELETAL MODEL OF ROOMS FOR THE GENERIC FRAMEWORK FOR ADAPTATION INTO INTERACTIVE 3D DESIGN PROCESS MODEL

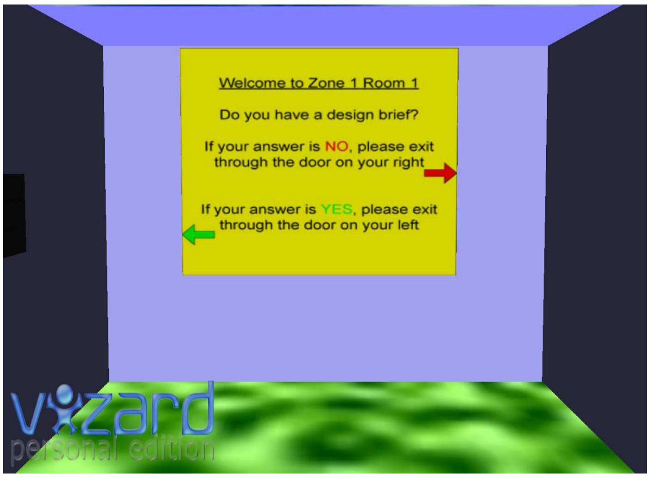

FIGURE 3
REPRESENTATION OF 3D VR ONE ROOM ENVIRONMENT DEVELOPMENTAL MODEL EXTRACTED FROM THE SKELETAL MODEL IN FIGURE 2

FIGURE 4
IMAGE OF SCREEN INFORMATION IN A TYPICAL 3D VR ONE-ROOM ENVIRONMENT SHOWING INTERACTION AVAILABILITY FOR USER HELP

TESTING AND VALIDATION

The preliminary 2D and 3D models have been introduced into the 'CAD and Product Definition' module in the MSc Advanced Technology Management award at this University to UK students and French students.

As part of the assessment in this module and to meet the specified teaching and learning outcomes, students have to consider the design of a product and then define the route taken through the design process model in the development of that product from conception through to retirement.

At this stage feedback from students has indicated that the models provide them with a clear vision of where they were within the design process and also helped them in deciding what stage they should progress to next.

In the future the 3D VR model will be further tested and validated using design undergraduate and postgraduate students at the University and also companies.

CONCLUSION

The global marketplace and industrial organisations require cost-effective solutions to real-time problems because of competitive pressures requiring the reduction in product lead times and costs. Felton [9] states that developing improvements in product innovation can be achieved through the early involvement of wide-ranging functions in the design process.

It has been demonstrated that the application of VR self-authoring software to build a developmental 3D design process model for engineering, product, industrial designers and architects provides an innovative solution for both educational and industrial applications. It has enabled a methodology, which can be utilised by companies and for the education of university students at both under-graduate and post-graduate levels.

Interaction has been provided to enable the user to access web-based sites by choosing the appropriate objects within each room. Case studies will be provided in appropriate zones to educate the users as they progress through the model.

It is anticipated that this generic framework and VR model in the future will eventually include gesture, audio and speech recognition contained within the software thus providing a necessary 3D platform for building various other emerging VR environments for both educational and industrial applications.

REFERENCES

[1] Oakes, G. L., Felton, A. J., and Garner, K. B. (2006) From the formal to the innovative An inclusive design process model for education of product/industrial designers. *European Journal of Engineering Education,* 31(5), pp.567-579.

[2] French. Cross, N. (1991) *Engineering Design Methods*. Chichester, UK: John Wiley & Sons Ltd.

[3] Jones. Cross, N. (1991) *Engineering Design Methods*. Chichester, UK: John Wiley & Sons Ltd.

[4] Archer. Cross, N. (1991) *Engineering Design Methods*. Chichester, UK: John Wiley & Sons Ltd.

[5] Pugh, S. (1991) *Total Design.* Padstow, Cornwall, UK: T. J. Press Ltd.

[6] Heskett, J. (1980) *Industrial Design*. London, UK: Thames and Hudson.

[7] Phillips, P. L. (2004) *Creating the Perfect Design Brief.* New York: Allworth Press.

[8] Powell, D. About: Product Design. *Design Council.* Available online at: http://www.designcouncil.org.uk (accessed 5 April 2007).

[9] Felton, A. J. (2000) *Developing an integrated approach to Product Design*. *In* CoDesigning 2000 (2000) *Proceedings: September 11-13, 2000, Coventry University, UK,* edited by Stephen A R Scrivener, Linden J Ball and Andrée Woodcock, London UK, Springer-Verlag, pp 485-492.