Context and Cohabitation of Linear and Non-Linear Systems in Design

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Abstract: The world of design is enmeshed with discourses concerning the application of linear and non-linear concepts, systems and methods. Both academics and practitioners have debated the values; use and location of both types of approach in design and the density of either type of system can be observed across diverse creative disciplines, sometimes fluctuating according to historical circumstances. Industrial design and engineering have long enjoyed the cohabitation of a problem space composed of a sophisticated mixture of linear and non-linear systems which narrate the breadth of thinking from the innate through to the ultra rationalist approach. The relationship of these systems illustrates the diversity of problem solving that in many ways is mirrored across the whole spectrum of art and design disciplines and maps the range of problem types from the definable through to the meta and the wicked.

Key words: Context, Cohabitation, Design, Engineering, Linear, Non-Linear.

1. Introduction

Locating the context and cohabitation of systems in design and engineering can perform the useful functions of assisting designers to navigate the increasingly complex landscape of problem types and solutions, particularly in relation to cross-disciplinary projects and to identify areas of activity based on creative outlook. MBT and similar evaluations including the Wilde test are widely shown to illustrate the types of activity that individuals are comfortable working with. Kim [1] demonstrates that the Wilde test based on Jung's cognitive theory can be used to analyse an individual's personality type and link it to specific areas of creative performance. Therefore an understanding of the location and relationships of these activity types are valuable in order to discern if there is a structure or pattern that relates to choice of activity in design. With increased professional demands, practitioners have also begun to concurrently engage in both linear and non-linear problem solving systems.

2. Definitions

I would like to begin with definitions of linear and non-linear systems as they occur in design. Linear systems for problem solving are those, which follow a prescribed progressive movement along a path calculated in advance by problem definition. Offshoots, feedbacks and parallel processing of problems may occur but the trajectory remains the same. These systems function well where problems can be clearly predefined or forecast in advance.

Non-Linear problem solving systems are highly complex and have novel features. These include problem-solving tools that can be used in a wide variety of combinations. In this system small influences can have disproportional benefits: a kind of 'sensitive dependence on initial conditions' [2] to which the designer is attuned through practice and reflection. To summarise, linear and non-linear systems can be thought of as those that determine the problem before the solution, and those that proceed with undetermined problems [3].

3. Problem space

The overlaps between design and engineering have long been a breeding ground for a diverse range of problem solving techniques while at the same time operating as an attractor for those interested in practical challenges. Linear and nonlinear solutions are inextricably linked to problem spaces [4]. Some problem spaces require linear systems in order to be solved, e.g. those of safety critical and structural types while non-linear processes are used more commonly in densely populated areas where differentiation and innovation are highly prized. In mature industrial problem spaces the main functional and structural solutions have long been established. For many product types a certain saturation point is reached where a technology, function or combination exploit the best possibilities. For example in furniture design both Charles Eames and Harry Bertoia can be argued to have created 'ultimate typologies' in their office and wire chairs which cleverly saw the best forms and constructions available. More than fifty years later these are still seen as major benchmarks. Several types of problem space are evident in Industrial design from the definable to the meta and wicked [5]. In reality the boundary between well-structured and poorly structured problems are vague [6] and it's interesting to consider where solving strategies overlap.

4. Context & Cohabitation

Design and engineering disciplines used to follow quite distinct routines. Engineering problems were resolved from a logical process that began during the renaissance with the close relationship between science and engineering. Design disciplines have largely followed artistic methods and with the evolution of industrial design courses from university engineering faculties and the continued professionalisation of disciplines [7] methods have begun to overlap. Successful designers have begun using a mix of innate skills for highly publicisable experimental works alongside logical convergent processes for consulting projects encouraging an overlap or *cohabitation* of design methods. In practice linear and non-linear problem solving systems can be shown to cohabit in a number of contexts from:

1. Project scale. A component may be designed with highly rationalist needs whilst the assembly itself could be highly innate in its conception.
2. Designer scale. A designer may be working on separate projects with both linear and non-linear approaches to problem solving.
3. Company scale. A design consultancy can be composed of several groups or units with specialist skills working with different problem solving processes.
4. Discipline scale. Across the industrial design and engineering disciplines including the bridge or hub discipline of industrial design engineering where linear and non-linear systems occur.

5. Design process models

Research was conducted by the author on the visualisation of problem solving systems by new applicants completing an entrance examination for the MA/MSc dual masters in Innovation Design Engineering Degree at the Royal College of Art and Imperial College London. Applicants were asked to draw a diagram of their conception of the design process. Fifty papers were analysed representing the three different backgrounds of applicants including: industrial design, engineering and other. The papers were categorized into:

1. Linear processes where the applicant was demonstrating single strand convergent creativity.
2. Semi linear processes where there was some parallel processing or feedback loops.
3. Non-linear processes where the applicant was demonstrating divergent multi strand creativity.

Table.1 Applicant design process diagrams

Discipline group ⇨	Engineering	Design	Other	Process Total
Linear	7	11	3	21
Semi linear	7	5	1	13
Non linear	7	5	4	16
Discipline Total	21	21	8	

The findings highlight that engineering applicants had the most even spread of problem solving systems whilst designers appear to be dominated by linear thinking. Candidates from other backgrounds were narrowly ahead in non-linear systems. It's interesting to speculate whether the dominance of linear systems in design reflects the convergent teaching of designers with simplified process formulas rather than reflecting the reality of their day-to-day practice. The results also point to the value of establishing the relationship and position of linear and non-linear systems in design in order that novice designers are able locate their creative abilities in relation to disciplines and problem spaces. The relationship between linear and non linear pedagogic systems are discussed at a meta level by Houghton [8], contextualised by Hall & Childs [9] and analysed from a cybernetic perspective by Robinson [10].

6. Modelling

The relationship between problem space, problem type and solutions in industrial design and engineering has been modelled in Fig 2 below. The diagram is constructed in three layers. The base layer sets out the relationship between linear and non-linear on the horizontal axis and industrial design and engineering on the vertical. The second layer plots known problem types and the third layer superimposes systems that are in effect solutions to the problems below. The diagram aims to link problem definition to problem solution via the contexts in which they take place to provide a map of context and cohabitation of linear and non-linear systems in design & engineering. An initial observation of the diagram is the strong diagonal arrangement of non-linear industrial design to linear engineering problem-solutions running bottom left to top right. In many ways this mirrors Buchanan [11] who states that:

> " Industrial design tends to stress what is possible in the conception and planning of products; engineering tends to stress what is necessary."

This explains the non-linear divergent quality of design reflecting the search for all possibilities whereas engineering requires a convergent focussed outlook illustrating the emphasis on theory, formulas and tried and tested methods. Alongside many other disciplines including theoretical physics, biology and engineering [12], industrial design has continued to embrace non linear systems, replacing the early simplified problem-solution theory borrowed from engineering and science. In the top left of the diagram, chaos, entropy and complexity reside in the engineering section. With this is mind, the diagram poses a good question: Engineering uses non-linear (in its widest sense) theories to explain chaos, entropy and complexity yet for operational aspects it does not seem to incorporate divergent non-linear thinking into problem solving?

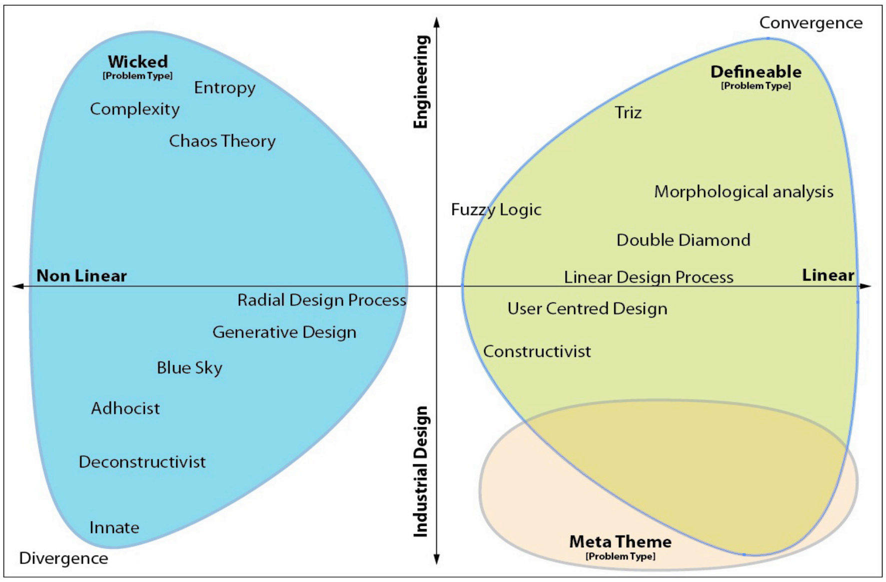

Figure.2 Mapping of linear and non-linear systems in design and engineering.

7. Conclusions

In this paper I have explored the background to linear and non-linear systems and through a piece of research and a diagram, hope to show the value in locating problem types with solutions and connection to extrovert and introverted personal attributes. The conclusions in many ways draw more questions that answers. The identification and description of problem types in industrial design are still at an early phase and many are imported or created via observations from other disciplines. A useful future goal would be a matrix composed of findings of the Wilde test superimposed over the context of design problem types. Further refinement is needed before comprehensive analysis and location of problem types in design can been undertaken.

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