A Role of Quality of Information for Innovation:

Leadership Style and Information Management

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Abstract— Several factors must be in place to enable innovation to happen. It is recognised that the availability of information and information management tools and leadership style can all have major impacts on the effectiveness of innovation processes. Many problem solving methods exist for decision making and these can be used for innovation. However, any method requires adequate quality of information as an input. The purpose of this paper is to discuss the role that quality of information can play in innovation, leadership styles and use of various information / knowledge management techniques. In this work, Profile Theory is used as a tool for the analysis and measurement of information capabilities and compatibilities to ensure the required quality of information.

Keywords— component; Leadership; Culture; Capabilities and Compatibilities; Profile Theory.

I. INTRODUCTION

Study, analysis and management of information resource capabilities become a focus of attention in a knowledge-based environment. In fact, the success of innovation is reliant on how project leaders and/or managers can assemble information with the adequate quality of information resources. This is because, information, which is used for decision making, requires multiple information components and must satisfy the particular combination of information for innovation. The misapplication and/or poor capabilities of information resources may lead to confusion in decision making and failure of innovation.

This paper presents measurement techniques, which are applied to information resource management. In this work, Profile Theory [17] is used as a tool for the analysis and measurement of information capabilities and compatibilities. The concept of a profile [17] is used as a representation of information. Information resource usage is defined via a series of integrated capability and compatibility measures. These measures are used for effective information resource allocation and utilisation, to ensure that information resources fit the needs for innovation.

This paper explores the concepts of information quality and leadership style and how these relate to, and can enable innovation. The paper starts with the discussion of some critical aspects of innovation, leadership style and tools/methods for innovation being used across different fields to address important points that define a key role of information for innovation. It also outlines our research position. Then it presents profile-based measurement techniques, providing an answer to the question of how to measure information resource capability and compatibility; and constructs an argument for the need for further research in this area.

II. INNOVATION, CREATIVITY AND COGNITIVE TASKS

Innovation is based on creative processes. In a business environment, creativity is considered as the process that leads to products that are novel and have functional utility. Creativity is the process through which new ideas are developed and used for innovation [15], [3]. Innovative ideas could be generated during the course of on-going work when available current solutions are not found.

Innovation is a cognitive process and like other cognitively driven tasks has specific character. That is, in many cases, innovation [16]:

- cannot be expedited (or in some cases even solved) by human resource reallocation or by adding extra resources: that is, it is not a resource-driven task
- is dependent first of all on people's (knowledge/skill, learning) capabilities which are different; that is, they cannot be defined as fixed-duration tasks
- is managed by individuals (self-managing intellectual work), rather than being administratively managed
- can not be subdivided into smaller sub-tasks (i.e. cognitive tasks can not be defined as nested or fine-grained tasks).

New tasks and/or problems can demand new/innovative solutions and require new knowledge and capabilities of project resources. Creative thoughts cannot be controlled or scheduled by a leader or manager. But creativity and cognitive processes must be inspired and supported by leaders.

III. ROLE OF LEADERSHIP STYLE FOR INNOVATION

A. Vision

It is recognised that organisational innovation capability under a suitable leadership style leads to good innovation performance [10]. "Management is doing things right; leadership is doing the right things" [5]. But "Leadership is doing the right things" – finding, determination and selection of the right things should come first.

Leadership is about development of vision. Vision is defined as intelligent forethought which is intended to be used as a clear guide for future development when choosing the right courses of action. Vision is about the realistic aspirations of organisations (i.e. it is about doing the right things). Vision is essential for successful innovation.

B. Leadership Style Management

To address the variety of real-life problems a leader should be flexible in his/her leadership style since one style may not be appropriate for every situation. There is no universal leadership approach. The most important aspect in leadership style/culture is it has to support innovation, organisational development and performance. Nowadays leadership style is considered as the key driver for developing a creative culture, a creative workplace and innovation [3]. Therefore, it is crucial for leaders to learn different types of leadership to ensure that the most effective leadership style is employed for the problem/situation. Thus, leadership culture should accommodate different leadership styles in a flexible manner. Experience is a great thing; but it has to be taken into account that experience without relevant education/ knowledge may not lead to the right direction and bring the desired outcomes. Leadership style management thus becomes a crucial task for innovation processes and performance.

It is recognised that leadership style has direct impact on the cost of projects that involve cognitively-driven processes such as software development [9]. Therefore, ideas can be generated and can be profitable, and lead to innovation but the leadership style may not support them. Many ideas do not become profitable. In many cases this is not because of the failure of the idea. The generation and implementation of new ideas are tasks of equal importance in innovation.

C. Leadership Style Importance - Workplace Environment and Climate

Since innovation is a cognitive process; leadership style must ensure that the workplace environment is a cognitively-friendly space where people can open their minds for creativity, sharing their ideas and supporting them. It is important to note that any fantastic, effective, and reliable processes, technologies, methods, approaches and ideas do not work if they do not find the right work environment. Happy

people produce good results. The work environment must inspire and support people and, therefore, organisational capabilities.

Command-and-control leadership methods are inefficient [13] and do not work successfully in the fast changing knowledge-based economy. Leadership should be progressive to create a climate that encourages creativity and innovation.

D. Knowledge Quality and Limited Knowledge

Captain William Bligh's problem on the *Bounty* is a very well-known example on how a united team could achieve a common goal under very little information. This story is about how, more than 200 hundred years ago, Captain Bligh navigated 3,600 miles to the Dutch colony in Timor without any use of technology, i.e. charts or navigation tools. People could navigate across oceans and arrive at their destination by using their comfort zone. People had to make decisions in a situation of increasing time pressure and uncertainty.

In this example, people did not know if they were making the right decisions until they arrived. It is very similar to the innovation process, i.e. innovation can be identified after it has occurred. Innovation is a journey where we do not know the results until we arrive.

E. Command-and-Control Decision Making

According to Kemp [11] "the nature of effective command-and-control decision making is that an immediate decision and action implementation strategy is needed. When time is less of an issue, a more time consuming approach to decision making can occur."

However, there is evidence that command-and-control decision making methods are not effective for immediate decisions, e.g. consider Captain William Bligh's problem. A "comfort zone" approach could work well for decision making under time pressure if the capabilities of a team of people are integrated to satisfy the needs.

IV. ROLE OF INFORMATION / KNOWLEDGE MANAGEMENT FOR INNOVATIVE LEADERSHIP

The French sociologist and criminologist Jean-Gabriel De Tarde (1843 - 1904) believed that among any 100 people we could find 1 person who is inventive. This is also very true in this technological era.

Now we say and/or believe that lots of people are capable of innovating. Some people may say that it is very much encouraging belief and relevant to motivation, respect, and equal capabilities. But the use of information technology provides us with great opportunities for information and knowledge management. And it makes an impact on degree/level, spread and speed of innovation. Technologies have a crucial influence on leadership styles. And leadership methods should accommodate fast changing technological capabilities.

However, information can be considered as the critical resource for decision making for innovation. Nowadays leadership and management are based on information-intensive

activities for “doing the right things right”. Therefore, information and knowledge management is a key task for supporting innovative leadership.

The most critical task for leaders is to define or identify information that direct organisations to profitable economic outcomes. Not all information or knowledge is useful for innovation, i.e. some information can not help define a clear vision and support decisions.

V. SOME TOOLS FOR INNOVATION

The strategic organisational capabilities for innovation are determined by abilities of organisations to process rapidly changing information. There are lots of problem solving methods for decision making that are used for innovation, but any method, as a tool/model, requires quality information as an input for optimal performance.

A. *Comfort Zones as a Decision Making Tool for Innovation:*

The comfort zone approach is considered as a very basic tool that could be used to make achievements. The comfort zone approach is discussed in relation to various people management aspects, e.g. performance management, optimal performance zone [21], leadership style [2], and outdoor adventure education [6], [12], [19].

We consider a comfort zone tool from the viewpoint of intellectual capital and we believe that the comfort zone approach is based on knowledge/skills that people utilise comfortably to obtain optimal performance. Therefore, it can define a very reliable background for innovation if the workplace can offer the right conditions.

B. *Qualitative Methods*

Many leading methodologies are used for innovation processes. Innovation methodologies are mainly derived from the objectives and expectations of the main stakeholders. Some well-known approaches are Brainstorming [14], Brainwriting [8], Delphi Method [4], [7], Heuristic Redefinition Process, Transformation of Ideal Solution Elements with Associations and Commonalities (TILMAG) [20], and Theory of Inventive Problem Solving (TRIZ) [1].

These tools are used for making quality decisions and they work best where there is a free flow of ideas and opinions (i.e. the working environment is right) and where there are lots of opinions and ideas (i.e. multiple viewpoints and inputs of information). There is also a place for wrong viewpoints, perspectives, opinions and decisions. But with time and high volume of information, more right results or outcomes will be produced rather than wrong. Time and experience put decisions on the right track.

There are two key interrelated processes: divergent thinking and convergent thinking. A critical component of the qualitative methods framework for innovation is time, which is required for information / knowledge communication.

C. *Research vs. Case Studies*

Meantime it is recognized that innovation should be based on strong research, and not purely on anecdotal case studies. Case studies can have a subjective nature and can be interpreted differently, depending on what people know and what they already believe. Independent research examines, and tests key assumptions, constraints and relationships, and defines a reliable basis for innovation. However, case study results can serve as input information for research. Case study results can be used as a source of information for conducting research.

D. *Data Mining Technologies*

Data mining technology can be used to extract useful information from datasets; particularly in a situation where any available information can be useful and quality of this information is not a critical issue.

But there are lots of real life examples where available information does not lead to effective outcomes. In Captain William Bligh's example, people could not achieve their common goal without good quality of information, e.g. positions of stars, and without relevant knowledge of natural resources.

VI. QUALITY OF INFORMATION: INFORMATION CAPABILITIES AND COMPATIBILITIES

We believe that innovation is not just a matter of “Eureka” moments or experimentation. Many innovations are initiated by new information and research. Quality of information has a major impact on the effectiveness of innovation processes; and information resource capability and compatibility must be an important focus of decision making. However, for innovation (i.e. cognitively driven) tasks, involving information capabilities and compatibilities as critical variables, existing heuristic approaches to the definition of information resource capability/compatibility do not sufficiently examine how effectively information resources fit the needs. Therefore, there is a need to develop evaluation techniques for information capability and compatibility determination, in order to provide support for the effective solutions to innovation tasks.

VII. PROFILE THEORY: PROFILE DEFINITION

In this work, Profile Theory [17], [18] is used as a tool for the analysis and measurement of information capabilities and compatibilities. A profile concept is used as a representation of information. Information resource usage is defined via applications of capability and compatibility measures. These measures are used for the information analysis, comparison and management of information resource capabilities and compatibilities, effective information resource allocation and utilisation for innovation.

In Profile Theory an object is described by its internal characteristics. That is, an object is described by a set of factors, and in turn each factor may be defined by multiple characteristics. A set of such factors forms a profile. More factors are used for an object description, and more explicit identification and definition of object is provided. We represent

a factor by both qualitative and quantitative information. A quantitative description of the i th profile factor is defined by an indicator characteristic $\mathcal{E}_i$, property $\mathcal{V}_i$, and weight $\mathcal{W}_i$ ¹. In particular,

- $\mathcal{E}_i$ - is the indicator characteristic that indicates and expresses, by factor presence in the object description, the existence of certain conditions. In particular,

1. $\mathcal{E}_i$ may be defined as a time characteristic of the i th factor $\mathcal{E}_i = \mathcal{E}_i(t)$;

$$\mathcal{E}_i : \mathcal{T} \rightarrow \mathcal{E}_i \text{ or } \mathcal{T} \times \mathcal{E}_i = \{(t, \mathcal{E}_i), t \in \mathcal{T} \text{ and } \mathcal{E}_i \in \mathcal{E}_i\}$$

Where $\mathcal{T}$ is a set of time characteristics; $\mathcal{E}_i$ is a set of possible indicator characteristics of the i th factor.

Domain constraints may define bounds, i.e. $\mathcal{E}_i^b \leq \mathcal{E}_i \leq \mathcal{E}_i^u$, where $\mathcal{E}_i^b \geq 0$, $\mathcal{E}_i^u \geq 0$ represent bottom (lower) and top (upper) values of the i th factor time range, respectively.

The time characteristic can represent the duration (or length) of experience or factor utilisation.

2. $\mathcal{E}_i$ may also represent a number of times of factor utilisation (e.g. a number of projects (or tasks) where a particular knowledge/skill was utilised)
3. $\mathcal{E}_i$ may also represent a binary case. For instance, factor existence $\mathcal{E}_i = 1$ or non-existence $\mathcal{E}_i = 0$; Boolean variable: $\mathcal{E}_i = 1$ if factor is true or $\mathcal{E}_i = 0$ if factor is false.

- $\mathcal{V}_i$ - is the property of the i th factor (e.g. depth, range, complexity, capability, degree, grade of compatibility or level of a factor): $\mathcal{V}_i \geq 0$. Since a property may change with time, $\mathcal{V}_i$ can be defined as a function of time $\mathcal{V}_i = \mathcal{V}_i(t)$;

$$\mathcal{V}_i : \mathcal{T} \rightarrow \mathcal{V}_i \text{ or } \mathcal{T} \times \mathcal{V}_i = \{(t, \mathcal{V}_i), t \in \mathcal{T} \text{ and } \mathcal{V}_i \in \mathcal{V}_i\}$$

where $\mathcal{V}_i$ is a set of property characteristics of the i th factor.

Domain constraints may define bounds, i.e. $\mathcal{V}_i^b \leq \mathcal{V}_i \leq \mathcal{V}_i^u$, where $\mathcal{V}_i^b \geq 0$, $\mathcal{V}_i^u \geq 0$ represent bottom (lower) and top (upper) values of the i th factor property range, respectively.

- w_i - is the weight of a factor which defines either the factor importance or the factor priority: $w_i \geq 0$. Factor weights can vary, and therefore, w_i can also be considered as a function of time $w_i = w_i(t)$;

$$w_i : \mathcal{T} \rightarrow \mathcal{W}_i \text{ or } \mathcal{T} \times \mathcal{W}_i = \{(t, w_i), t \in \mathcal{T} \text{ and } w_i \in \mathcal{W}_i\}$$

where $\mathcal{W}_i$ is a set of possible weights of the i th factor.

Domain constraints may define bounds, i.e. $w_i^b \leq w_i \leq w_i^u$, where $w_i^b \geq 0$, $w_i^u \geq 0$ represent bottom (lower) and top (upper) values of the i th factor weight range, respectively.

In order to define completeness of an object description with respect to the required factors, we consider the property for completeness of profile factors. That is, the profile represents a complete set of the key profile factors if the set of the factor weights for the particular profile satisfies the following conditions:

$$\sum_{i=1}^n w_i(t) = 1, \text{ where } w_i(t) \in [0, 1]$$

The completeness property is important for identification of the essential profile factors to be incorporated into the profile description.

Weight can be defined by deterministic and stochastic approaches. In particular, in the deterministic approach weight is defined as a function: $w_i = w_i(t)$.

In the stochastic case, weight can be defined as a probability measure. That is, profile factors are represented by their associated probabilities of occurrence or importance. In fact, weights of the factor can be determined in the context of practical applications.

We define a profile b as a set of factors $b_1, b_2, \dots, b_n$:

$b = \{b_i, i = \overline{1, n}\}$, where the i th factor b_i is represented by a pair $b_i = (l_i, e_i)$ with

- l_i - an identification of the i th factor, i.e. a name or label or type of the i th factor
- e_i - the 3-tuple of the i th factor as the Cartesian product: $e_i \in \mathcal{E}_i \times \mathcal{V}_i \times \mathcal{W}_i$

$$e_i = \langle \mathcal{E}_i, \mathcal{V}_i, \mathcal{W}_i \rangle$$

- n - a number of factors.

¹ It should, however, be pointed out that each profile factor may be described by an N -dimensional tuple [17].

A “deviation“ of the available information profile $b \in E$ from a required information profile $b^{(0)}$ can be measured by the covered power index [17]:

$$\rho(b) = \rho(b, b^{(0)}) = \frac{m}{n}, \quad 0 \leq \rho(b) \leq 1$$

where m is a covered power of b ; n is the required information profile power.

The distance $d(b^{(i)}, b^{(j)}) = |\rho(b^{(i)}) - \rho(b^{(j)})|$ between two covered power indices can be considered as the distance between the available information profiles $b^{(i)}$ and $b^{(j)}$ (or as a compatibility-length metric) [17]. Factor capability is defined as [17]:

$$V_i = V(b_i) = w_i \left(\frac{\varepsilon_i}{\varepsilon_i^{(0)}} \right) \left(\frac{v_i}{v_i^{(0)}} \right)^2$$

Information resource usage is defined via a series of integrated capability and compatibility measures. These metrics are used as tools for the analysis and measurement of information capabilities and compatibilities to ensure the required quality of information.

VIII. ILLUSTRATIVE EXAMPLE

Recruitment of the right type of project leaders, who are compatible with the nature of a project and by organisational needs, has a significant impact on project performance.

Hamdan et al [9] use a profile notion as a representation of information on leadership qualities. An illustrative scenario of organisations within private and governmental agencies in the United Arab Emirates are shown in Table I, outlining the capability and compatibility for each leadership characteristic [9].

Hamdan et al [9] define leadership (L) by the following five factors $\{t_i; i=1,2,...,5\}$: Interaction and relationship (t_1); Decision-making (t_2); Ability to motivate (t_3); Understanding project culture (t_4); Active thinking (t_5).

Thus, in this example, the level of competence for description of i th factor (v_i) ranges from 1 to 3, where one denotes beginners, two refers to intermediate skills, and three refers to advanced skillful manager. In addition, each i th characteristic (w_i) is associated with a special weight of significance.

The required level of the leadership is advanced/high = 3. The weight is equal priority for all factors, i.e. $w_i = 1/5$. For example, the leadership profile capability is defined as:

$$V_{L1} = 0.20 \left(\frac{7.1}{9} \right) \left(\frac{3}{3} \right)^2 = 0.158$$

where the levels scale is: 1 for low, 2 for nominal and 3 for high/advanced.

Leadership quality is defined by capability and compatibility measures. These measures are used for analysis of leadership profiles and for the selection of the most suitable leadership profile that matches the project manager job position. It enhances the decision making and also supports the recruitment process to improve effectiveness of the employment procedure in organisations.

Leadership capabilities and compatibilities measures are used for the analysis, comparison and management of leadership quality; effective leadership allocation for innovation.

TABLE I. QUANTITATIVE DESCRIPTION OF LEADERSHIP ASPECTS

Description	Aspects	No of Factors (n)	Max Scale (s)	Factors	Actual Value (v)	Max Factor Weight (w)	Weight Aspect (q)	Z_norm
Leadership	L	5	9	t1	7.1	0.20	0.040	0.032
				t2	7.0			0.031
				t3	6.6			0.029
				t4	6.8			0.030
				t5	7.2			0.032
w(L)								0.15
Team Culture	T	6	9	t1	6.7	0.2	0.033	0.025
				t2	6.9			0.026
				t3	6.8			0.025
				t4	7.1			0.026
				t5	6.5			0.024
w(T)								0.025
Organisational Type	G	1	3	Functional	0	0.2	k = 0 1/3 1	-
				Matrix	0.5			-
				Prj. Oriented	1			0.200
w(G)								0.20
Communication Skills	C	2	9	Leader C	7.1	0.2	0.10	0.079
				Team C	7.1			0.079
w(C)								0.13
Project Complexity	X	1	2	Support	0	0.2	k = 0 1	0.100
				Core	1			-
w(X)								0.10
Total required weight (Z)								0.63

IX. CONCLUSIONS

There are lots of problem solving methods for decision making that are used for innovation. However any method, as a tool/model, requires relevant quality of information as inputs for its performance. Yesterday's information management strategies may not work in an information-intensive environment. We have to consider what is best for making quality decisions: quality of information and/or quantity of information.

Researchers have various different viewpoints on the use of different leadership styles; and on creative, information and knowledge management tools for innovation. However, what is clear is that quality of information plays a key role in effective and successful innovation processes and their performance. The quality of the information that we use for decision making and for innovation is critical and is an open area for study and research.

In this work, Profile Theory is used as a tool for information management, in particular, for the analysis and measurement of information capabilities and compatibilities in order to support effective solutions to innovation tasks.

The application of profile theory technique could provide organisations with:

- superior management of information resource capabilities and compatibilities
- support for an identification/development of innovative objects, tools and/or functionalities based on analysis of object's capabilities and compatibilities
- streamlining of development of innovation through better management of resources, tasks, etc.
- increased opportunities for organisations to implement innovation based on the constructive criticism derived from self analysis.

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