# COMPUTER TOOLS IN PRODUCT DEVELOPMENT

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## Abstract

This paper outlines current research into a new and novel form of design model or map aimed at providing an interactive interface to co-ordinate tools and information within the design process through the use of gaming strategies. As 'players', the participants in the design process navigate themselves around the map, referred to here as the 'Island Map', on the way to reaching their goal - a satisfactory design solution. By undertaking creative or analytical tasks in the form of structured games at various stations on the map, the players are assisted in reaching a suitable concept. The paper provides a discussion of the development of the concept of the Island Map from an initial examination of the use of computer based tools in product development to the current research investigating the use of gaming strategies and techniques and their integration with the Island Map to help the different stakeholders in reaching an agreed design solution. The discussion is initially focussed on the early, conceptual stages of the design process as it is here that many of the problems associated with the communication and integration of ideas can be identified.

Keywords: Communication, design process, gaming techniques

# 1 Introduction

## 1.1 Background

Experience with various product design consultancies has shown that computer based tools are increasingly used to support many aspects of the design process. However, while specific tools can greatly increase the productivity of an individual designer in relation to specific tasks, when incorporated into the design process as a whole their use can often become unwieldy. Indeed, where non-expert users are concerned they may be seen as a hindrance to the conceptual process by interposing an additional stage, requiring the support of an expert user, into the process of transference of ideas. Of particular concern therefore is the requirement to properly establish the differing roles of computer based tools within the overall design process. Especially to define their relation with and contribution to the need to ensure the effective *communication* and *capture* of ideas between all of the stakeholders in that process. The research therefore began in November 2001, with a working title of '*Computer Tools in Product Development*'.

## 1.2 Initial research

The studies of Whybrew et al [1] have shown levels of communication between different areas of expertise and recurring task clarification due to poor customer requirement definitions to be areas of particular weakness in a typical product development cycle. The two themes of communication and capture directly address these problems, and were each

examined in turn. Firstly, regarding communication, it is readily apparent that different individuals or stakeholders are important at different stages of the design process. The design process was therefore broken down into five typical stages of project definition, idea generation, evaluation, concept development and detailing and a prime communication flow established for each. This approach allowed an understanding of the types and intensity of communication taking place at each stage, as suggested by Fig. 1 for the project definition stage of the development of an emergency patient ventilator to be used by ambulance crews, the final form of which is also shown in Fig. 1.
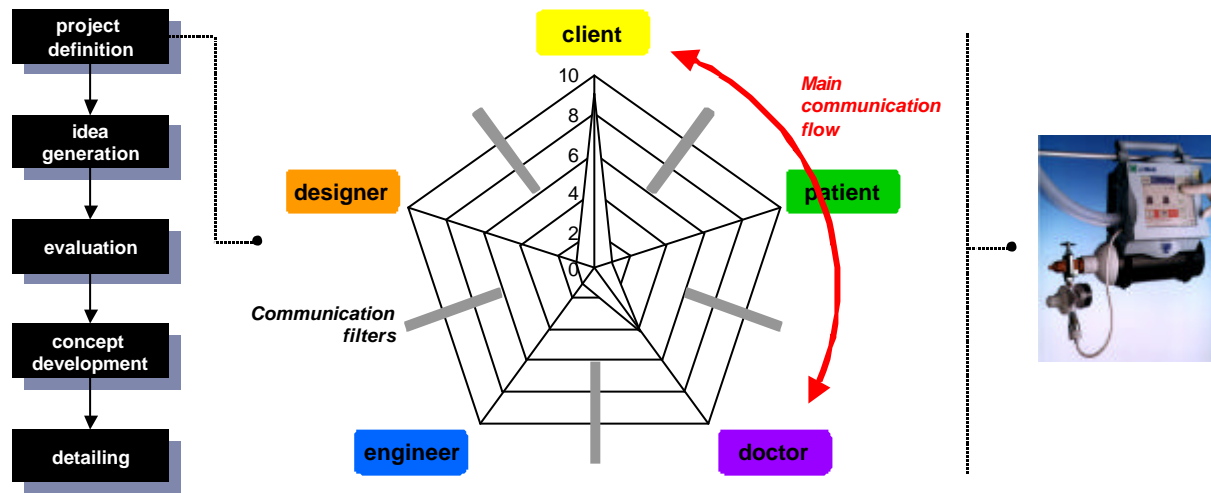


Figure 1. Comunication in design

An examination of the many different types of computer based tools used throughout the design process was then carried out to establish their role in the design process, with particular reference to the provision of support for the communication between design stakeholders. Figure 2 sets out the relationships established between various such tools and their application to the capture of ideas and information within the design process leading to the development of the ventilator concept referred to above and shown in Fig. 1.

The various information and data generated by individual programs and their compatability or otherwise have been highlighted in Fig. 2. The general pattern of usage indicates that as the project develops, the tools become more complex and specific, with relatively little interaction occuring between tools. For example, it was observed that information generated regarding the Product Design Specification (PDS) early in the design process was often discarded later in the design process and that there was no way of reflecting changes within the available tools. There is also a bridge between the information used in the concept creation and concept development stages - often this will be in the form of rough data which can represent a concept but which is then discarded for later detailed design work – which is difficult to handle and represent using available tools. Additionally, there is, as might be anticipated, a lack of tools supporting the evaluation stage as this is where the irreplaceable human quality of common sense takes priority over the computer. The results of the analysis of Fig. 2 served to reinforced the fact that there is a requirement to better coordinate the tools and the associated communication of information, particularly in the early stages of the design process.
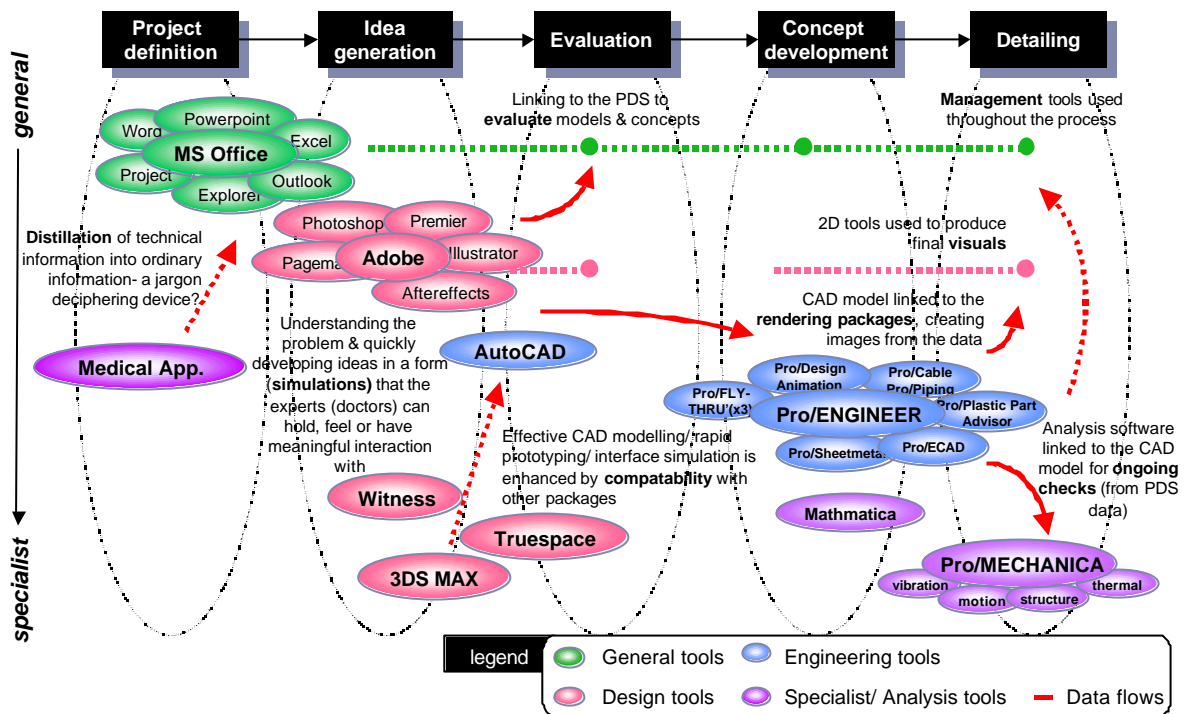
Figure 2. Computer tools in the design process

Having examined the use of tools in the communication and capture of design information and knowledge, it was possible to establish that, as indicated in Fig. 3, the most intensive communication takes place in the early stages of the design process where most information and ideas are created. Additionally, the capture of information and ideas in this area is at its most critical for establishing the direction of the overall product development process. It was therefore decided to focus on these early stages and to examine ways of better integrating them.
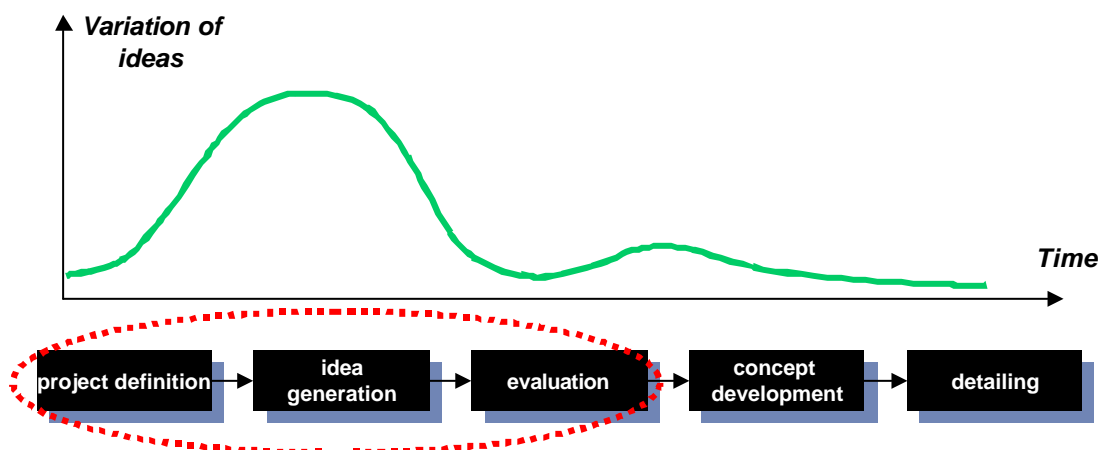


Figure 3. Variation of ideas in the design process

# 2 Evolution of Island Map

## 2.1 Idea generation

A period of ideas generation resulted in a number of concepts related to different aspects of product develoment as shown in the page extracted from a designer's notebook of Fig. 4.
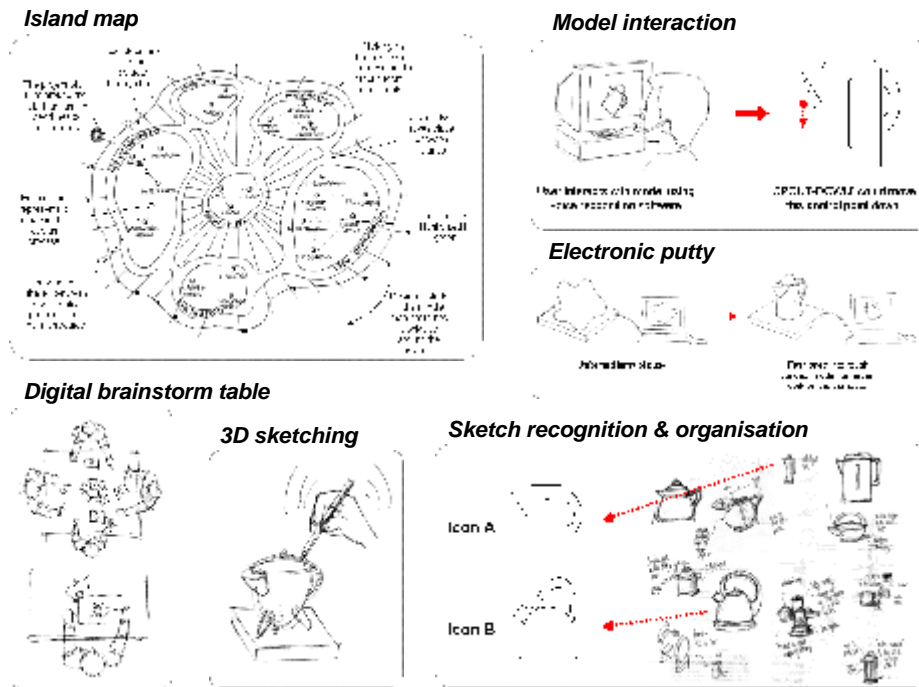


Figure 4. Ideas generation

From these initial thoughts, the concept of a novel computer-based tool evolved as a means of drawing together different IT and design technique strands. Referred to as the 'Island Map', this was considered to be the most appealing of the ideas examined because of the way in which it was felt to directly address the problem of the effective organisation of design tools.

## 2.2 Organisation of tools

Bradley et al [2] when describing the mechatronics design process talk of processes, people, tools and information as being the four interdependent absolutes (Fig. 5) which must be managed if a development is to succeed.
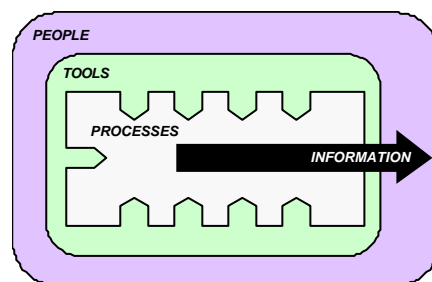


Figure 5. The mechatronic design framework

The conception was thus that of providing an easily understood and visual means of organising the different elements of the design process and of highlighting the links between them. Figure 6 shows the design process broken down into several 'islands', each of which represents a specific stage of the design process. The various tools and techniques associated with the island activities can then be identified. It was initially envisaged that the designer could move from tool to tool as required and the system would co-ordinate information and suggest appropriate 'information routes' for the designer to follow in navigating around the map.
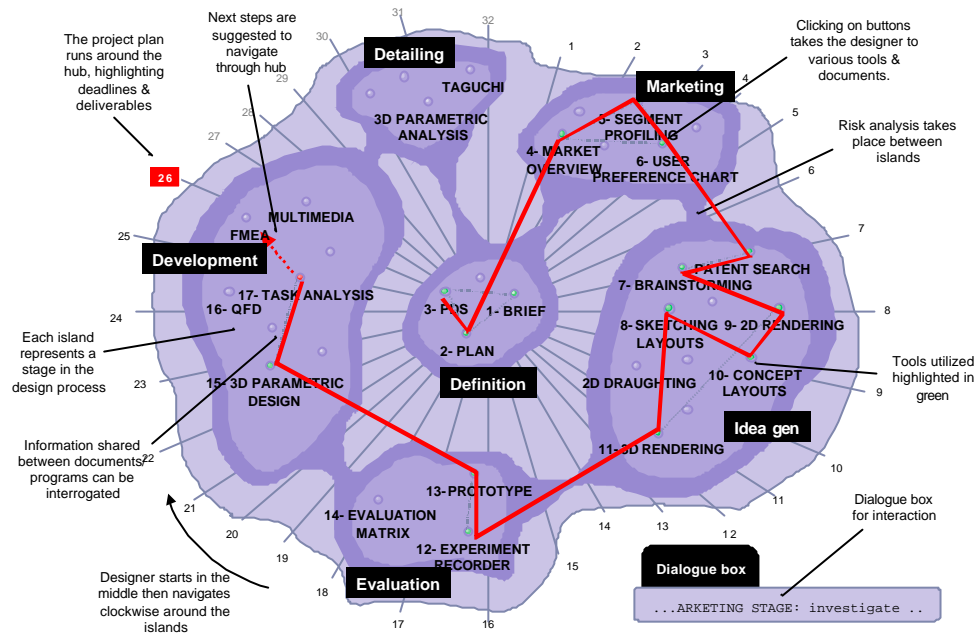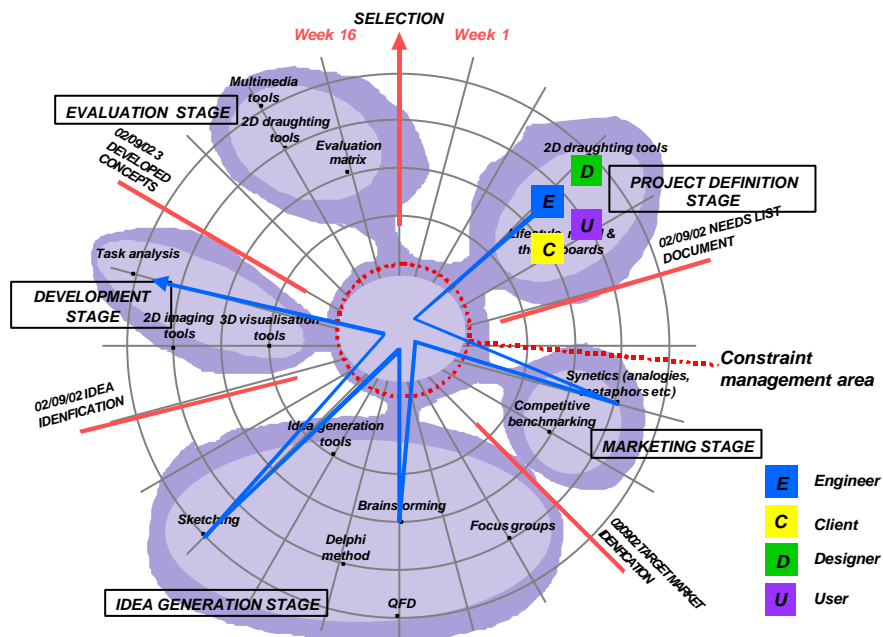
Figure 6. Original form of the Island Map

Figure 7. Dynamic PDS form of the Island Map

## 2.3 Dynamic PDS

Pugh [3] talks of a dynamic PDS as being the 'Design Core' for a product development:

> "*Wherever we are in the design core, whatever the stage we are concerned with at a particular time, this specification is our basic reference. By designing in a particular product/process area, we are, or should be, attempting to meet the specification.*".

This treatment of the PDS as a set of dynamic boundaries which is applicable throughout the development process is one of the key advantages envisaged for the computer-integrated approach. This consideration resulted in the development of a 'constraint management area' at the centre of the map (see Fig. 7) where it was envisioned that the product design specification could be continually updated between design tasks.

## 2.4 Interactive process

In their paper on '*The Content and Nature of a Design Concept*", Hansen and Andreasen [4] consider what it is that makes up a design concept. They describe the "idea with" and the "idea in" to indicate:

> "…. *the dual nature of a design: the transformation from an understanding of a need to a required functionality and a transformation from required functionality into structure of the solution.*".

The thinking was therefore revised to include a separate marketing branch for the Island Map framework which then assumes ideas can be either market, user or technical driven. Solutions and constraints are created in each of these areas and the results are then synthesised in the island core. By analysising actual project information, it was possible to fit design practices to the suggested theoretical structure. Figure 8 illustrates how Post-It? notes were used to identify the design tools used for a particular project and the information flows therein, and how this approach was then refined and integrated within the Island Map structure.
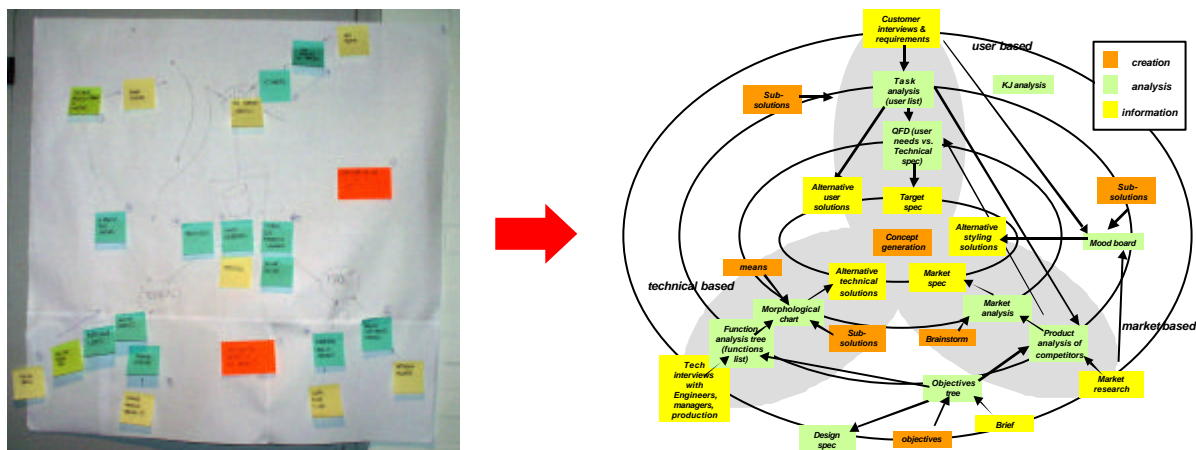


Figure 8. Analysis of a design project

Having then evolved this structure, consideration could be given as to the means by which the stakeholders could navigate around the map, and in particular how constraints would be managed and directions given to the participants. The analysis of stakeholder activities as they moved around the map identified activities such as information searches and information management that were consistent with similar activities observed in a number of computer

games, particularly strategy games. It was therefore decided to investigate a range and variety of game types with the aim of identifying features which could be used support the design process and the mapping of these features onto design activities. The means by which this was achieved are discussed in the following sections.
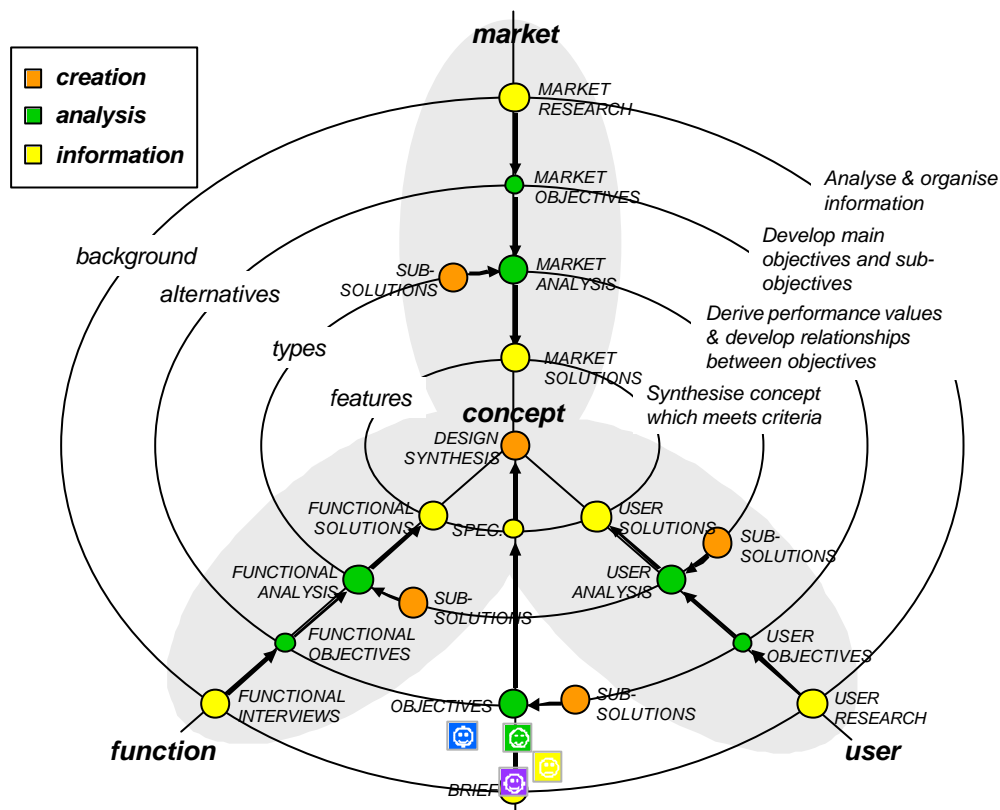


Figure 9. Current form of 'Island Map'

## 2.5   Current map structure

It is believed that the current form of the Island Map, shown in Fig. 9, provides a novel, interactive interface to support the co-ordination of tools and information within the design process. As 'players', the participants in the design process (e.g. client, engineer, designer) navigate around the map, between different island games, on the way to reaching their goal - a satisfactory design solution. Andreasen and Hein [5] suggest that for every design, reaching a final concept can be analogous to closing the 'solution space'. By undertaking creative or analytical tasks in the form of games at various locations on the map, the players are assisted in reaching a suitable concept (at the centre of the design space) by creating and then evaluating various design options.

At this stage it is suggested that main benefits of the Island Map are that it:

o   Allows team members to communicate effectively through a common interface.

o   Organises information visually according to the product design specification.

o   Supports constraint management.

o   Uses game analogies to develop knowledge and ideas from information.

o   Synthesises concepts by dynamically managing the product design needs.

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# 3 Implementation

## 3.1 Types of thinking and computer games

Despite the introduction of techniques such as Concurrent Engineering, the design process remains as an essentially linear, iterative approach where problems are defined and then solved. However, in many product development situations 'solution' and 'problem' are tightly coupled or linked, creating difficulties in reaching a conclusion unless taken together (Cross [6]). This may sometimes lead to the problem being redefined, or solutions outwith the original boundaries.

An extension of the idea of organising tools in a flexible manner is to use gaming strategies and techniques for each region of the map. One of the major advantages of using a game-based format for design tasks is that the inputs and outputs can be controlled, leaving the user to concentrate on the manipulation of the relevant information. The map therefore provides for *solution-based* and *analysis-based games* at each level of the design process to allow for different types of thinking. Currently, the types of thinking employed when using traditional design techniques are being analysed and compared to possible game formats. It is anticipated that different types of game should be applicable to different parts of the design process.

## 3.2 Benefits of the game-based learning

An entire generation has now grown up in a digital arena populated by instant and visual games. This environment is now part of the modern mindset, and computer users demand a higher and more sophisticated level of engagement with computer programs than ever before. There is also a growing industry based around game-based corporate learning, where the key aim is to utilise the huge potential of software to make learning activities more engaging. Pahl & Beitz [7] talk of design as a learning process and how "*...creative design is the most complex part of this process ...*" and the application of this engaging, interactive element of computer gaming to the design process provides an opportunity to create a powerful, cross-company tool. According to Prensky [8] game-based training has several key advantages:

o   Games give us *enjoyment and pleasure.*
o   Games spark our *creativity.*
o   Games give us *doing.*
o   Games give us *learning.*
o   Games give us *adrenalive.*
o   Games give us *structure.*

o   Games give us *intense involvement.*
o   Games give us *motivation.*
o   Games give us *flow.*
o   Games give us *ego gratification.*
o   Games give us *social groups.*
o   Games give us *emotion.*

After Prensky [7]

## 3.3 An example from a design-led organisation

Cross [6] talks of product alternatives, types and features as levels of generality and the map has been adapted so that the games developed on each ring of the map reflect more detailed thinking as the stakeholder approaches the centre. This means that different tasks can be tackled at the user's discretion and the controlled inputs and outputs of the game will allow whatever is possible within the specified framework to be completed.

Andreasen and Hein [5] talk of specification and ambition - a product that is highly specified leaves no scope for innovative design thinking. The Island Map tackles this issue by allowing the players to move freely from game to game, working in a more flexible manner. This

differs from the traditionally more linear design process used even by a design-led company, with the initial problem sources being drawn from both within the company and from analysis by external design consultants before being tackled in an iterative manner. Within such a company, several models are typically constructed as project milestones before reaching a stop-go point at which point progress is evaluated and a decision made as to whether to proceed. This can be compared to the Island Map of Fig. 11 where problems are addressed at each level of product analysis in whatever order the player decides is appropriate, and the games themselves can thus be regarded as milestones en route to the product solution.
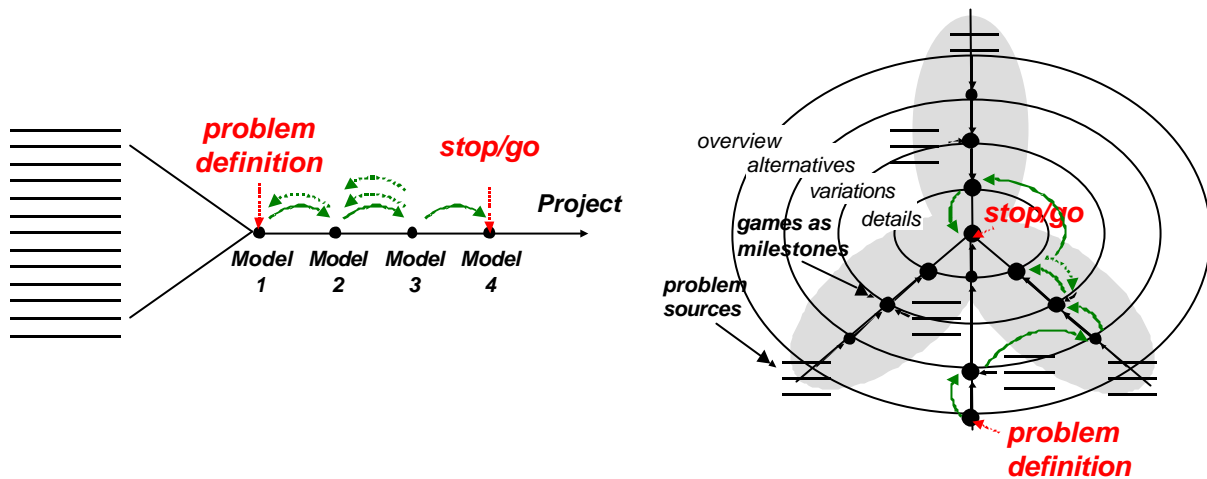


Figure 11.  Comparison of a design-led company and Island Map approaches

In the Island Map model, all stakeholders (client, engineer, designer, user) have been given equal status, even though one or more may be part of the same organisation. This highlights the different viewpoints of those involved in the process- each 'player' navigates around the map and contributes to the concept solution. In a typical design process, however, it is generally accepted as necessary to recognise the designer as the 'orchestrator' of the project and they essentially drive the process.


# 4    Future development

The next stage of research involves a detailed examination of the psychology and types of games available and how they can be mapped onto the design process to replace or augment traditional tools and techniques. Two separate strands of development are therefore in progress:

o   Developing the overall game-board structure, i.e. how players navigate through the design process. This involves establishing the inputs and outputs from each game and the information which must be in place to allow a player to move from game to game together with any restrictions placed on movement when certain information is missing.

o   Developing the design games by examining the psychology of g+ames and mapping them onto traditional design tools. Certain types of thinking, e.g. puzzle games, lend themselves more readily to particular activities in the design process and by applying the appropriate gaming methods, these discrete activities can be made as engaging and as integrated as possible.

It is intended to continue with these two strands of work to evolve the Island Map to a higher level. At this point, it should be possible to evaluate which game modules provide the greatest interest and then to focus on developing these in more detail. Consideration will also be given once the gaming strategies have been identified as to how the overall concept can be used both as an educational tool to aid understanding of the design process and as a means by which companies can examine their own approach to design and design management.

# 5    Conclusions

The research has evolved from considering the broad umbrella of computer based tools in product development to an examination of how gaming techniques can be used to co-ordinate the design process in its earliest stages. This has resulted in the development of the concept of the Island Map as a novel, interactive interface to co-ordinate tools and information in the design process and which uses gaming techniques to break design activity into discrete tasks. The shift in focus of the research has been a natural one and it is felt that the realisation of a highly integrated model of the design process can be a valuable addition to the current body of design research.

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