Comparative Analysis of Categorization Systems for Innovative Projects

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***Abstract*--Innovation drives economic growth and improved living conditions throughout the world. In the essence innovation projects can be defined as contribution to human knowledge that addresses some need.**

However, when studying the design, construction or creating a new artifact the traditional science may have limitations. It is therefore the need for a science that breaks with the Cartesian barriers. From this disruption, it would be possible to build knowledge from the interaction between the observer and the object of study.

In this study a comparative analysis of two studies regarding categorization systems are used to consider four different process of organizational learning. The first artifact was designed for identification of four different types of projects following a combination known and unknown goals and methods. The second artifact was designed to categorize of four different types of innovation considering the domains of problem maturity and solution maturity, as high and low.

Other than identify similarities between the types of innovation projects we argue herein that all kinds of organizational learning presented in the two categorization systems follows an abductive reasoning. In both categorization systems, knowledge creation requires interaction between observer and the object of study.

I. INTRODUCTION

According to Schumpeter [1] the Innovation drives economic growth and improved living conditions throughout the world. Countries and companies around the world participate in the intensive competition and this make the Innovation and their management in one important to many stakeholders across a large range of business and schools of management. However, the progress is being stymied by the lack of a clear understanding about the essence of innovation: innovation projects can be defined as contribution to human knowledge that addresses some need. In other words, a true innovation must advance human knowledge in a form that improves the human condition [2].

To improve the real human conditions, the innovation process need turn ideas into reality. We innovate when converting new ideas into realities. And the most adequate tool to converting ideas into realities is the project management discipline.

Innovation and project are disciplines closely connected, in conformance with Project Management Institute, a project can be defined as a temporary endeavor undertaken to create a unique product or service [3]. Project is associated with the initial stage in the product life cycle, however, in complex projects, like Space Systems Projects, the project management process encompasses all product cycle life. One important aspect makes difficult to carry out the project management is the fact that project managers often fail to seriously consider their management methodologies alternatives [4]. This may be partly because they do not consider this analysis as part of project management, but also due to lack of decision support tools, which discourages such consideration [5].

The development of categorization system aims to provide an artifact that allows the comparison of different projects, give visibility to their characteristics and their implementation methodology [6]. One important base to the development of an artifact to categorizing of system is the realization that significant differences exist between things of a same area into the total spectrum of government, business and industry, but, on the other hand, can find similarities interesting to management the process to converting new ideas into realities.

II. METHODOLOGY - DESIGN SCIENCE RESEARCH

When studying the design, construction or creating a new artifact the traditional science may have limitations. Van Aken [7] shows a lack of relevance of research carried out only and exclusively under the paradigm of the traditional sciences. Only the understanding of a problem is not enough for your solution, so the study and development of a science that takes care of the real problems solution and creation of artifacts that can contribute to the improvement of existing systems is critical, or even new.

Le Moigne [8] explains their discontent and distrust of traditional science when he says that one should look escape the Cartesian dualism. This philosopher defends the need to study the interaction between the object and the observer. This interaction would provide the actual construction of knowledge rather than a simple observation of given reality.

In this work the term “Design” is the activity comprises performing changes in one system, making the search for situations its improvement [9]. The change of activity is drive for innovation efforts by the man who, therefore, applying knowledge to create, that is, developing devices that have not yet exist.

The process of using knowledge carefully, systematically and rigorously analyzed on the effectiveness with which reaches its goal can be called research. This type of research is used to plan and create an artifact is called Design Science Research [10]. The Design Science seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts [10].

The design-science has its roots in engineering and the sciences of the artificial [9]. The objective of this methodology is to create innovative artefacts in form of ideas, practices, technical capabilities, and products.

Design science research strategies starts with a systematic review of the existing knowledge-base on that issue, to be followed by a synthesis of design propositions. The review and synthesis can produce design propositions to be developed further, but can also uncover gaps in the existing literature – for example, insufficient explanatory theory on certain aspects, deficient field testing and/or the absence of any knowledge for grounding the propositions. On the basis of these limitations, research questions or development objectives are defined and further research is initiated. The findings are incorporated in the existing knowledge-base, which in turn may lead to further research questions, and so forth (**Figure 1**) [11]

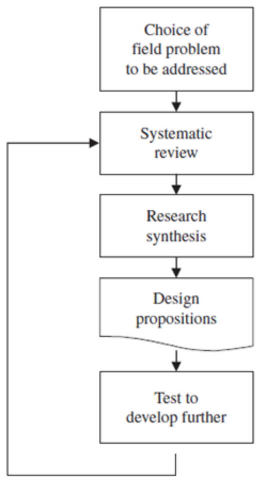

Fig. 1: The design science research cycle [11].

Hevner [10] systematized a set of seven guidelines for to understand and evaluate the research method Design Science, table 1.

TABLE 1: DESIGN-SCIENCE RESEARCH GUIDELINES [11].

Guideline	Description
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and/or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

What is common among these sciences is that in both traditional and Design, research should be conducted from the fundamentals of the methods scientific. However, while the traditional methods Science scientific commonly used are inductive, deductive and hypothetical-deductive, Design Science in fourth scientific method presents: abductive [12], [13], [14], [15].

III. TECHNOLOGY READINESS LEVELS

The development of create innovative artefacts typically depends upon the prior success of advanced technology research and development (R&D) efforts. These developments inevitably face the three major challenges of any project: performance, schedule and budget. Done well, advanced technology programs can substantially reduce the uncertainty in all three of these dimensions of project management [16].

Technology Readiness Levels (TRLs) are a systematic metric/measurement system that supports assessments of the maturity of a particular technology and the consistent comparison of maturity between different types of technology. The TRL approach has been used on-and-off in NASA space technology planning for many years and was recently incorporated in the NASA Management Instruction (NMI 7100) addressing integrated technology planning at NASA [17] **.**

Manufacturing Readiness Levels (MRL) are a systematic metric/measurement system that supports assessments of the maturity of manufacturing readiness, similar to how Technology Readiness Levels (TRL) are used for technology readiness. They can be used in general industry for more specific application in assessing capabilities of manufacturing.

IV. CATEGORIZATION SYSTEMS

A. Goals and Methods Matrix

In this artifact of categorization the projects can be judged against two parameters, whether the goals are well defined, whether the methods of achieving them are well defined. This concept leads to the definition of four types of project (**Figure 2**) [18]:

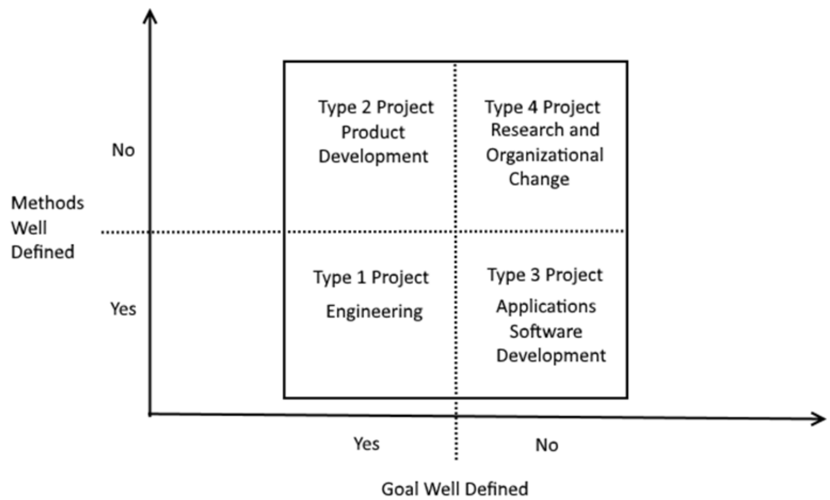

Fig. 2. Goal and Method Matrix - goals are well defined x the methods of achieving them are well defined [2].

- **Type-l projects**: In these projects, the goals and methods are well defined. They are typified by large engineering projects, and are the type of project on which many of the authors have gained experience, and hence the definitions above [18]. This type of projects has high readiness level, however, does not present relevant innovations.
- **Type-2 projects**: In these projects, the goals are well defined, but the methods of achieving them are not. They are typified by product-development projects [18]. This type of projects has high readiness level, however, does not present relevant innovations.
- **Type-3 projects**: In these projects, the goals are not well defined, but the methods are. These are typified by software-development projects, in which it is notoriously difficult to specify the users' requirements. The goals are known to exist, but cannot be specified precisely until users begin to see what can be produced, often during the testing stages [18]. This type of project has low readiness level, however, presents relevant innovations.
- **Type-4 projects:** In these projects, neither the goals, nor the method of achieving them, are well defined. They are typified by organizational-development projects [18]. This type of project has low readiness level, however, presents relevant innovations.

V. KNOWLEDGE INNOVATION MATRIX

Hevner and Gregor proposed a formal typology for categorizing innovations and the levels of both new knowledge contribution and real-world impact. The Knowledge Innovation Matrix (KIM) results from a classification of innovations and knowledge contributions on the two dimensions of application knowledge maturity and domain maturity. KIM provides a clarifying lens through which stakeholders can strategically manage innovation in multiple contexts. The matrix has four distinct quadrants termed (1) Invention, (2) Improvement, (3) Exaptation, and (4) Exploitation [2] **(figure 3**).

- **Invention – New Solutions for New Problems:** True invention is a radical breakthrough innovation – a clear departure from the accepted ways of thinking and doing. While this process of invention is perhaps ill-defined, invention activities can still be recognized and evaluated in a real world context based on their resulting artifacts and knowledge contributions. Innovation projects in this quadrant will entail research in new and interesting applications where little current understanding of the problem context exists and where no effective artifacts are available as solutions [2].
- **Improvement – New Solutions for Known Problems**: The goal of innovation in the improvement quadrant is to create better solutions in the form of more efficient and effective products, processes, services, technologies, or ideas. Innovators must contend with a known application context for which useful solution artifacts either do not exist or are clearly suboptimal. The key challenge in this quadrant is to clearly demonstrate that the improved solution genuinely advances on previous knowledge. Much of the previous and current innovation work belongs to this quadrant of improvement research [2].
- **Exaptation – Known Solutions Extended to New Problems:** Original ideas often occur to individuals who have experience in multiple disciplines of thought. Such training allows interconnections and insights among the fields to result in the expropriation of ideas and artifacts in one field to solve problems in a different field. Thus, we may face an innovation opportunity in which artifacts required in a field are not available or are suboptimal. This type of innovation project is common where new technology advances often require new applications (i.e., to respond to new problems) and a consequent need to test or refine prior ideas. Often, these new advances open opportunities for the exaptation of theories and artifacts to new fields.

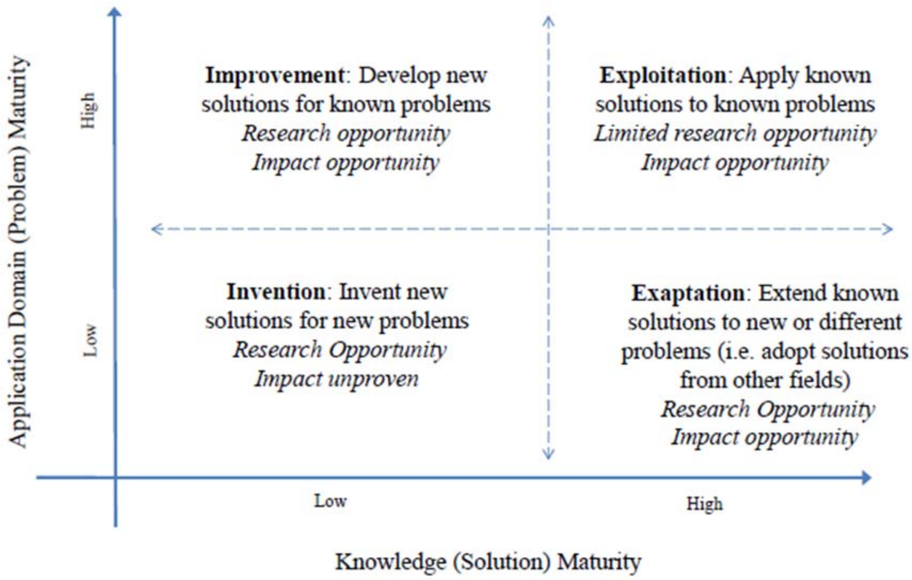

Fig. 3: Knowledge Innovation Matrix (KIM) with Opportunities for Research and External Impact Outcomes [2].

- **Exploitation – Known Solutions for Known Problems:** Exploitation occurs when existing knowledge for the problem area is well understood and when existing artifacts are used to address the opportunity or question. Opportunities for knowledge contributions in this quadrant are less obvious, and these situations rarely require research methods to solve the given problem. Such work is not normally thought of as innovation (i.e., contributing to new knowledge) because existing knowledge is applied in familiar problem areas in a routine way.

VI. COMPARISON BETWEEN ARTIFACTS OF CATEGORIZATION

Comparing each category of each artifact has had results:

- Goal and Method Matrix Type-l projects (the goals and methods are well defined) have a strong correlation with KIM- Exploitation (Known Solutions for Known Problems); In this innovative projects, the maturity level is high, and the Project Manager work with one slow level of uncertain and risk.
- Goal and Method Matrix Type-ll projects (the goals are well defined, but the methods of achieving them are not) have a strong correlation with KIM – Improvement (new solutions for known problems). In this innovative projects have slow maturity to improvement of processes to attain desired results, however, the requirements of final product is clear. The uncertain about final product is slow, more the Project Management focus should be on development process.
- Goal and Method Matrix Type-lll projects (the goals are not well defined, but the methods are) have a strong correlation with KIM –Exaptation (known solutions to new problems). In these innovative projects the Manager Project have high maturity for archive the results in this in this type of project and at improving the technical quality of the productions, more the requirements of final product are uncertain.
- Goal and Method Matrix Type-lV projects (neither the goals, nor the method of achieving them, are well defined) have a strong correlation with KIM – Invention (New problems and new solution). In these innovative projects the Manager Project have slow maturity in process and targets, the risk and uncertain are high.

VII. MATURITY LEVEL MATRIX

Bringing together the two artifacts, we can establish an artifact for the innovative project management, which allows assess the risk of each type of project in relation to the Manufacturing Readiness Level and Technology Readiness Level.

This device would allow the Project Manager:

- comparing differences projects in relation to Technology Readiness and Manufacturing Readiness levels;
- display the project parameters of characteristics of each project;
- establishing the controls of each of these characteristics.

This Maturity Level Matrix is show in figure 4.

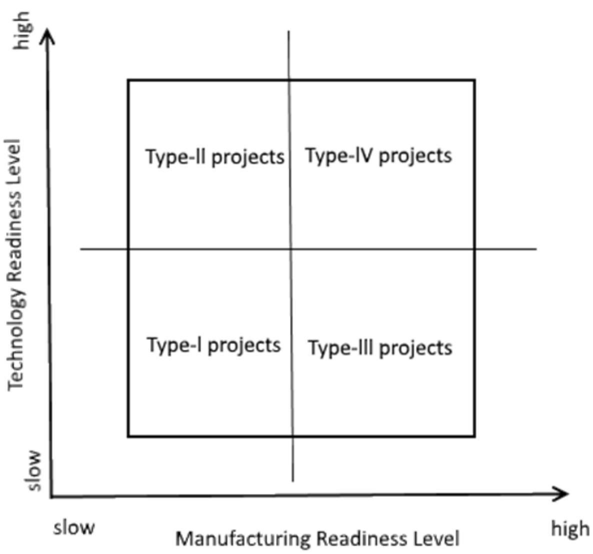

Fig 4: Maturity Level Matrix

VIII. CRITICIZES THE MODEL

The deductive method is to study facts and propose a theory to explain them, so the abduction is a process of creating explanatory hypotheses for a situation. The abduction is considered a process, above all, creative. And because of this feature is most useful for understanding a situation or problem, precisely because of the intrinsic creative process for this type of reasoning [12].

The first artifact, Goals and Methods Matrix, was designed for identification of four different types of projects following a combination known and unknown goals and methods. The second artifact, Knowledge Innovation Matrix, was designed to categorize of four different types of innovation considering the domains of problem maturity and solution maturity, as high and low.

Both artifacts studied were developed through an abductive approach. Abduction is considered a process, most of all, creative. And because of this feature is useful for understanding a situation or problem, precisely because of the intrinsic creative process for this type of reasoning.

The general scheme of abductive arguments, in a simplified way, such which appear in contemporary discussions, is the statement of evidence (a fact or set of facts), the alternative hypotheses to explain such evidence, and an appreciation of the value of these explanations. The conclusion is that the best explanation is probably true if, and higher compared to the others, is good in some absolute sense.

In both categorization systems, knowledge creation requires interaction between observer and the object of study, there is therefore no certainty about conclusions, in special for general applications of artefacts in different realities. As a possible consequence of this, different observers arrive at different results of categorization for the same reality or the same observer arrives at different results of categorization for the same reality in different times.

IX. CONCLUSION

In order to allow the Project Managers in innovation project to:

- comparing differences projects in relation to Technology Readiness and Manufacturing Readiness levels;
- display the project parameters of characteristics of each project;
- establishing the controls of each of these characteristics.

This work proposes one artefact for characterization of innovative project on the basis to Matrix KIM and Goal and Method Matrix.

Despite the importance of the application of the presented categorization of artifacts, assisting in the management and study of innovation and for converting new ideas into realities, the difficulty of establishing a methodology that knowledge creation requiring no interaction between observer and the object of study, becoming subjective the results of applications of artifacts in a variety of environments and observers.

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