# A MODEL TO IDENTIFY AN APPROPRIATE METHODOLOGY TO SOLVE PROBLEMS AND OPPORTUNITIES

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## ABSTRACT

The purpose of this research is to highlight the relevance of an adequate methodology to solve problems or opportunities by executing continuous improvement or innovation projects. There is a need to develop models to choose the right methodology for the needs of companies to solve simultaneously different problems such as quality, time delivery, design and innovation, especially in in a context of Industry 4.0. Thus, it is required to achieve a full comprehension of the elements that constitute the issues an organization affronts when it should identify an adequate initiative for improvement. This leads to a conceptual model proposition to keep up with the needs of Future Lifelong learners, which is also explained through a real study case.

**Keywords**

Six Sigma, Lean, operational excellence, Design, innovation.

## INTRODUCTION

What initiative should I follow to improve our organization? This is a question that several organization leaders face when they want to decide for an initiative for organization improvement. There are many known initiatives for continuous improvement. Some of the most popular are Six Sigma, Lean, Agile, Design Thinking, TQM, Taguchi Method, Shingo, PDCA, Root Cause Analysis, among others. Are they good for all kind of problems? How are these initiatives classified? Is there a holistic way to organize them? Do they complement each other? Under what scenarios should they be used?

Six Sigma has been widely used in recent years. In fact, a variety of platforms and approaches have been designed for the Six Sigma deployment. However, the industry is changing constantly in order to adjust its requirements to the businesses environment. This situation is achieved through continuous improvement projects, focused on the efficiency or on the effectiveness of the organizations. This inherent need for systems to survive has led the methodologies to change and to adapt to the new realities.

The success of a project depends on the right selection of a methodology to solve it (Albliwi, Antony, Halim, and Wiele, 2014). This has been the challenge for the international certification program in Lean Six Sigma offered by Tecnológico de Monterrey, in association with The Lean Methods Group, where participants believe these methods are the stepping-stone to solve any situation. The integration of both techniques in Lean Six Sigma has been helpful exposing participants to both methodologies to help them select the proper one for their projects.

A similar situation is arising with new programs like *Design Thinking* and *Innovation*, and also new initiatives such as *Industry 4.0*, where the nature of the projects to be solved are different between them, and it gets more complicated when design and innovation projects are proposed and tried to be solved with Lean Six Sigma tools. Depending on the nature of the problem, an appropriate set of tools should be selected. However, there is a propensity of decision-makers to continue investing in a failure course of action (Chakravorty, 2009). Each one of those methodologies have advantages and disadvantages that require to be analyzed before taking a right selection.

In the manufacturing environment, sometimes the comfort or the fear to increase variability leads the managers to apply the same methodologies without noticing that is time for a change (Monden, 2011). In fact, some authors explain that Six Sigma not necessarily is going to be applied in all industry levels (Pyzdek, and Keller, 2014, Montgomery, and Woodall, 2008). Then, when a project is generated, the initial phase to solve it is to identify properly how the problem will be studied. The wrong selection of a methodology to solve a project might cause waste of time, waste of opportunities, increase the complexity to address a problem, among others. Currently, the projects classification is evaluated through project management strategies but, if the environment where the project is developed is using Six Sigma, usually the tendency is to continue applying the same methodology (Pyzdek, and Keller, 2014).

A model called here IDEALS (Innovation Design & Lean Six Sigma) is proposed to analyze the level where the business is located and, based on this study, to identify what methodology should be applied to accomplish the mission and vision of the organization based on projects of continuous improvement, operational excellence, design or innovation. The flexibility of this model allows to use it as a road map to select the most appropriate methodology for a first approach during a transition between objectives.

The paper is structured as follows: first a conceptual development is established and the relevance of work is discussed in three different states (baseline, mission and vision) supporting this idea through the literature review of several methodologies; next the model is shown, defined, and explained, followed by an application case, in which the results show that the model can be used as an initial platform and as a support tool to design, improve and control the deployment of projects and that it can be the base for the development of a new continuous education and consulting program in Innovation & Design Lean Six Sigma 4.0. Through the IDEALS model the use of diverse statistical assessment tools is feasible in all levels.

The literature review shows that currently there is a great number of methodologies proposed by diverse authors. However, due to a lack of organization, usually the final user is lost in the middle of a sea of information. For that reason, IDEALS model is useful to order the strategic thoughts in function of the reality of the organization.

## CONCEPTUAL DEVELOPMENT

This model starts with three different states in an organization: The baseline, the mission and the vision. This model considers an organization executes its process in function of its mission and vision, which has been previously established. Then the organization should adjust its efforts to change from an original state (baseline) to a mission state (situation where its requirements are accomplished), with the finality to achieve the vision state (the future situation). The next step is to identify which methodologies are more suitable to be used for each different state.

Starting with the idea that a challenge in an organization is the variability of its process, it is decided to start the review based on Six Sigma as a methodology designed to explore and analyze the impact of the variability.

Six Sigma (SS), at first instance, looks strikingly similar to previous quality management approaches because was originally applied at the management operational level (Pyzdek, and Keller, 2014; Schroeder, Linderman, Liedtke, and Choo 2008). The objective of SS is to try to reduce the variability to work in environments under statistical control (Montgomery, and Woodall, 2008). This tool was designed to demonstrate the improvement when the variability is reduced (Barney, 2002b; Folaron, 2003). In fact, the methodology was developed with the aim to establish, control, and improve the working baseline in an organization.

Once the system is stable and its variability is under statistical control, the next step is to do the “right work” through quality, time, and costs in order to achieve the mission goals (Nolan and Provost, 1990). In this research this state is called the mission state. According to Womack and Jones (2003), Singh et al. (2010), the methodology required to improve the add-value processes based on the client requirements is Lean manufacturing. Lean has helped many organizations to identify how they are wasting resources and how they should work instead. This gives them an advantage: the ability to work based on their critical process but simultaneously satisfying the requirements of the organization and clients. In other words, the use of Lean establishes a culture and discipline based on the mission state, as long as the organization work environment is stable and its variability does not create divergence in its objectives. When the variability is under control and the processes are not wasting resources, the next step is to improve and try to achieve the vision state. This will require not just re-design but also an innovation process (Pyzdek, and Keller, 2014).

In fact, in this point some organizations usually are looking for improvement or innovation projects. At this stage, the objectives and methods inherent to Lean and Six Sigma are required simultaneously. Snee (2010) talks about the deployment and improvement sustainment as major issues that can be overcome by building a suitable infrastructure and identifying critical factors such as the generation of cash in difficult economic times, the development of data-based process management systems and the use of innovation tools. For these situations, the Lean Six Sigma methodology seems to fit in the state where the objective is to re-design to reach a future state. Focusing on improving quality, reducing variation and eliminating waste, Lean Six Sigma can be used as the ideal approach for projects to be executed within several new goals and different perspectives (Furterer and Elshennawy, 2005; Pepper and Spedding, 2010).

## GENERALITIES OF THE PROPOSED MODEL

Defining where is an organization, strategically speaking, has become crucial in these days. In fact, most of improvement projects are focused on achieving the expected results of the organization (Meredith and Mantel, 2011). There is a common necessity to identify where and which is the scope and approach of the organizations that are using improvement projects as foundation to reach their goals. Usually, the success is granted by executing the methodology properly adjusted to the environment of a project. However, each methodology focuses on solving specific issues. For example, to reduce variability, reduce waste, increase innovations, create a disrupting change, among others. With this idea in mind, the practitioner has the task to identify the path which maximizes the results of the project. The following model is an assessment tool to identify the challenge of the organization, the adequate methodology to solve the problems and the latent opportunities, all based on a set of objectives previously stated by the system.

IDEALS is the name for the proposed model, based on the idea that different methodologies should be applied according to the strategic objectives and requirements of the organization. This way of thinking is mentioned by several authors for example: Andersson et al. (2006) describe similarities among Six Sigma, Lean, and TQM concepts, but clarify the differences and gaps of the methodologies. The authors explain that TQM focuses in customer satisfaction, Six Sigma deals with variation reduction, and Lean removes waste. Chakravorty (2009), describes something similar considering one Six Sigma implementation model involving strategic and tactical decisions. Bañuelas and Antony (2003) compares the Six Sigma's approach with DFSS, for the evaluation of six-sigma projects in order to determine when the six-sigma approach becomes a priority over DFSS by introducing an analytical hierarchy process (AHP) to select the appropriate methodology. Hilton and Sohal (2012) denote a Lean Six Sigma deployment model for continuous improvement programs, which have independent variables such as technical, interpersonal skill as well as organizational competences. Below, the model is detailed.

## IDEALS MODEL

The proposed model is based on the features that an organization requires to survive and adapt to the diverse changes according to the practical and theoretical expertise acquired by the authors. These features considered are: Innovation Design & Lean Six Sigma (IDEALS). Figure 1 shows a scheme for the proposed model. The model has 4 levels and shows a matrix of 12 cells. In first instance, the vertical axis represents the behavior of a project in order to achieve a specific objective (Y). In the bottom of the axis there are all the variables, features or characteristics used in the process (X´s). With this information it is necessary to apply the SIPOC method (Suppliers-Inputs-Process-Outputs-Customers) to establish a clear idea of how the internal processes are working and which are the variables that have more impact in the final result (Pyzdek and Keller, 2014). Then, those variables are evaluated through a cause effect diagram. The finality of all these processes is to understand how the system is working and how the failures might change its behavior.

With the variables established, it is possible to identify the baseline of the current situation in the system. In other words, it is possible to take a picture of what is happening right now in the system and this information will be represented by f(x). When f(x) is under control and working without wasting resources it is possible to say that the system has achieved the mission established. The next step is to try to reach the vision state, but in order to accomplish that objective the system needs to change and adapt considering the external and internal challenges. For that reason, we need to design a new strategy that focuses on transforming the system f(x) into a new and improved system G(X).

The model shows the presence of "big" problems during the first levels. This happens because, if the baseline is not the same as the mission state, that situation means that the organization is not working properly. In fact, Six Sigma and Lean are originally designed to control and increase the effectiveness of the system removing most of problems and roots causes that are the impediment to accomplish the mission state. The next levels represent the opportunities the system has to increase its efficiency. Usually Lean Six Sigma and Design Thinking are the theoretical bases to discover, improve and transform the opportunities into projects with the finality of reaching the vision state.

Each one of the levels can be applied jointly with other methodologies, but considering the authors' expertise in the area, the next deployment is proposed:

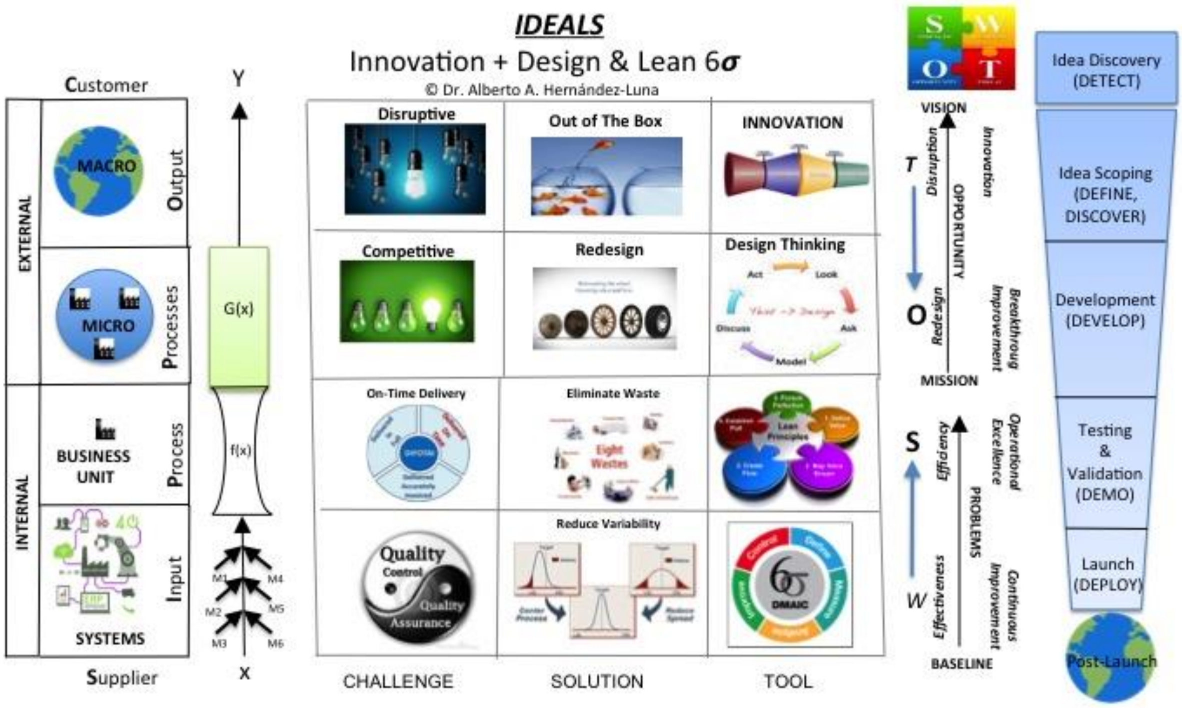


**Figure 1 IDEALS Model**

## Six Sigma Level

The Six Sigma methodology and its tools constitute the fourth level. The challenge in this level is that the system is not under control and the impact of the variability in the metrics has a huge effect. According to Schroeder et al. (2008), the systematic and organized parallel-meso structure of Six Sigma is decisive to reduce the variation in the organizational processes through the use of specialists trained with statistical criteria.

The Six Sigma elements, which are used to reduce the variability of processes that are under control, are the reason for considering it methodology as the basis to support the whole IDEALS model. De Mast et al. (2012) explain that Six Sigma deployment provides a stepwise procedure that allows setting parameters and quantifying problems under the control of the primary metrics. These series of features turn Six Sigma methodology into a balanced starting point to drive projects through the DMAIC methodology.

For the model it is proposed: first, to determine the level of variability that is present in the process, or in other words, how far or dispersed is the process between the baseline and the mission state, and if its capacity is enough to tolerate the changes. Then, the objective requires to be stated, for that reason the objectives are represented using the Taguchi's quality loss function. The loss function pretends to model the concept that any departure from the original targets generates economic loss (Ames, Mattucci, MacDonald, Szonyi, and Hawkins, 1997). For this context, the quality loss will be in function of both, upper and lower, specification limits set by the customer requirements. With this information, the objective that is needed to achieve is established. Once the status of the process and the objective is determined, it is possible to apply the DMAIC methodology. For more detailed explanation about DMAIC and how to apply it the reader could refer Pzydek and Keller (2014).

**Lean Level**

The second level, after the process is under control and the variability has been reduced, is to eliminate all the processes that are not adding value to the final customer. In other words, the waste is going to be reduced. Historically, the methodology for excellence to apply in this level is Lean. After its origins in Japan, Lean has been implemented in a great number of companies following its own framework (Monden, 2011). The first approach is to identify the waste generated, and it will reach a cost reduction without losing the quality (Abdulamek, and Rajgopal, 2007). According to Melton (2005), for a full understanding of the Lean philosophy, it is important to keep in mind the three key components: the identification of value, the elimination of waste and the flow generation of value to the customer. For this reason, the objectives in this level can be stated using the Value Stream Mapping (VSM). The VSM will provide the macro picture of the system. This tool simultaneously with the seven quality tools will establish the set of objectives around the reduction of the seven fundamental wastes: over-production, waiting, excess motion, over-processing, transportation, defects and excess inventory (Bhasin, 2006). The advantage of the use of VSM is the easy way to identify where is located the waste and how it is affecting the internal or external customers (Melton, 2005).

**Design Level**

The third level is a more mature stage of the system. Once the mission is achieved, new factors and variables are identified; for this reason, a new way to see the organization is generated, thus represented by G(x). The methodology Lean Design for Six Sigma is the appropriate method under the new circumstances, due to its match with the functional process where all the input variables (x) are being transformed to obtain an improved output (y), besides it is designed to identify potential opportunities.

First, to identify the challenges in this level it is proposed to use the Kano model for product development and customer satisfaction. The idea is to establish the challenges in function of the three zones in the Kano model (delighters, must-be, or performance) in order to increase the customer satisfaction (Mikulic and Prebezac, 2011). Once identified the adequate qualitative treatment in the Kano model for the current inputs, the next step is to enhance the actual process.

A process can be improved through the response surface methodology, where the factors (X´s) are known and previously studied. The methodology Design for the X gives the opportunity to develop a new or an improved product based on the critical features required for the customers. For more detailed information about how to apply the Design for the X the reader could refer to Yang and El-Haik (2003).

**Innovation Level**

The final level, and considered the most challenging, is the innovation approach. The challenge presented for the individual or the organization is to maintain the competitiveness level. The introduction of this concept is another way of finding out if the company is capable of keep improving and creating value (Pyzdek, 2014). According to Azis and Osada (2010) the goal of innovation is the positive changes that reach the organization lead to an improvement.

In first instance, in this level the innovation model S- curve is shown. This model is applied when the system is in a maturity level. The first challenge here is to identify the changes required to create a disruptive situation and use it to improve the whole system. For this step, it is necessary to evaluate what is needed to be done. For this reason, an analysis of prioritization is useful as a starter point. All these changes are based on highlights adequate for the client needs. In fact, once the specific need is identified, the Design Thinking process starts (Shahin, 2008). This is the most complex step due to the necessity of changing the usual way of management and thinking. Bisgard and De Mast (2006) and Silverstein et al. (2013) mentions that it is required to use two systematic processes during the design thinking. First, the 5 D's method, because this is considered as a generic and incremental innovation method. Simultaneously, it is required to work with scientific systematic approaches like problem solving or decision-making models in order to affront the possible problems generated during this changing process.

## APPLICATION CASE

The model was applied in a Mexican company which works with glass products. The company has already implemented the Six Sigma methodology and its processes are under control. The company tries to improve the efficiency of its production line, especially at the molding machines. According to the experts in the company, it is possible to increase the throughput in the production line but right know the molding process is the bottleneck. After some previous studies, the experts realized that is necessary the redesign of a part of the molding machine.

The IDEALS model is used to identify how to start with this redesign process and how to achieve the objectives. The application case is located in the third level of the IDEALS model (see figure 2). In order to identify how the company started with this study, a part of the problem defined is shown: "Increase the efficiency of the H28 machine, considering as a primary metric the throughput of the machine…, the stage where the difficulties are detected is the cooling stage, due to it is a slow process,… considering the possibility of a redesign into a more robust process".


**Figure 2 IDEALS Model third level**

The challenges during the project application are selected in function of the Kano model to increase the performance to satisfy the client's needs. The company also applied in this point the DFSS methodology jointly with the TRIZ model to increase the level of detail, then the optimization of the critical metrics was performed.

The application case describes a ten steps implementation method (Hernández-Luna, 1988) The first step explains the design problem, in this case the injection mold and cooling zone. Specifically, the part to be designed was the die, and a comparison of similar mechanisms was done. The second step addresses the problem definition under the Six Sigma methodology. The problem statement is defined considering the entitlement. The third step involves the statistical analysis to make objective statements. The data was gathered from a period of 24 months with a sample size of 120 units, and the objective of improvement was stated according to the baseline. Then, the fourth step involves reaching the entitlement to justify the methodology. Figure 3 shows an overview of some results obtained from the methodologies applied.

The steps 5 to 10 prepare the project to work under the methodology Lean Design for Six Sigma. First, following the DFSS methodology, the Taguchi focus was used, and a robust measurement was established to keep the monotonicity of the Y, which is the temperature of the product inside the ejection mold. Afterwards comes the data gathering respect to Y and the making of a design of experiments to identify the significant factors on the cooling process.

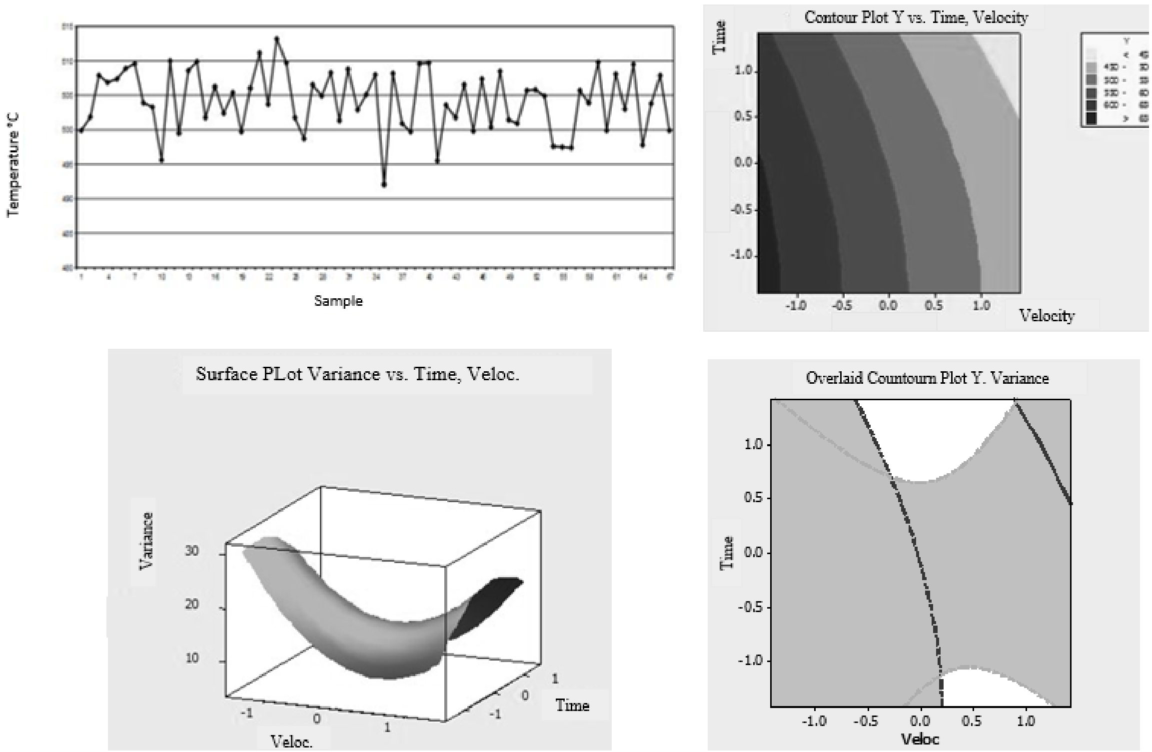


**Figure 3 Overview application case**

The analysis of the DOE results highlighted the relevant factors and the response surface was used to identify the optimal working levels. However, the products limitation did not allow to reach the optimal levels, which was an indication of the necessity of making an improvement to the model, thus it was required to inspect if the constraint was due to design coupling or any other event. The results showed that the air injection and the cooling head were the responsible for the limitations. However, to study the separation, and therefore accomplishing the independence axiom, the TRIZ approach was executed. The findings were that the air did not reach the bottom of the mold and the cooling temperature was never achieved. Thus, after applying all the methodologies and tools leaded by the IDEALS model, the new coupling matrices were designed to find through innovation tools an innovative and patented solution (Hernández-Luna, 1985).

## CONCLUSIONS & RECOMMENDATIONS

IDEALS model has the finality to identify in which level of deployment is currently an organization, based on its strategic objectives and its baseline entitlement. The flexibility of this model allows to use it as a road map to select the methodology appropriate for a first approach during a transition between objectives.

The proposed model has been applied in a real case. The results show that the model can be used as an initial platform and as a support tool for the design, improving, and controlling deployment of projects. Through the IDEALS model the use of diverse statistical assessment tools is feasible in all the levels, the model helps to organize and classify them according to the objectives of the project.

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