Using Morphological Analysis for Innovation and Resource and Development: An Invaluable Tool for Entrepreneurship

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ABSTRACT

Innovation is a key value creator for organisations. It is perceived to be a key driver of growth (through introduction of new products and services) and efficiency (through process improvements) in organisations. In times of intense competition, an organisation's success depends on its ability to continuously innovate faster and better. Morphological analysis is an invaluable tool for organisations to achieve breakthrough innovations and indulge in continuous research and development. Morphological analysis helps capture the 'form' and 'structure' of entities (both physical and conceptual) and serve multiple purposes. For an entrepreneur or a product manager, it facilitates new product development by highlighting gaps in existing products, thereby aiding in identifying new market opportunities. It can also be used as a learning tool by academicians/researchers to teach new concepts and identify research gaps. This paper introduces the basic concepts of Morphological Analysis, and elaborates the same through relevant examples. It is hoped that it would aid organisations and entrepreneurs to improve their competitive advantage by leveraging morphological tools.

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Introduction

The key to sustained competitive advantage for an organisation, in times of intense competition, is its ability to innovate continuously. Innovation not only helps organisations differentiate their products and services in the market place, but also acts as a key driver of growth for them. *Innovation* is commonly defined as the process through which a creative idea is implemented (in many cases, commercialised) for organisational benefit (Utterback and Habernathy, 1975). Today, many organisations have dedicated teams for Innovation, Research and Development (R&D), and New Product Development to ensure that they continuously develop and launch innovative products and services, thereby sustaining their competitive advantage. To this effect, organisations employ a variety of tools to aid innovation and R&D. Morphological Analysis (MA) is one such tool. The concept of MA was developed by Fritz Zwicky (1967, 1969) as a method for structuring and investigating the total set of relationships contained in multi-dimensional, non-quantifiable, problem complexes. Zwicky applied this method to diverse fields, such as the classification of astrophysical objects, jet and rocket propulsion systems, and legal aspects of space travel. He also founded the Society for Morphological Research. Since then MA has been applied to several fields of enquiry by researchers including policy analysis, future studies, and organisational studies (Ritchey, 2002). MA is a method for rigorously structuring and investigating the internal properties of inherently non-quantifiable problems which contain any number of disparate parameters. It compels practitioners to examine a number of configurations and solutions (Ritchey, 2002).

The term 'morphology' comes from the Greek word *morphe* meaning shape or form. Thus, the general definition of morphology is the 'study of form or pattern', i.e. the shape and arrangement of parts of an object, and how these relate to create a whole. Objects can be either physical (organisms, products, etc.) or conceptual (ideas, concepts, linguistic forms, etc.). MA has been used heavily in science based subjects such as botany, geology, and zoology. It was Zwicky (1967) who first proposed a general

model of morphology and advocated the use of MA to analyse abstract ideas, concepts and phenomena. In this paper, the strengths of MA is presented through some examples, and it is hoped that it will motivate entrepreneurs, researchers, academicians and students to utilise MA as a tool for innovation and learning.

Morphological Analysis

As mentioned earlier, morphological frameworks are powerful in representing the anatomies of entities – both physical and conceptual. Morphological frameworks consist of two components: (1) the *dimensions* of the entities; and (2) the *options* of the dimensions. These dimensions and options completely represent the *form* and *structure* of the entities. The steps to be followed in developing a morphological framework as recommend by Zwicky (1967) are underlined in Table 1. These steps are more relevant for organisations wanting to use MA for problem solving or developing new products/services.

Table 1: Steps in Morphological Analysis

Step	*Tasks*
One	Formulate the problem to be solved (e.g. designing a new product or feature)
Two	Identify all the parameters/dimensions and corresponding variants/options of the key entity in focus
Three	Construct the morphological framework by mapping the dimensions (and sub-dimensions if any) and the corresponding options of the entity
Four	Scrutinise and evaluate all the options available in the morphological framework
Five	Choose the best option that solves the problem that was formulated in step one

The power of MA is explained by presenting morphological frameworks for toothbrush, pen, and innovation in the following sections.

Morphology of a Toothbrush

As a first example, the MA of a toothbrush is discussed. The basic dimensions of toothbrush include *body, neck, head*, and *bristles* (Figure 1). Based on this, a basic morphological framework of a toothbrush is presented in Table 2. The *dimensions* and corresponding options of the

various dimensions of a toothbrush are elaborated in the framework. It should be noted that the list of dimensions and options presented in the framework is only indicative and not exhaustive. Every toothbrush that is available in the market can be placed along a dimension (or dimensions) of the morphological framework. For a layperson, the morphological framework will provide a bird's eye view of the available toothbrush options, and for a practitioner it will be a basis for designing a new toothbrush that is currently not available in the market.

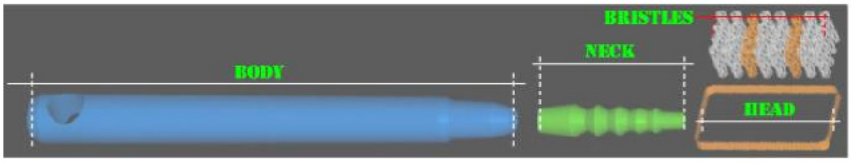

Figure 1: Dimensions of a Toothbrush

The toothbrush that is being daily used could be square in shape, made of plastic, having a bent neck with a round head, and having nylon bristles arranged in three rows. Similarly, every toothbrush that is there in the market can be mapped to this framework. In a New Product Development exercise, teams can use this framework to identify new combinations of features that are presently absent in toothbrushes.

Table 2: A Basic Morphological Framework of Toothbrush

Dimension	*Options*				
Body	Length	Different Lengths			
	Width	Different Widths			
	Thickness	Different Thickness			
	Shape	Square	Circular	Hexagonal	Rectangle
	Material	Plastic	Wood	Steel	Aluminium
	Grip	Rubber	Soft Squishy	Ribbed	
Neck	Length/Width	Different Lengths/Widths			
	Flexibility	Flexible in one direction	Rigid	Other modifications	
	Profile	Straight	Bent		
Head	Number	One	Two		
	Length/Width	Different Lengths/Widths			
	Cross section	Different cross sections			
	Shape	Round	Diamond	Others	

Bristles	Material	Nylon	Animal Hair	Others	
	Texture	Extra Soft	Soft	Medium	Hard
	Arrangement	In three rows		Others	
	Length/Width	Different Lengths/Widths			

Morphology of a Pen

To further elucidate the concept of MA, a basic morphological framework of a pen (that we use commonly) is presented in Table 3. It can be observed that the major dimensions of a pen, namely, Body, Cap, Refill, and Nib are identified as key dimensions. Further, sub-dimensions such as *shape, material, colour*, etc., are also identified, and the variants/options are explicated in the framework.

Table 3: A Basic Morphological Framework of Pen

Dimension	*Options*				
Body	Shape	Cylindrical	Hexagonal	Square	Cube
	Material	Steel	Plastic	Rubber	Wood
	Colour	Black	White	Grey	
Cap	Type	No Cap	Presence of Cap		
	Material	Plastic	Steel	Rubber	Wood
Refill	Material	Plastic	Steel	Rubber	
	Ink-material	Gel	Liquid		
	Ink-colour	Blue	Black	Red	
	Type	Cartridge	Jotter	Tube	
Nib	Roller	Fine-tip	Diamond		

As explained in the case of a toothbrush, any pen available in the market can be mapped uniquely against the morphological framework presented above. For instance, the pen being used could be of a cylindrical shape, made of steel, grey in colour, having a cap made of steel and gel ink with a roller type of nib. When an entrepreneur looks at this, he/she could design a new pen which has a hexagonal shape and is made of wood. There could be several such combinations of dimensions/options that is currently not available in the market, but would meet customer needs. Thus, the framework would serve as a good starting point to initiate New Product Research and Development.

Morphology of Innovation

To explain how MA can be applied even to abstract concepts or ideas, a basic morphological framework of Innovation is presented in Table 4. The basic idea here is to develop morphology of Innovation. Thus, the scope is restricted to the concept or idea of Innovation. Based on literature (Gopalakrishnan and Ganesh, 2003) and experience, the key dimensions of innovation, namely, *types*, *stages*, *modes*, *participants*, *strategies*, and *outcomes* are identified, and the options corresponding to these dimensions are also listed (see Table 4). The framework is explained in detail below. This framework could be used by researchers to understand the landscape of research studies conducted in the area of Innovation. For example, researchers can map every research paper that has been published in the area of Innovation onto this framework and identify existing research gaps. Academicians could use this to teach the concept of Innovation while organisations can devise Innovation strategies based on the framework. However, it has to be noted that this framework is not exhaustive and has scope to be developed further.

Types

Innovations are generally classified into two types, product and process innovation (Utterback and Abernathy, 1975). However, Pavitt (1990) quotes Schumpeter's view of Innovation, which includes new forms of organisation, new markets and new sources of raw materials. Here, we classify innovations into three types:

- *Product* (includes *Services*)–Microsoft introducing Windows XP software in the US market; A logistics company offering on-line tracking of goods.
- *Process*–Increase in the capacity utilisation of a power plant; Reductions in customer turn-around time in a bank.
- *Structural*–Changes in team structures within an organisation; Changes in the manner an organisation structures its market.

Table 4: A Basic Morphological Framework of Innovation

Dimension	*Options*				
Types	Product		Process		Structural
	Continuous/Incremental			Radical/Breakthrough/Disruptive	
Stages	Ideation	Selection	Develop-ment	Implemen-tation	Dissemina-tion
Modes	Concentrated		Distributed		
Participants	Organization	Customers	Suppliers and Partners	Education and R&D Institutions	Competitors
Strategies	Outsourced			Self-Managed	
Outcomes	*Tangible*	Patents, Products, Processes, etc.			
	Intangible	Frameworks, Architecture, Brand, etc.			
Context	New Product Development		Training and Development	Customer Support	Operations

Innovations are also classified as:

- *Continuous* (or, incremental), i.e. step-by-step improvements – Introduction of new versions of existing software.
- *Discontinuous* (or radical), i.e. something radically new – Introduction of a totally new software (e.g. introduction of the LINUX operating system).

Stages

Innovation processes in organisations go through different stages starting from the generation of an idea, and ending in commercialisation (in the case of product innovations) or implementation (in the case of process and structural innovations). The first stage in the innovation process is the creation of a suitable environment for generation of new ideas. Only 'promising' ideas are chosen for further development. Managers allocate resources for the growth of these chosen ideas. After an idea is sufficiently developed, it can be taken to the market. When a creative idea is implemented it transforms into an Innovation. The next stage is the diffusion of knowledge about this Innovation within the organisational boundaries. Thus, Innovation processes go through the stages of (idea) generation, selection, development, implementation (or commercialisation) and dissemination (or diffusion).

Modes

Innovation processes can either be:

- *Concentrated*–The task is allocated to a small team and the whole process takes place within a small unit (say, the R&D division or a Strategic Business Unit).
- *Distributed*–Small teams that are distributed across the spatial units of an organisation work on the same or different aspects of the Innovation.

The choice of the mode of generation will depend primarily on the type of innovation, the infrastructure, and knowledge requirements.

Participants

Innovation processes are increasingly becoming collaborative. Now, Innovation is not solely an organisational process where only employees belonging to the R&D unit of an organisation contribute. It has evolved to include multi-disciplinary teams that make it an organisation-wide process. The recent trend is 'Collaborative Innovation' where organisations involve their customers, suppliers and partners, educational and research institutions, and sometimes even competitors, in the Innovation process.

Strategy

There are two broad innovation strategies:

- *Self-managed*–where the whole Innovation process is managed within an organisation, utilising its own resources.
- *Outsourced*–adopted mainly when an organisation does not possess the necessary infrastructure, resources or competence, or wishes to focus on its core competence.

Outcomes

The main outcomes of Innovation are new products, processes or organisational structures. Innovation also generates knowledge assets–both tangible (like products, patents, processes, design, etc.) and intangible (like new frameworks, architectures, competencies, brand image, etc.).

Context

Lastly, the context in which Innovation takes place within an organisation could be: (1) New Product Development; (2) Training and Development; (3) Customer Support; or (4) Core Operations.

Conclusions

The intention of this paper is to introduce and emphasise the effectiveness of using tools such as MA to support innovation and R&D in organisations. The power of MA was revealed through the examples of morphological frameworks developed for a toothbrush, pen and innovation. From an academic and research perspective it is hoped that the use of MA would provide fresh insights into their disciplines of inquiry, and make the teaching-learning process more interesting. From a practitioner's perspective, MA would serve as a basis for identifying new products and market opportunities, and designing new systems.

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