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Integrating Value Engineering and Lean Six-Sigma for Enhanced Process Improvement

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ABSTRACT

Every organization strives its best to achieve an investment output by adopting various business process initiatives such as Lean Six Sigma (LSS), Theory of Constraints (TOC), Value Engineering (VE), etc. This paper focuses on an integrated approach for process improvement by investigating the synergy between value engineering and lean six sigma. While VE and LSS have limitations, the integrated approach is intended to explore opportunities where these business initiatives can be used together to increase the likelihood of obtaining improvements beyond the capability of just one approach. The literature on VE and LSS analyses the strengths and weaknesses of these methodologies and highlights opportunities for collaboration. The literature examining these methodologies also points to areas where VE can improve the application of LSS and vice-versa.

Keywords: *Value Engineering, Job Plan, Lean Six-Sigma, DMAIC, Process Improvement.*

INTRODUCTION

Considering the degree of competition between the companies in the world, advantages in competition will be won by those companies who focus on performance improvement, customer satisfaction, reducing the costs and increasing the efficiency, and overlay try to purify their organizations and processes. In this way, Lean Six-Sigma strategies can help us to identify and eliminate on value-added resources. Value engineering recognizes product/service functions and produces those in maximum value in the lowest cost without wasting production or service quality and safety. Today, companies need powerful methods for their business, in order to survive and promote their place in international competitions [1].

For manufacturing companies to succeed in today's unstable economic environment, it is necessary to restructure the main components of its activities: designing innovative product, production using modern reconfigurable manufacturing systems, a business model that takes into account the global strategy and management methods using modern management models and tools [2].

The main objective of this paper is to investigate the factors behind the convergences and divergences between Value Engineering and Six Sigma, when used as a combination for the continuous improvement of processes in manufacturing environments. The importance of this study is based on the extent of the use of approaches that focus on continuous improvement by organisations; as a rule, such approaches have reached their limit of performance given the current competitiveness and complexity of some markets. Moreover, it is necessary to find elements of other approaches to make more robust the current strategies that adopt continuous improvement in the face of global competitiveness [3].

VALUE ENGINEERING

Society of American Value Engineering defines VE as: "A systematic application of recognized techniques which identify the function of a product or service, establish a monitory value for that function, and provide the necessary function reliability at the lowest overall cost". VE is an organized way of thinking or looking at an item or a process through a functional approach. It involves an objective appraisal of functions performed by parts, components, products, equipment, procedures, and services; and so on anything that costs money. Value methodology is commonly applied under the names Value Analysis (VA), Value Engineering (VE), and Value Management (VM). These

terms can be used interchangeably with value methodology throughout the places according to the need of the situation [4].

Value Engineering is a technique for determining the manufacturing requirements of a product/service; it is concerned with its evaluation and finally the selection of less costly conditions. It is a process for achieving the optimal results in a way that quality, safety, reliability and convertibility of every monetary unit are improved. Value Engineering is usually applied in the analysis and design of service/product. In fundamental terms, VE is an organized way of thinking or looking at an item or a process through a functional approach

It is an effective tool for cost reduction and adversely affecting quality, efficiency and other customer features [5].

Value Engineering Methodology

VE works under job plan which has eight phases as shown in Figure 1.

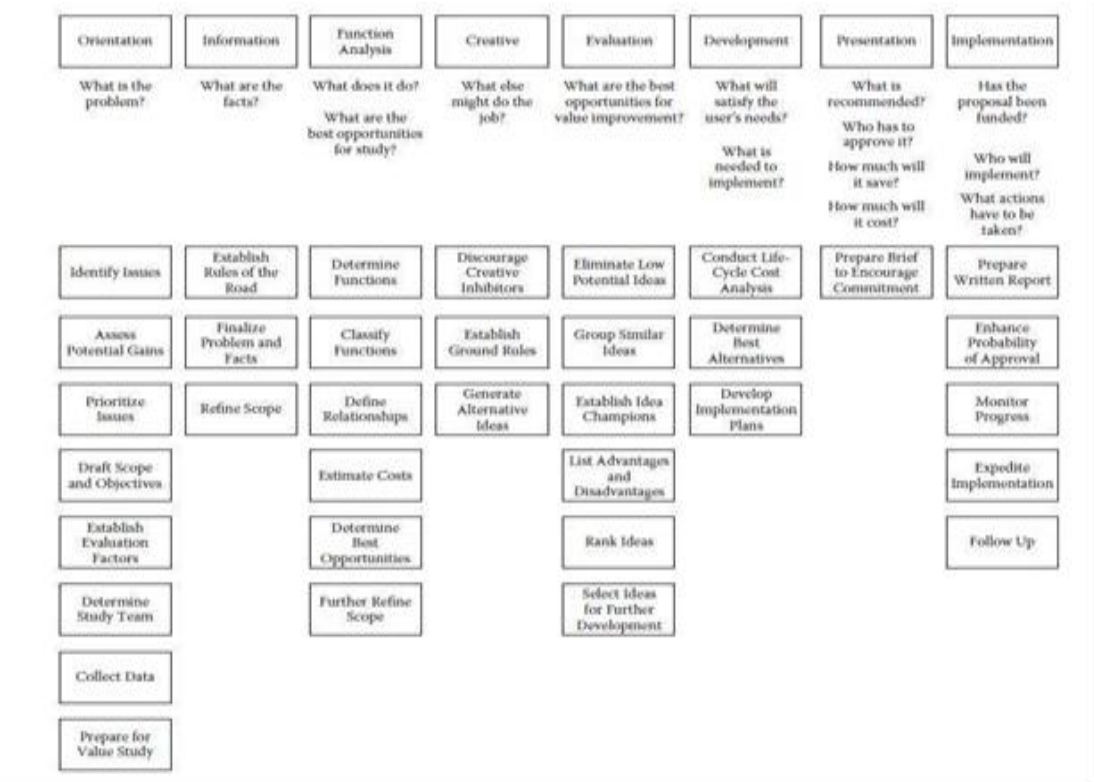

Figure1. *The Original VE Job Plan [6]*

This Methodology includes eight steps:

- Orientation Phase: refines the problem statement and prepares for the workshop.
- Information Phase: Gathering of information to better understand the project.
- Function Analysis Phase: Analyzing the project to understand and clarify the required functions.
- Creative Phase: Generating ideas on all the possible ways to accomplish the required functions.
- Evaluation phase: Synthesizing ideas and concepts to select feasible ideas for development into specific value improvement.
- Development Phase: Selecting and preparing the "best" alternative(s) for improving value.
- Presentation Phase: Presenting the value recommendation to the project stakeholders.
- Implementation Phase: The purpose of the Implementation phase is to obtain final approval of the proposal and facilitate its implementation. Throughout this phase, the team should be mindful of factors that contribute to successful change [7].

Benefits of Value Engineering

Listed below are typical benefits of Value Engineering [7]:

- Simplification of methods and procedures resulting in less recurrent costs and a more efficient process.
- Savings in time cost and energy.
- Expedited decision making.

- Risks can be better forecasted and understood by all.
- Resources and time wastage can be minimized.
- Savings can be redirected to add value.
- Better communication and understanding of the project's objectives.
- Appropriate quality.
- Responsiveness to client's priorities.
- An opportunity for the client to formally participate in the design process.
- Client insight into the project.
- Improved communication between the parties.

LEAN SIX-SIGMA

Lean Six Sigma is used to describe the integration of lean and Six Sigma philosophies. It is a combination of well-known waste elimination and process improvement techniques. Lean Six Sigma is a business strategy and methodology that increases process performance resulting in enhanced customer satisfaction and improved bottom line results. The Lean Six Sigma helps companies flourish in a new world where customers expect no defects and fast delivery at the minimal cost [8].

The key concept for the integration of the two continuous improvement approaches (lean manufacturing and six sigma methodology), as a state of equilibrium needs to be achieved between the two, moving away from an inflexible approach in any one direction, risking becoming too lean and therefore rigid in responses to the market and subsequently impacting on value creation. The other extreme is to concentrate too much on reducing variation beyond the requirements of the customer, and therefore wasting unnecessary resources in the pursuit of zero variation. The balance lies in creating sufficient value from the customer's viewpoint, so that market share is maintained, while at the same time reducing variation to acceptable levels to lower costs incurred, without over-engineering the processes [8].

Generally, both Six Sigma and Lean Manufacturing are only approached for their performance improvement and organizational transformation. If Six Sigma means detailed analysis during operating, Lean Manufacturing gives a big picture about whole operation. A Six Sigma and Lean Manufacturing are a strong strategy today and for the future in all business industries. Some companies only use Six Sigma for efficiency and effectiveness. Other companies just use Lean Manufacturing to save lead and cycle time, and to eliminate waste [9].

Dmaic Methodology

The methodology includes its phases as Define, Measure, Analyze, Improve and Control. As an improvement technique, each phase of the methodology (Define, Measure, Analyze, Improve, Control) is augmented by a question which leads to an action-oriented as shown in Figure 2 [6].

Define Phase

The goal of this phase is to reflect the problem statement. Defining the process begins with a bird's eye view of the process, also known as a high-level process map. The classic tool here is called a SIPOC which stands for Suppliers, Inputs, Process, Outputs and Customers. The focus of each project is the customer of the process. Customers can be external to the organization or an internal component of the organization. During the Define phase, the team must contact customers to better understand their requirements of the process, or the Voice of the Customer.

Measure Phase

Precision in defining the problem should facilitate the measurement phase. In this phase, the objective consists of measuring the actual performance of the process to define its actual state. Common areas of measurement include cost, time, quality. The best measures will prove to be those that are: quantifiable, easily measured, robust, reliable, valid. The measures should be prioritized so it is clear to everyone which measures are most important. This phase should reduce a risk of measuring the wrong things or measuring the right things in the wrong way. Bad information is driving bad decision making.

Analyze Phase

This phase has as its objective the identification of the causes that could be at the root of the problem and identify the relations of Cause-Effect, i.e., how is it that one of more independent variables affects the dependent variable. It includes identification of the issues that lead to dissatisfied customers, unnecessary costs, dwindling margins, and frustration. In this phase, the date collected during the Measure Phase is reviewed.

Improve Phase

This phase has the objective of finding and implementing solutions that eliminate the causes

of the problems identified in the Analyze phase, preventing a re-occurrence or reducing the variability of the process. Making effective change is not an easy thing for any organization. While there may exist various possible solutions for the same problem, the best, or top two should be selected to be applied. Ideally, these identified solutions should not imply such large investment costs and they should be tested before being implemented such that their efficacy can be checked and to avoid wasting time on solutions that require a great deal of effort for little benefit.

Control Phase

In Control phase, the improvements implemented are controlled, or in other words, the new system. Actions should be defined to guarantee that the process is continuously monitored, so as to assure that the key variables maintain within specified limits. This phase focus on avoiding complacency when the project is going well and goals are being met and taking corrective action when either the projects strays or the environment changes.

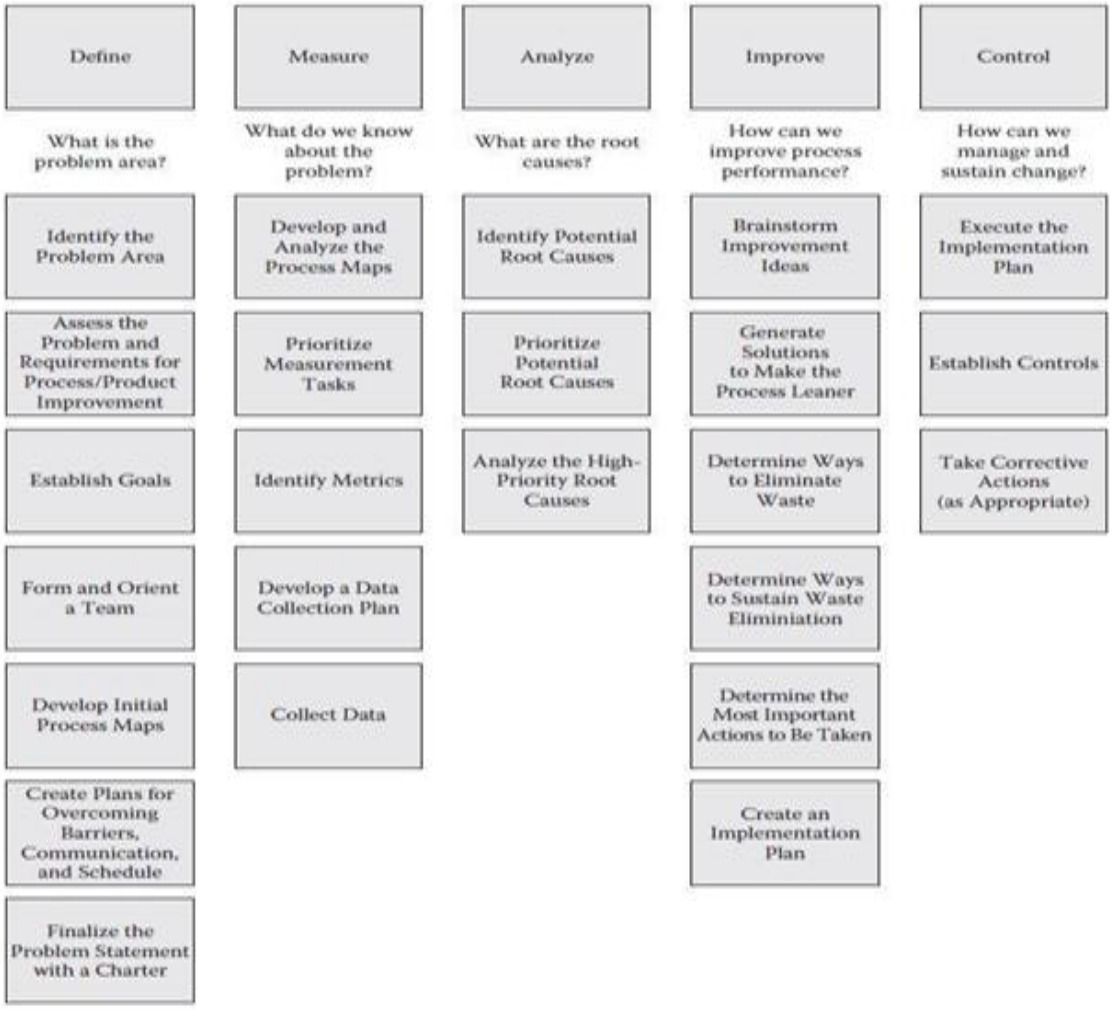

Figure2. *The Original LSS DMAIC Methodology [6]*

Benefits of Lean Six-Sigma

Listed below are typical benefits of Lean Six-Sigma [2]:

- Operational improvements;
- Reducing lead times by 70%;
- Increasing productivity by 50%;
- WIP inventory reduction by 80%;
- Improving the quality of 80%;
- Reduction of the area occupied by 75%.
- Reducing the number of errors in the processing of orders;
- Optimization to help clients.

COMPARISON OF VE AND LSS

Table 1 shows the comparison of Value Engineering, Lean Production and Six-Sigma based on a selected set of criteria.

Table1. *Comparison between Value Engineering, Lean Production and Six-Sigma*

S/N	Criterion	Value Engineering	Lean Production	Six-Sigma
1	History	1947 [General Electric] – Lawrence D. Miles	1950's [Toyota Motor Company] - Taiicho Ohno	1986 [Motorola Corporation] - Bill Smith and Mikel J Harry
2	Objective	➢ Reducing cost, ➢ Increasing profit, ➢ Improving the quality, ➢ Increasing market-share, ➢ Doing things in a shorter time more efficiently	➢ Establishing value stream ➢ Eliminating Muda's and waste ➢ Maximizing value stream ➢ Ensuring flexibility in operations	➢ Decreasing process variations ➢ Eliminating defects, ➢ Improving process ability, ➢ Increasing profitability,
3	Application Guideline	➢ Orientation ➢ Information ➢ Function analysis ➢ Creative ➢ Evaluation ➢ Development ➢ Presentation ➢ Implementation	➢ Value specification ➢ Value stream identification ➢ Flow ➢ Pull ➢ Perfection [VVFPP]	➢ Define ➢ Measure ➢ Analyze ➢ Improve ➢ Control [DMAIC]
4	Concept of Value	➢ Principles for adopting the product with customer demands.	➢ Principles for improving the process through waste elimination.	➢ Statistical principles for improving project capital turnover through variation reduction.
5	Tools and Key Techniques	➢ Chart methods ➢ Function analysis of system (FAST diagram) ➢ Decision tree ➢ Value index ➢ Pareto analysis/Pareto voting ➢ Weight matrix/Paired comparisons	➢ Layout optimization ➢ Continuous improvement (kaizen), ➢ 5S, SMED, TPM, Pull systems ➢ Cellular manufacturing ➢ visual management (poka-yoke) ➢ Value stream mapping	➢ Statistics method and process analysis ➢ Problem solving methods SPC, FMEA, MSA, DOE ➢ Quality improvement tools ➢ Hypothesis test, ANOVA, regression ➢ Cause and effect analysis
6	Project Selecting Criteria	➢ High cost project ➢ too much complexity ➢ repetitiveness of whole or a part of the project ➢ Unique quality, limited budget ➢ limited time designing schedule ➢ sensitive political or biological projects ➢ involving various parts of organization	➢ High waste resources ➢ Low profitability ➢ Lack of flexibility ➢ Customer dissatisfaction ➢ Lack of efficiency and effectiveness	➢ High defects and errors ➢ high process variations ➢ high quality costs ➢ low rate of return and efficiency customer dissatisfactions
7	Driving Principle	➢ Value thinking	➢ Waste elimination	➢ Variability reduction
8	Limitation	➢ Lack of ability to recognize some organizational activities.	➢ Lack of equipment to resolve potential bottlenecks.	➢ High dependence on statistical methods.

BENEFITS OF VALUE ENGINEERING PLAN IN LEAN SIX-SIGMA

In determining what should be changed, VE's function analysis identifies areas that cost more than they are worth. VE's separation of function from implementation forces engineers to understand and deliver the requirements. For required functions that cost more than they are worth, VE uses structured brainstorming to determine alternative ways of performing them. LSS brainstorms to identify how to fix the root causes. Because functional thinking is not the common way of examining products or processes, VE augments the structured innovation process in a way that generates many ideas. VE develops solutions by evaluating the feasibility and effectiveness of the alternatives [6].

In studying the different improvement methodologies, such as VE and LSS, it is always imperative to identify correlations, similarities and differences among them. However, the greatest gain is finding potential opportunities for synergies between any two methodologies. Figures 3 and 4 provide excellent illustrative examples of DMAIC

processes that can be enhanced by the VE function analysis processes.

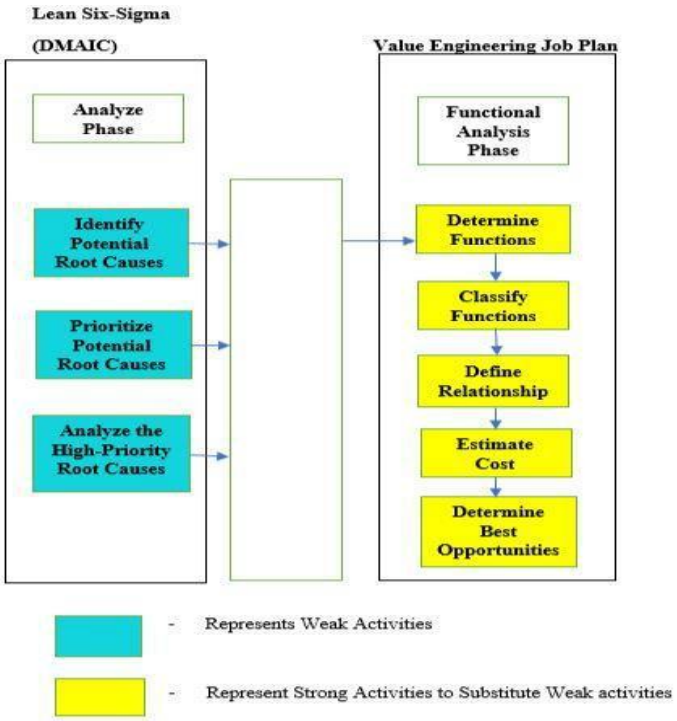

Figure3. *VE Function Analysis Phase Cross-Referenced with Analyze Phase of DMAIC*

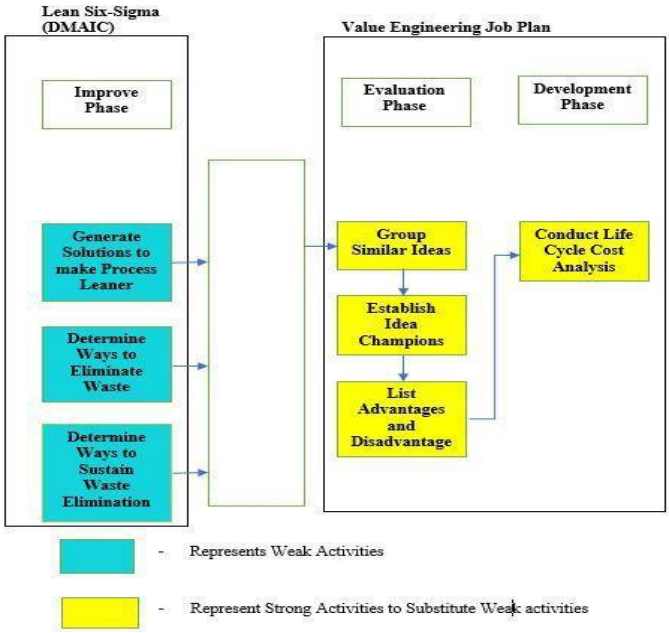

Figure4. *VE Evaluation and Development Phases Cross-Referenced with Improve Phase of DMAIC*

The Analyse Phase of LSS DMAIC methodology with three potential activities namely: (1) identify potential root causes, (2) prioritize potential root causes, and (3) analyse the high priority root causes are good candidates for enhancement by replacing them with five strong activities from the Functional Analysis Phase of the VE methodology as shown in figure 3.

Furthermore, the Improve Phase of LSS DMAIC with three potential activities namely: (1) generate solution to make process leaner, (2) determine ways to eliminate waste, and (3) determine ways to sustain waste elimination can also be enhanced by substituting three strong activities from the Evaluation Phase of the VE and one strong activity from the Development Phase of the VE methodology as shown in figure 4.

Figure 5 represents an enhanced LSS DMAIC process as the combined outcome of figures 3 and 4 based on the synergistic effect from value engineering application. Thus, the VE processes that greatly contribute to the suggested improvement of the LSS DMAIC methodology

are Function Analysis, Evaluation and Development Phases.

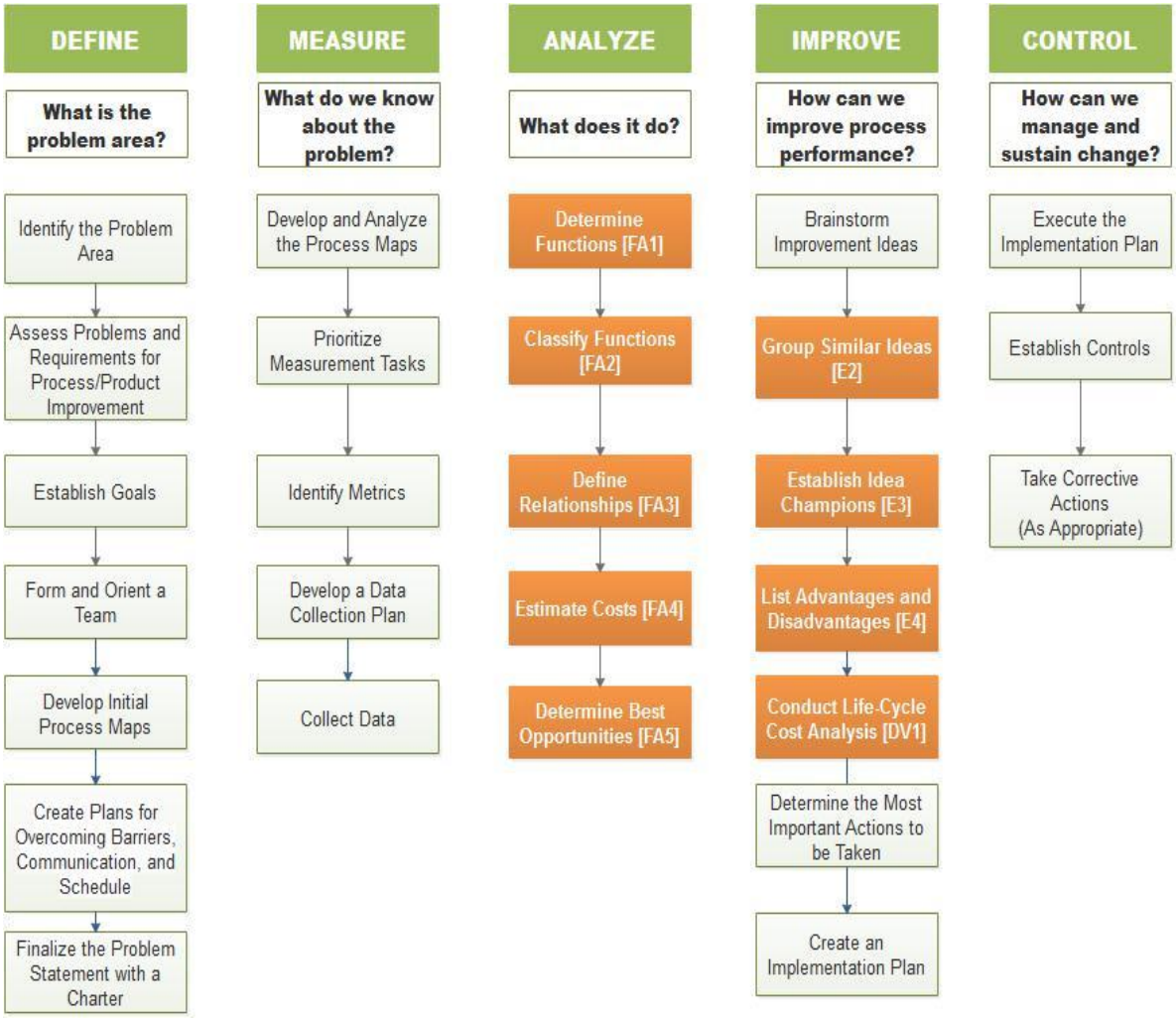

Figure5. *The Synergistic Effect for LSS DMAIC Process Due to VE Job Plan Impact*

Benefits Of Lean Six-Sigma Plan In Value Engineering

When LSS establishes goals in the Define Phase, customer communication tools such as Likert scales, surveys, interviews, and focus groups are used. The VE counterpart, "Prioritize Issues," is more focused on potential gains and the feasibility of implementation. LSS has a more detailed front-end process for data collection. Whereas the VE methodology simply focuses on cost data. The LSS SIPOC framework is used to understand the entire process and where the problem fits in. VE's use of SIPOC could add insight to its Function Analysis Phase [6].

In similar fashion, figures 6 and 7 provide illustrative examples of weak areas in VE that are potential candidates to benefit from DMAIC application processes. For example, the activity named "Collect Data" under the Orientation Phase of the VE Job Plan as well as the activity named "Finalize Problems and Facts" under the Information Phase of the VE Job Plan are good candidates for enhancement by replacing them with two activities from the Define Phase namely: (1) develop initial process maps and (2) finalize the problem statement with a charter as well as four activities from the Measure Phase namely: (1) develop and analyse the process maps, (2) prioritize measurement tasks, (3) develop data collection plan, and (4) collect data as shown in figure 6.

Similarly, the Implementation Phase of the VE Job Plan with three activities namely: (1) enhance probability of approval, (2) monitor progress, and (3) expedite implementation can be replaced with a combined substitution of one activity from the Improve Phase and three activities from the Control Phase of the LSS DMAIC methodology as shown in figure 7.

If the analysis done in figures 6 and 7 are carried out as suggested, it will result in an enhanced VE methodology as shown in figure 8. Thus, the DMAIC processes that greatly contribute to the

suggested improvement in the VE methodology are the Define, Measure and Control.

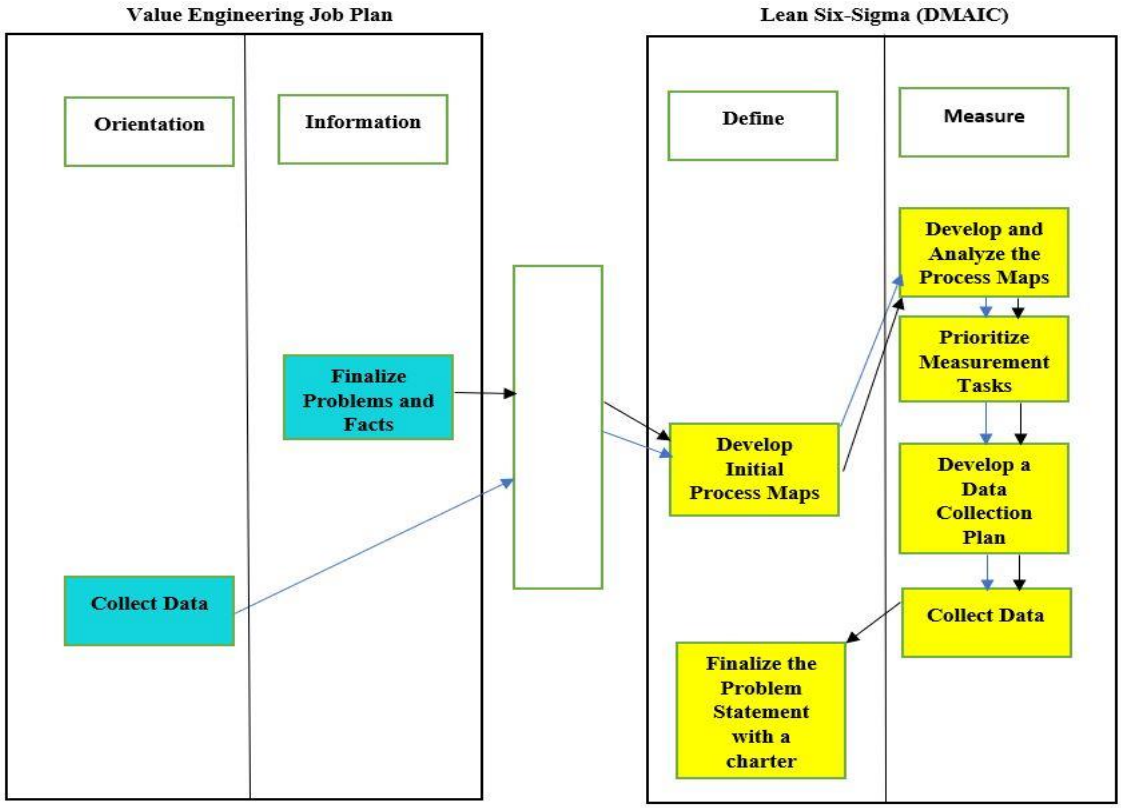

Figure6. *Define and Measure Phases of DMAIC Cross-Referenced with Orientation and Information Phases of VE*

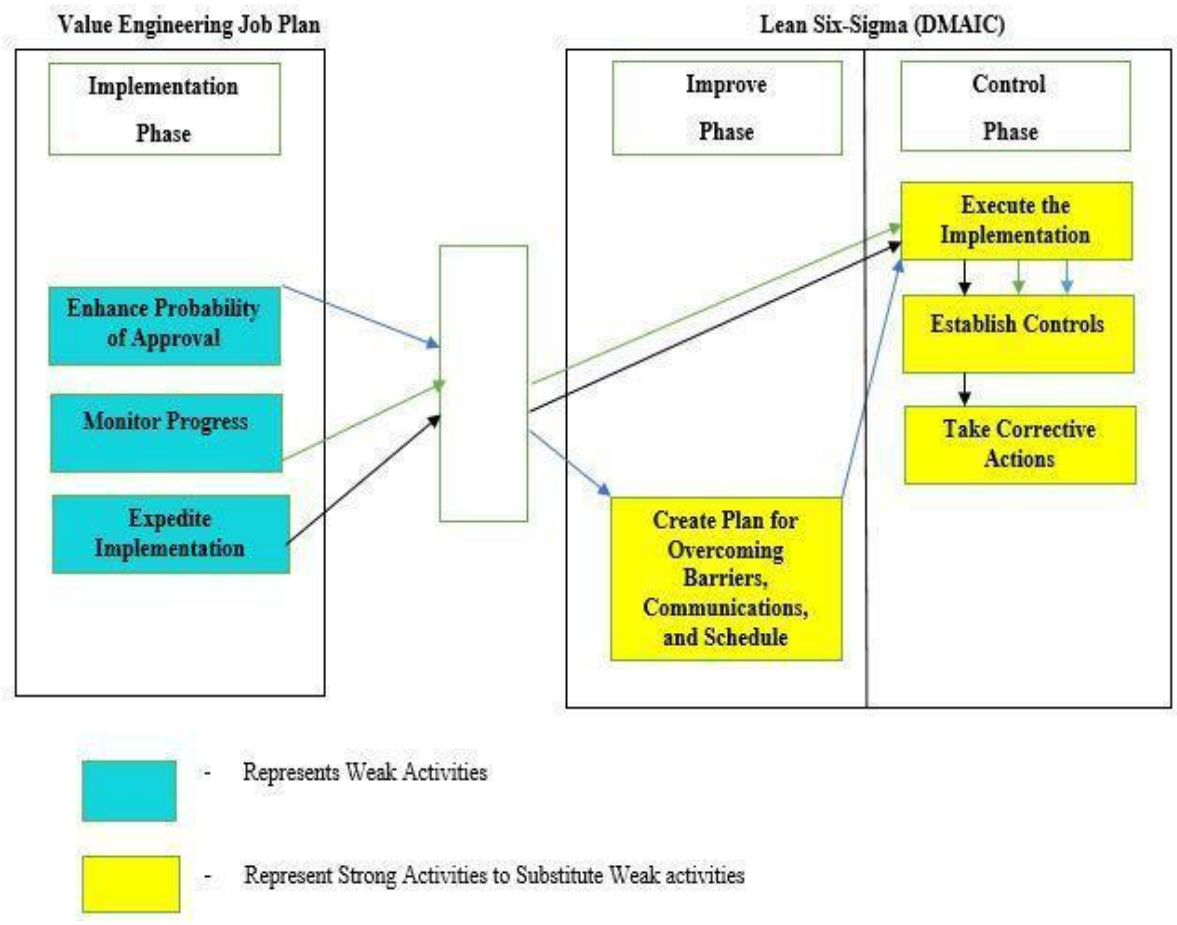

Figure7. *Improve and Control Phases of DMAIC Cross-Referenced with Implementation Phase of VE*

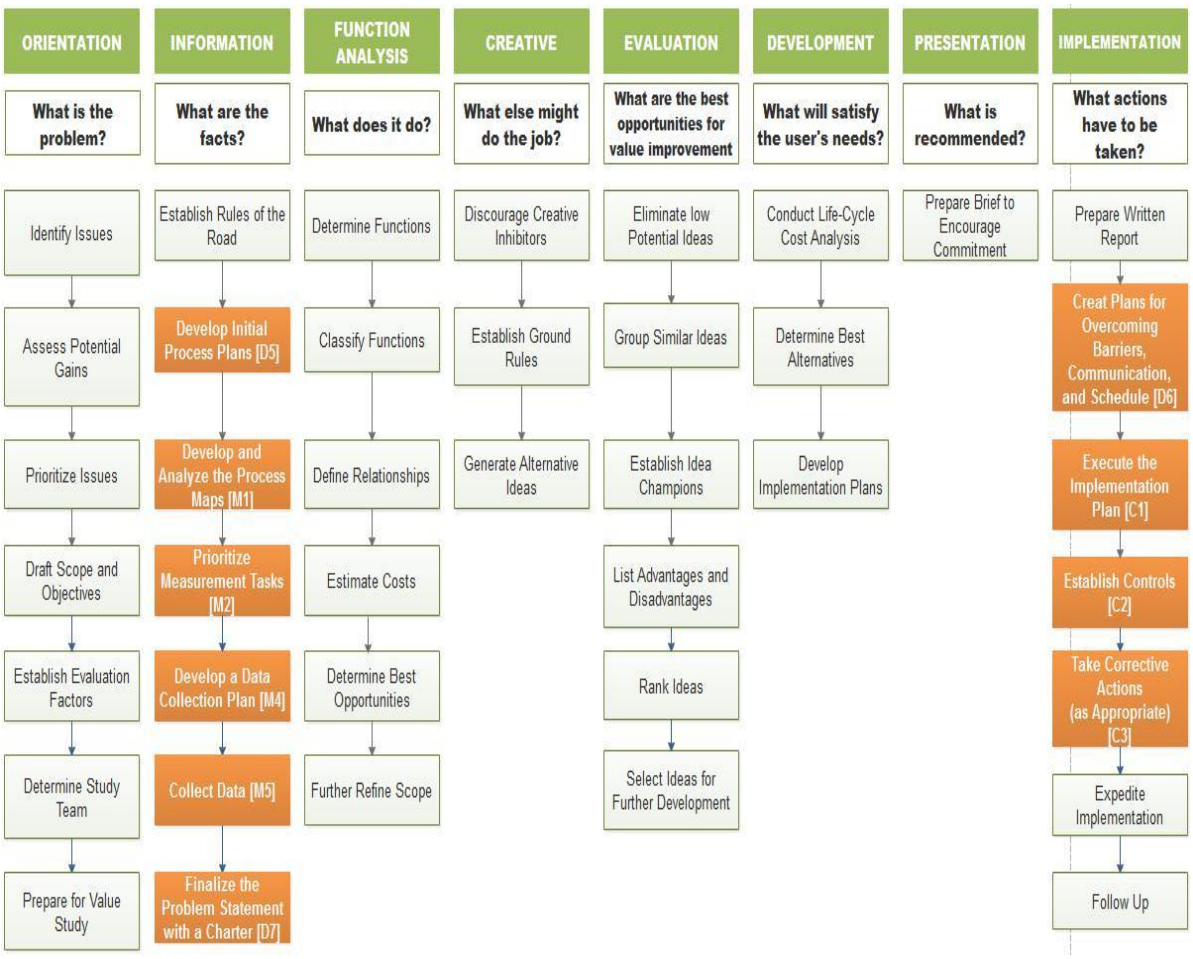

Figure8. *The Synergistic Effect for VE Job Plan Due to LSS DMAIC*

CONCLUSION

Integrating Value Engineering and Lean Six-Sigma methodologies would allow organizations to explore effective options for enhanced improvement performance. While the benefits of enhanced improvement performance from the integration of these methodologies have been widely recognized in the literature [1, 10], this paper distinctly specifies elements of the current LSS DMAIC methodology that should be enhanced by incorporating some VE application methodology and vice versa for current VE methodology.

It is, therefore, highly suggested that organizations using LSS DMAIC methodology to strongly consider the synergistic effect for the methodology due to VE Job Plan incorporation as reflected in **Figure 5,** because it will yield benefits beyond the following: decreased defects, scraps and variations, increased savings due to less wastes, decreased production cycle time, personnel, and costs, increased production capacity, increased customer satisfaction, and improved suppliers and customers relations. Similarly, organizations using value engineering methodology are strongly encouraged to consider the synergistic effect for the methodology due to LSS DMAIC methodology as reflected in **Figure 8** in order to yield benefits beyond the following: omitting surplus functions, optimized allocation of resources, documenting the reasons of selecting the project, increasing the value of goods, reduction of costs and risks, identifying the principles for reducing costs, increasing the technicians' abilities for recognizing improvement areas, and increasing the ability for recognizing the unclear costs and their quantity. An integrated implementation of these methodologies as suggested in this paper would promote enhanced creativity, innovation, and knowledge in the organization and increase customer value while optimizing cost, quality and delivery time.

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