Creativity and Innovation in SPI: an Exploratory Paper on their Measurement?

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Abstract

In recent years, some software organizations have been successful at improving their maturity level, thanks to the successful application of methods and techniques which help them to achieve better performance and more consistent production processes. Models such as the Sw-CMM (and its evolutions and derived models) have provided roadmaps to process improvements.

Creativity and innovation have been placed at Level 5 of the CMMI and the P-CMM respectively. A suggestion is made in this paper to consider creativity and innovation management earlier on in such SPI models. Also in this paper, we propose, in an exploratory way, a method for mapping, tracing and measuring creativity, based on two entities: the CA matrix and the Creativity Indices.

1. Introduction

People cannot be managed as a second-level asset, as strongly emphasized in quality models like the Malcolm Baldridge Model [21] and the EFQM [9]. The Malcolm Baldridge National Quality Award 2001 criteria, for example, take into account 375 points of 1000 (37.5%), split among Enabler processes (Human Resources Focus: 85 points and Customer and Market Focus: 85 points) and related Results (respectively, 125 points plus another 80 points). For its part, the EFQM Excellence Model, with 1999 weight criteria, takes into account 18% of the total number of points, the People Enabler being responsible for 9% and the related results for another 9%. Similarly, the Balanced IT Scorecard (BITS) designed by the European Software Institute [15][26][27] and the AIS BSc [10] have both added a fifth perspective, "*People*" and "*Employee*" respectively and devoted to the human assets.

The People CMM (P-CMM) [8] provides guidelines on how to manage and develop people assets. Is it proper to insert or integrate into process improvement some processes actually covered by such people models?

Software Process Improvement (SPI) has been identified to be a subset of TQM in the context of software processes. SPI models cover only the process side of TQM, as applicable to the software world. In parallel, some leading organizations are implementing the management concept of the "Learning Organization", in which people represent the most relevant organizational strength, as inferred by quality models such as the Malcolm Baldridge Model and the EFQM. The objective of this paper is to analyze this issue from a specific perspective in TQM: creativity and innovation.

To this end, this paper also proposes some exploratory candidate measures derived from a Creativity versus Application (CA) matrix. Finally, the paper illustrates the use of the four quadrants of this CA matrix to maintain and consolidate the advantages stemming from better people management (including management of creativity and innovation).

2. Innovation and Creativity in SPI models

According to the TQM philosophy, creativity and innovation represent two valuable topics when continuous improvement is the main focus. **Creativity** is defined as " *the ability to create especially new and original things*" and **innovation** as "*the introduction of something new*"[1]. Thus, it is possible to consider

[1] All these definitions are taken from the online version of the Merriam-Webster dictionary, available at http://www.m-

creativity as the enabler and innovation as the concrete instantiation of this enabler in the everyday reality of the organization.

Saiedian and Kuzara have described SPI as a subset of TQM for the software world [28]. Mark Paulk, in a Q&A session published on the SEI website, addressed this question in 1997 [23], saying that SPI models like the CMM cover just the process side of TQM[2], specifically for software engineering, and deliberately do not address other relevant aspects like people issues[3]. The focus in this paper is on one aspect of people issues and management, that is, creativity and innovation as an important factor in these improvement models.

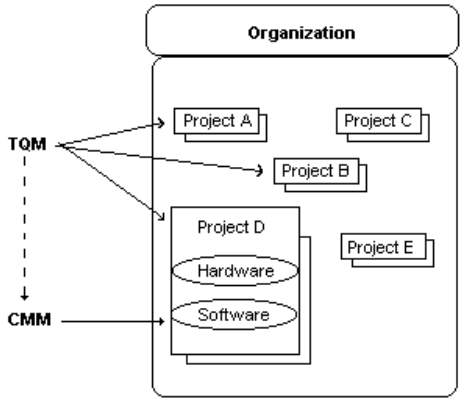

Figure 1 - Relationship between TQM and SPI [23]

Some have argued that SPI models do not catch and capture the multiplicity of existing organizational aspects in a single model, and that *"the CMM reveres process, but ignores people"*[1,2]. Some also hold that creativity would be choked by the major emphasis given to processes and seems to be confined to other maturity frameworks such as the P-CMM, as if managing creativity were not also part of ICT companies' responsibility for developing something more innovative and newer than its competitors' products or services.

Bach also stresses that current SPI models miss the dynamics of processes, according to Jones [17] and Weinberg [31]. In [1], it is claimed that this is why companies such as Microsoft and Borland, where innovation is a key success factor, have been given low CMM level ratings, as has General Magic, one of the pioneers in the personal digital communication technology field, rated at Level 1. Highsmith [14] is also of the opinion that too often a process-based structure leads people to simply work according to processes, leaving too little time for experimenting with new paradigms and new ways to solve problems), as evidenced by the low level of importance given to R&D departments where creativity represents one of the main inputs.

By contrast, the proponents of SPI models are of the opinion that a higher level in SPI models would leave people more time to think and be creative. From this viewpoint, a process does not suggest how a person should think; processes simply represent, as Grey suggests [11], frameworks that provide structured roadmaps to help organizations to organize their own work.

As usual, there is always potential for *misuse* [19]: SPI models must be used as guides to do the work better, addressing results and daily efforts in a profitable way.

High organizational maturity levels in SPI models are considered better because useless heroism is avoided, the risk of failure and errors is lower and they provide the required flexibility for innovation and its successful and orderly deployment.

Of course, those models present some elements of rigidity. A key positive value of SPI models, however, is that they also offer greater stability of processes, which permits control of the work, in turn reducing effort through the tailored usage of those models as checklists. The following are examples of this: the SEI Technical Report on CMM tailoring [13] and the evolution of existing CMMs toward the CMMI with its two versions: staged and continuous, according to the principles originally presented in the Trillium model [3] and then translated into the ISO/IEC 15504 [16] standard on software process assessment and improvement (initially referred to as the SPICE model).

Well managed new ideas can be significant inputs for creating new business, for differentiation from competitors and for adding value to the whole organization. How is creativity management positioned

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w.com/dictionary.htm.

[2] Covey [7] states: "*Total Quality is an expression of the need for continuous improvement in four areas: 1) personal and professional development; 2) interpersonal relations; 3) managerial effectiveness; and 4) organisational productivity*". Silver [30] lists several CMM flaws, from the reduced importance given to processes' cultural dimension to the lack of quantitative process-performance metrics.

[3] Bøttcher [4] identifies key differences between CMM and TQM after an analytic summary of their characteristics. It must be stressed that SPI shares many of the common goals and success factors that characterize not only TQM, but also the Business Process Reengineering and Learning Organization management approaches <http://www.objectif.fr/~spire/pages/section4.html>.

in the SPI model's architecture? The latest version of the CMMI v1.02 [29] in its *staged* version, the creativity and innovation factor is limited to Level 5 (*Optimizing*), as shown in Table 1[4]; however, no specific reference to people and the ways in which they might express creativity is included, nor is how an organization should manage creativity and management in support of overall organizational goals. By comparison with another people-oriented KPAs, training is a KPA in both models (Level 3 in the CMMI and Level 2 in the P-CMM). In these models, training is considered as a base practice to be implemented as soon as possible to provide people with the necessary skills to become proficient in the organization.

The question can then be raised as to whether or not creativity management could be more adequately taken into consideration is such models. For instance, wouldn't it be better not to wait until Level 5 in the model architecture to manage new ideas, but rather to position this activity earlier on the maturity scale?

There is no doubt that great creativity management is challenging. Its integration within a staged model could help teach organizations how to tackle it progressively. This would require, for example, that related creativity and innovation elements be specified earlier in the model architecture, as was done for the Measurement & Analysis PA which has been repositioned, from Level 5 to Level 2, or by adding some dedicated *common features*, as in the Training Program PA.

	CMMI v1.02 (2000) [29]
KPA	**OID** – Organizational Innovation and Deployment
Maturity Level	Level 5 (*Optimizing*)
KPA Main Objective (*first sentence*)	"*The purpose of OID is to select and deploy incremental and innovative improvements that measurably improve the organization's processes and technologies. The improvements support the organization's quality and process performance objectives as derived from the organization's business objectives*"
Metrics and Indicators	The "Measurement & Analysis" CF has been deleted in the CMMI, since the measurement issue has become a Level 2 Process Area (PA). There are four new CFs: ° Commitment (CO) ° Ability (AB) ° Direct Implementation (DI) ° Verifying (VE) Measurement activities are positioned in: ° Selection (SP 1.4) ° Deployment (SP 2.3) ° Monitor and Control of processes (GP 2.8 – DI3)
Remarks	*Focus on the selection and deployment of methods and tools. More attention to the innovation aspects in the maturity evolution path.*

Table 1 – Creativity issues in the CMMI v.1.02

In this repositioning process, it will be useful to compare how creativity and innovation are addressed in TQM and SPI respectively, and to identify potential linkages across the two perspectives (as stated in the Introduction). In the first (TQM), *Kaizen*[5] (a Japanese word that means "*continuous improvement*") is a continuous series of incremental improvements referring to the *gemba* (workplace), most often performed internally by the organization's own staff. In the second (SPI), there is an assumption of more dramatic innovations which bring about more radical changes; such major innovations are usually developed by groups outside the organization itself and brought in for internal deployment.

Furthermore, a look at Kaizen reveals that two different levels can be distinguished:

- **Pure creativity**: a problem-solving style which is not model-based (as in TQM)
- **Guided creativity**: a problem-solving style led by the models (as in SPI)

The specifics of a further integration of creativity within an SPI structure, and of such a repositioning within current SPI models, is beyond the scope of this paper. Here, we develop, in an exploratory fashion, a single aspect required for such a repositioning, that is, their measurement, from an organizational perspective.

[4] The staged representation of the CMMI, ith OID at Level 5, spreads the boundaries of this issue when compared to the TCM KPA in the Sw-CMM v1.1 [22].

[5] For further details on Kaizen, please refer to: Imai M., *Kaizen: the key to Japan's competitive success*, McGraw Hill, 1986.

3. Exploratory assessment of creativity and innovation

3.1 Inputs from related work

The focus of this paper is, then, on how to integrate management of the creativity of employees within SPI models, how to measure it and how to "read" and interpret these points in current SPI model frameworks whenever possible.

Table 1 illustrates where innovation is tackled in the CMMI models, that is, at Level 5 in the Organizational Innovation and Deployment (OID) KPA. In the Remarks section of this table, it is also stated that there should be "*more attention to innovation aspects in the maturity evolution path.*"

In this paper, we propose to address this issue by identifying the 'what' and the 'how', that is, by proposing a 'format' within the model. Few studies have approached creativity and innovation from a quantitative (or a "not-qualitative") viewpoint, since too often the focus is on guidelines and techniques to stimulate creativity and innovation in people (brainstorming, serendipity, experimentation, observing the customer, using notes effectively, etc.). One author in particular has proposed a measurement approach for innovation: Redelinghuys [24] [25]. But his measurement approach differs significantly from the one put forward here in the following ways:

- Analysis of the performances of a single designer (*Redelinghuys*), while here the focus is on innovation management from an SBU/Corporate viewpoint
- Focus on the product quality derived from a stronger creativity level (*Redelinghuys*), while here the focus is on processes and application of these skills to the SBU/Corporate reality
- Usage of an N-dimensional vector to extend the calculation to N possible qualitative variables (*Redelinghuys*), while, as discussed in [6], "*A correspondent relationship between the number of elements to represent and the dimension in which the representation format is expressed must exist*" [5]. Therefore, an N-dimensional concept must be expressed in an N-dimensional space, while the vectorial representation at maximum can be expressed in a 3D space.

Moving from the above points, we drew up a focused proposal with the objective of detecting which creative path an ICT company is following and if it is able to properly adopt and manage the creation and innovation process. For this purpose, some elements needed to be established. Of the journalistic "5Ws + H" (who, why, what, where, when and how), also adopted in writing a measurement plan, the **what** and the **how** are of particular interest to us (Section 2.2), since the other four are implicitly defined:

- **Why**: to measure the creativity and innovation level in the organization
- **Where**: at the SBU/Corporate level
- **Who**: the owner of this measurement task, usually the Project Quality Assistant (PQA) or the Project Quality Manager (PQM) directly
- **When**: with the frequency established by the management PQM

3.2 Aspects that should be measured

For the measurement of creativity, the key concepts must be identified first:

- The **what** (***object***): usage in the organization of methods, techniques and tools [6] which allows the improvement of implemented processes and therefore better results
- The **how** (***modality***): the evolutionary path followed for the progressive adoption of a method-technique; it is possible to identify a sequence of four path levels:
  - **Level 1** (L1) - base application (usage of *core features*)
  - **Level 2** (L2) - advanced application (usage of *full-mature features*)
  - **Level 3** (L3) - tailoring (*ad-hoc*)
  - **Level 4** (L4) - innovation – creation (*ex-novo*)

The first two levels fit well with the *selection* item (GP1) in the CMMI OID, while the last two levels fit with the *deployment* issue (GP2).

- The **how** (**format**): furthermore, the logical structure for expressing such a path must be established;. the one proposed, according to the four creativity maturity levels, seems to fit with the plot in a SYMLOG space of KAI[7] as well.

[6] A method is "*a procedure or process for attaining an object: as a systematic procedure, technique, or mode of inquiry employed by or proper to a particular discipline or art*", a technique can be defined as "*the manner in which technical details are treated*" and a tool as "*a handheld device that aids in accomplishing a task.*".

[7] http://www.symlog.com/internet/how_symlog_relates/Kai.htm.

3.3 Creativity - Application (CA) Matrix

The **format** chosen was a two-dimensional matrix and the **modality** for its work was a division into the above-cited four maturity application levels.

For the analysis of the presence of innovation, and of its specific positioning within an organization, two key concepts will be looked at, that is: its presence or its use in projects, referred to as its application level, and the presence or use of creativity, referred to as the creativity level. This information will then be represented by a two-dimensional matrix, the *Creativity-Application* (**CA**) matrix, wherein a specific instance of the two dimensions are the Application Level of a technique-method and the Creativity Level expressed in that application. Both dimensions are measured with estimations on a percentage scale. The matrix is subdivided into four quadrants, as in Figure 2, one for each of the levels described above.

The issue to be measured in the CA matrix is given by the distribution of the points in the matrix (every point represents a single implementation of a technique-method in the everyday work of the company's employees). There are several ways to measure these points, such as analyzing trends during a certain period in the adoption of a single technique or of the whole group. The logical trend that the application of techniques and methods could follow might be along an S-shaped curve among quadrants, since the experience of the employees devoted to R&D on those issues increases with time. So, the evolutionary 4-level scale presented above also coincides with the results of increased creative ability in the organization[8].

In terms of the CA matrix, the other relevant issue to face is what the best creativity maturity path to follow[9] is. This curve is preferable to a diagonal that goes straight from quadrant 1 to quadrant 4, since a certain time frame is necessary to mature the right amount of experience useful to "create and deploy" (as stated in the CMMI SP1.4) and not simply "select and adopt" (as stated in the CMMI SP2.3) something that exists already. Thus, this curvilinear trend could be more representative of how a company obtains a better result in the medium-to-long period, in terms of both reduced costs and resistance to change.

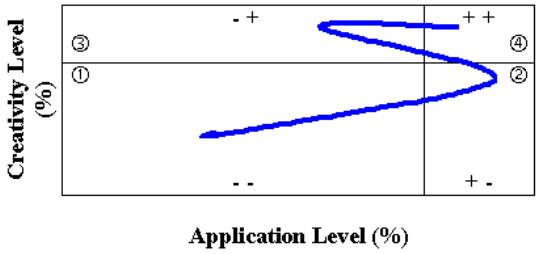

Figure 2 - CA Matrix and the S-shaped curve trend

3.4 Creativity Index (CI)

It has been observed that it is easier to adopt a technique "as is" (L1) than to use its advanced features (L2); it is also more common to encounter a tailoring of a method (L3) than the creation of a new one (L4). Similarly, we more often observe the adoption of a technique in a company (L1+L2) than its tailoring or creation from scratch (L3+L4). This is represented in Figure 3: the CA matrix area within the 4 quadrants does not have the same distribution, because of the differences between L1-L2 and L3-L4 (referring to the Application Level dimension) and between? L1+L2 and? L3+L4 (referring to the Creativity Level).

To provide a quantitative measure for the creativity expressed by an organization's personnel, simple geometrical formulas can be used. Using the CA matrix, every application of a method-technique represents a point on the Cartesian axes.

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[8] According to Kirton [18], an organization with a high proportion of innovators risks being less stable if it is not properly sustained by a "leadership for change", where communication between people with different and changing styles is of great importance. One key issue will be the perception of a potential agent of change of innovators by adaptors, and vice versa, looking at the common and shared values, and reducing the resistance to change. Green and Hevner [12] found that *Developer Involvement* (in terms of *adoption*) and the *IT diffusion environment* (in terms of *champion support, voluntary use, training* and *degree of novelty*) as the key enabling factors that positively influence IT diffusion success in software development. In this particular case, resistance to change has been reduced through the introduction and usage of the Personal Software Process (PSP).

[9] As also studied from an individual perspective, with a macro-economic style, in [25].

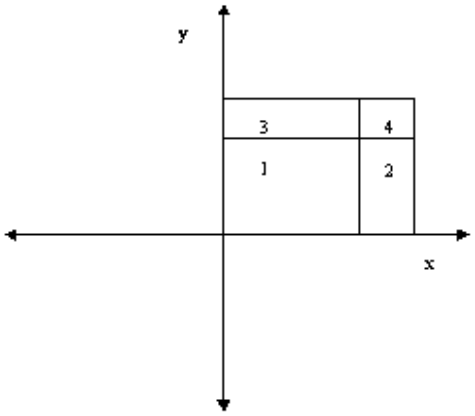

Figure 3 - Cartesian axes: positioning the CA Matrix

Every point represents a tuple:

P_A (*ApplicationLevel%; CreativityLevel%*)

Therefore, the distance *d* of a point from the origin represents the value of that implementation (Figure 4):

$$d = \sqrt{(x_2 - x_1)^2} + (y_2 - y_1)^2$$

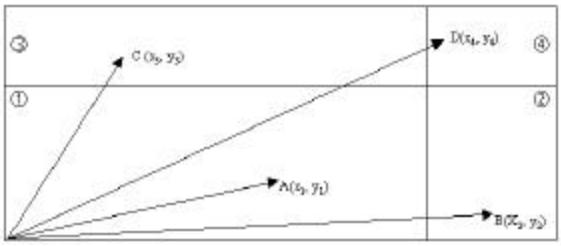

Figure 4 - CA matrix points: calculation of CI

Thus, in an embryonic form, the Creativity Index is given by the mean value from the methods-techniques applied in the organization. But it is necessary to take into account that a point placed in quadrant 2 could be at a greater distance from the origin than another placed in quadrant 3 or 4 (as in Figure 4).

It is therefore necessary to weight these points according to the quadrants they are in (that means according to the maturity level of the solution adopted).

In a generic form, the formula for the Creativity Index will be:

$$CI = \sum_{j=1}^{4} \sum_{i=1}^{m} \frac{P_{ji} * w_j}{n}$$

where:

n= total number of implementations (*points*)

m= number of points in the quadrant under study

i= current application

j= current quadrant / weight

Since companies can decide to adopt different series of weights, according to their internal policies about innovation management[10], we have decided not to insert any weights in Table 1, but just a simple reminder (w_j). For a specific CI calculation, each organization has to specify its own weight table and multiply the "*Dist from Origin*" value by the respective weight under the following condition:

$$w_1 \leq w_2 \leq w_3 \leq w_4$$

3.5 Example

A very simple example is presented in the following table to illustrate how to calculate the CI value. Consider four points, each representing the implementation of one method-technique, as shown in Figure 4 and in the following table:

Quadrant	Point	X value	Y value	Dist from Origin	Weight	Final Value
1	A	45	18	48.466	w1	
2	B	83	10	83.600	w2	
3	C	23	86	89.022	w3	
4	D	79	90	119.754	w4	
			Total	**340.842**		

Without weights: the CI is equal to 340.842/4 = 85.2105, that is, the arithmetical mean of the four points.

The maximum value that the CA matrix can express is the Z point, with coordinates (100, 100), with a distance from the origin equal to:

$$d = \sqrt{100^2} + 100^2 = \sqrt{20000} = 141.421$$

and normalizing the **CI** index between 0 (CI minimum value - CImin) and 141.421 (CI maximum value - CImax), and knowing that

$$0 \leq CI\% \leq 1$$

the **CI%** index will be equal to:

$$CI\% = \frac{CI - CI_{\min}}{CI_{\max} - CI_{\min}}$$

$$CI\% = \frac{85.2015 - 0}{141.421 - 0} \cong 0.6025$$

[10] Obviously, if Innovation Management assumes a strategic position in the company mission, the spread between weights L3 and L4 and those in L1 and L2 will be greater.

4. Summary

In this paper, how one of the issues in People management – creativity and innovation – is treated by ICT companies is discussed, in particular within the structure of current SPI models, such as the CMMI and the P-CMM, addressing the process side and the people side of this issue respectively. In both models, creativity and innovation practices have been set at Level 5, without further details. The premise that organizations with an understanding of how to properly leverage and manage the creativity of its people will be in a position to create new business, which will in turn differentiate them from their competitors and add value to the whole organization ☺ translating into an improved positioning in the SPI model, then becomes important. While this paper has not yet tackled such positioning, it has presented some exploratory work on a smaller subset of SPI model components, such as identification of generic organizational creativity measurement. Thus, a method for mapping, tracing and measuring creativity has been explored, based on two entities: the Creativity-Application (CA) matrix and the Creativity Indices (CI and CI%), using a vectorial approach in a 2D space. A short example on how these entities can be used (at the SBU level as well as at the level of the whole organization) has also been provided.

In future work, an analysis of "how" the current OID (Organizational Innovation and Development) KPA in the CMMI can be "restructured" for a better fit with SPI model architecture will be undertaken. More specifically, the feasibility of introducing creativity and innovation management as a Level 2 or 3 topic, as well as in the training process area, or of adding to it within some of the *Common Features* (CFs), will be investigated.

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