CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 BACKGROUND AND MOTIVATION

Over the past six decades, significant progress has been made in the development of techniques to enhance the skills of problem-solvers and inventors. However, because of the plethora of options available, users of these techniques are not only faced with a dilemma as to which technique to apply and how to go about making the selection, but also how to assess the quality and completeness of the thinking.

Whilst invention heuristics offer engineers, inventors and technologists guidance on approaches that may solve certain types of problems, they are not always efficient. A recent study on a diverse range of 130 mechanically-based engineering patents for instance estimated the efficiency of the classic TRIZ Contradiction Matrix (CM) to be around 50%. In addition, they utilise only a limited range of creative thinking mechanisms, are sometimes cumbersome to use and difficult to interpret.

Objectives

The purpose of this research was therefore to develop a rigorous and more scientific approach to inventive ideation techniques which would integrate the two areas and thus provide an enhanced inventive ideation capability. The objective was thus stated as:

"To develop a generic model that improves the understanding of the mechanisms that underpin inventive ideation techniques, as well as their use and relationships. The model should be tailored for application to physico-mechanical problems and demonstrate its value as a tool that enhances inventive ideation in such a context."

6.2 RESEARCH AND OUTCOMES

Analysis

The above objective was accomplished by firstly analysing the mechanisms used in a wide range of popular creative thinking techniques as well as the 40 inventive principles of the TRIZ invention heuristics. The creative thinking techniques included the so-called 'linear' techniques in which the attributes of the problem are explored incrementally within a range of viable options, as well as 'intuitive' or 'random' techniques where new ways of thinking are for instance stimulated through provocation and random analogies. The techniques were grouped into three categories, based (1) on the *metaphorical distance* that they remove the thinking from the problem space, and hence the degree of intuition that is required to create an idea, (2) the *number of steps* involved in creating the idea, and (3) whether these occur in parallel or in sequence.

Inventive mechanisms

The results suggested that the entire range of techniques analysed are based on a total of only ten conceptually distinct mechanisms, which can be grouped into five 'themes'. The themes (and the mechanisms that relate to them most closely) are: Separate (Segment and Remove), Change (Adjust and Distort), Copy (Association and Random analogy), Combine (Add and Re-arrange), and Convert (Other Use and Transform). These mechanisms may be used in different combinations and applied to one or more attributes of a problem.

Ideation model

A model for inventive ideation in physico-mechanical contexts has been developed by integrating the generic mechanisms with a systems model describing the major physical, temporal and spatial attributes of objects and their environments. In the ideation model, the mechanisms have been positioned such as to reflect their respective themes, the degree of intuition that they require, and their relative frequency of use, as determined from the literature survey of creativity techniques and heuristics. These features assist the user in following a systematic approach to inventive ideation.

Ideation Domains

The ideation model was used to develop a detailed picture depicting the full range of inventive ideation options that exist within the defined system and thus can be used to solve problems. For this purpose, 26 Ideation Domains (IDs) were identified by applying each of the inventive mechanisms to the attributes of the systems model. By way of example, the ID of Re-moving Object, *viz* the various ways in which an Object can be modified by either using Movement or Removing parts, includes: (a) removing the object from its environment, (b) extracting or separating useful or interfering parts or features away from the main body of the object; extracting only required parts, (c) removing (discarding or dissolving) used or spent parts, (d) allowing relative movement between parts, or (e) preventing movement of the object or between parts.

Verification and application

The ideation model was verified by testing it against examples sourced from the literature and elsewhere, supplemented by expert opinion and comparison with another model derived from the TRIZ invention heuristics. These have suggested that the model is comprehensive and conceptually sufficiently robust to be regarded as a valid new ideation tool. The practical value of this tool has been demonstrated by application to a range of examples sourced from the literature.

6.3 CONTRIBUTIONS

The ideation model offers a number of advantages; the following being considered the most significant.

Framework of understanding

The major emphasis of this work was on theory building, in providing a structured and comprehensive map of the inventive ideation landscape. This work not only elucidated the mechanisms of inventive ideation, their use and relationships, but also provided a basis of understanding that future studies in this area can conceivably draw upon.

Enhanced ideation capability

Secondly, the model enhances inventive ideation in some key respects. This includes:

(1) The application of ideation strategies best suited to the skills and needs of the individual or problem solving group and the type of problem. The model has been structured such that the relative position of a mechanism guides the user on the type of problem to which it would be applicable, the degree of creative intuition that would be required in using it, as well as the frequency with which it is used elsewhere (and hence, an indication of the likelihood of an inventive idea being produced).

(2) The use of IDs, detailing the full range of ideation possibilities that pertain to each attribute of the system. These provide a framework for the inventor to target specific areas for thinking, and detail the options that are available in doing so. It also highlights inventive mechanisms that may complement the TRIZ inventive principles and thus expand the scope of ideas; it has for instance been shown that the TRIZ heuristics account for only five of the ten inventive mechanisms.

The IDs were subsequently used as basis to develop a simplified version of the CM. This '4-attribute matrix' (4-AM) defines the four system attributes that are used most frequently for each engineering parameter, thus eliminating the need to define problems in terms of their technical contradictions. The tool was applied to 40 randomly selected mechanical engineering patents, which resulted in an overall success rate of 79%, i.e. in about three quarters of the cases the inventor would have reached the same idea by using the 4-AM. This compared favourably with the 54% achieved by the classic CM for the same examples. Complementing this strategy with an algorithm involving two additional attributes, *viz* Dimension and Function, increased, for the suite of examples, the success rate significantly.

(3) A methodology to audit the ideas that have been produced during brainstorming or other thinking sessions. Thus, inventive mechanisms and areas of the problem that may yield additional ideas can be identified.

(4) An ability to create novel ideas systematically, rather than relying on 'off-the-wall' approaches such as Random stimulation. To this end, it has been demonstrated that for simple, open-ended problems, direct association would be a more efficient approach than Random stimulation.

Importantly, this work supports the view that creative thinking does not need to be a random, chaotic process. Ideas can be generated by following a structured approach of 'forward thinking', which allows the parameters of the problem to be explored systematically and comprehensively. This structured approach may make creative thinking more attractive to people who prefer exploring and extending the known rather than using 'off-the-wall' or 'out-of-the-box' approaches that have no proven record of being more efficient.

Finally, an added advantage of using such a visual tool is that it removes people's minds from the immediate area of the problem. The fact that they can keep track of their thinking and try out new options or combinations brings an element of fun and experimentation to inventive problem solving. This is an essential ingredient of true and successful creative endeavour.

Sources of inventive ideation

A secondary contribution of the work lies in the formulation of a consistent definition of the sources of inventive ideation, based on the degree of problem definition and the nature of the ideation process. This framework explains the nature of the four sources of inventive ideas, *viz* Inspiration, Serendipity, Experimentation and Intervention, and has provided a platform for understanding the role of 'deliberate creativity' – the application of creative thinking techniques, heuristics and other tools to create ideas. This framework could improve the understanding of the different types of creative outcomes in organisations and thus form an important part of a creativity management programme.

6.4 RECOMMENDATIONS

The research has highlighted a number of areas that should be investigated to further improve the understanding and use of inventive ideation.

(1) First, the analysis of a range of creative thinking techniques has highlighted the fact that they possess distinct structures. A general model that describes these could not only simplify their application but also further help to clarify the usefulness and/or validity of such a large number of techniques.

(2) More work is required to improve the first version of the '4-attribute' contradictionless matrix. Whilst significant progress has already been made by the author in this regard, including the development of a unique graphic icon for each ID (Ross, 2006b), further qualification of the attributes in terms of the dominant inventive mechanisms could possibly render the tool even more powerful.

(3) Third, this work has been one attempt at providing a more generic framework for inventive ideation techniques. The further testing - such as by empirical investigation - and refining of the model should be an on-going process, and include the development of system models for a wider range of disciplines.