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Integrating Lean Six Sigma and Design Thinking for a Superior Customer Experience

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Abstract: Lean Six Sigma (LSS) is a proven problem-solving approach that uses the Define-Measure-Analyze-Improve-Control (DMAIC) framework and deductive reasoning to help problem solvers navigate from problem symptoms to root cause identification and solution implementation. Unfortunately, many Lean Six Sigma (LSS) programs are not sustainable long term as company leaders lose patience with its continuous improvement projects that takes several weeks and often several months to deliver results. Conversely, Design Thinking is an effective problem-solving technique that uses inductive and abductive reasoning to help the problem-solver prototype, evaluate and refine multiple potential solutions until they find one that is optimal for their end-user(s). This agile solution implementation approach has proven to shorten the time-to-value for the key stakeholders in a continuous improvement initiative. This paper aims to examine the integration of these seemingly diametrically opposed approaches to problem-solving to create a new approach that combines the best of both techniques. This paper also describes a conceptual model for their successful integration. A comparative study and a literature review of LSS and Design Thinking is provided using critical analysis, empirical knowledge and professional experience of the authors. In this paper, the DMAIC (Define-Measure-Analyze-Improve-Control) problem solving method is integrated with the Design Thinking DEDIPER (Discover-Empathize-Define-Ideate-Prototype-Evaluate-Refine) framework to provide superior solutions to complex problems; while delivering signature customer experiences. A case study will be used to illustrate how Lean Six Sigma, Design Thinking and Agile development practices can be integrated to bring out the best of deductive, inductive and abductive problem-solving methods to produce superior outcomes in a much shorter time.

Keywords: Design Thinking, Lean Six Sigma (LSS), Problem Solving Methodologies, Customer Experience

1. Introduction

The history of Lean Six Sigma (LSS) and Design Thinking as problem solving approaches are both interesting and extensive. What has today become known as Lean Six Sigma can be traced to the Motorola company in the 1980s, who was adopting Six Sigma across their U.S. manufacturing processes to drive continuous improvement. Six Sigma was developed to compete with the Toyota Production System (TPS or Lean manufacturing) business model that originated in Japan. During the early 2000s, Lean Six Sigma emerged from the union of Lean and Six Sigma and became its own unique process. While Lean Six Sigma developed as a new adaptation of Six Sigma, it also incorporates ideas from Lean manufacturing, which was developed as an integral part of the TPS in the 1950s. (Grant, V., et al., (2014). Design Thinking, while becoming more and more popular in recent years, has a long and successful history as well. In the 1960's and 1970's, it was recognized that designers solve problems in unique ways; which came to be referred to as a 'solution-centric' approach. Designers would develop multiple possible solutions, or prototypes, based on solution constraints and then test these solutions with their end-users. This approach is markedly different than how engineers and scientists are trained to problem solve; which is referred to as a problem-centric approach. Engineers place a strong focus on first understanding the problem and its causes before deciding on a solution. A couple decade later, in 1987, the term "Design Thinking" was first coined by Professor Peter Rowe of Harvard University in his book Design Thinking; although there were decades of prior research focused on design as a profound way of solving problems; especially complex or 'wicked problems'. Wicked problems are those where the cause and effect relationship for the problem and causes are ambiguous and/or complex. Interestingly, LSS also focuses on complex problems, but takes a much different approach that focuses on causality. More recently, Design Thinking has been adapted for business use; wherein David Kelley, the founder of the IDEO design consultancy and co-founder of the d.school at Stanford University. An evolution from a 'problem oriented' problem solving approach to today's Design Thinking approach; which is very 'solution-centric' has been taking place over the past several decades.

Deductive reasoning is well understood by Lean Six Sigma practitioners. In deductive arguments, if the premise is proven to be true, then the conclusion is also assumed to be true. Having confidence in a true premise or claim is the basis of deductive reasoning. Deduction follows the scientific method; much like LSS DMAIC is a scientific approach to problem-solving. In LSS projects, Black Belts and Green Belts apply Y=f(x) thinking to deduce root causes that are statistically validated as causal factors (x's) influencing a process outcome (Y). Once the sources of variation (x's) are determined to correlate with the process outcomes, Y, then process improvement actions are identified and implemented by practitioners to eliminate or mitigate the effect that these sources have on process performance. It is the objective validation by way of correlation of root causes to outcomes that makes LSS such a powerful and effective problem-solving approach. Provided the LSS team's improvement actions adequately address these validated root cause(s), then the team can have statistical confidence – often a very high confidence level of 95% or better - that the problem will be resolved.

Abductive reasoning (also called abduction, abductive inference, or retroduction) is a form of logical inference formulated and advanced by American philosopher Charles Sanders Peirce beginning in the later part of the 19th century (Josephson, J. R., and Josephson, S. G., 1996). It starts with an observation or set of observations and then seeks to find the simplest and most likely conclusion from the observations. Abductive reasoning takes away logical assumption, explanation, conclusion, inference, hypothesis or best guess based on an observation. This process, unlike deductive reasoning, yields a plausible conclusion but does not positively verify it. Abductive conclusions are thus qualified as having a degree of uncertainty or doubt, which is expressed in qualitative terms such as "best available" or "most likely" explanation. The U.S. legal system often employs this reasoning when circumstantial evidence is presented in making a case, but this approach often results in an element of reasonable doubt.

Inductive reasoning is another problem-solving approach, and it is based the use of empirical evidence to support hypotheses and theories. For example, experimentation is commonly used to make observations and gather empirical information that helps develop a theory or reach a conclusion. Design Thinking employs experimentation by way of rapid prototyping to gather empirical evidence of a solution's effectiveness. In Table1, a comparison of these three reasoning approaches can be observed. In Design Thinking, abductive and inductive reasoning is widely used as an approach to problem-solving. Design Thinking teams make direct observation of end-user, or customers, who are those dealing with the problem, they develop experiments (called prototypes) and make direct observation of the same users as they evaluate and refine their intended solutions. The paper will describe how abductive, inductive and deductive reasoning methods employed in LSS and Design Thinking can be effectively merged to yield a more holistic approach to problem-solving.

Table 1. Forms of Logical Reasoning (Josephson, J. R., and Josephson, S. G., 1996)

Reasoning	Departing point	Aim	Drawing conclusions
Abduction	Empirical observations (unmatched by/deviating from theory)	Developing new understanding	Suggestions (for future directions, theory/paradigm/tool)
Induction	Empirical observations (theory is absent)	Developing theory	Generalization/ Transferability of results
Deduction	Theoretical framework	Testing/evaluating theory	Corroboration or falsification

2. Problem Statement

Numerous research studies have shown that change efforts, like Lean Six Sigma, are not successful at achieving and/or sustaining their desired results. It is widely reported that around 70% of change efforts fail to meet business expectation (McKinsey Report, 2015; Forbes 2019; UNC 2019), and a recent study has this number of change agents who have experienced failure is above 90% (McKinsey Report, 2015). There are many reasons for change efforts falling short of business leaders' expectations, although some common reasons have emerged from these numerous studies. For those followers of John Kotter's 8-Step Change Management approach (Balestracci, D., 2009), Step #6 states: "Celebrate short-term wins to generate momentum for change, and gain organizational buy-in." Failing to create short-term wins puts the change initiative; e.g. Lean Six Sigma, at risk so change leaders must plan for visible improvements, create them, and visibly celebrate them. While there is always an opportunity for the application of 'Quick Wins' or containment actions to be implemented early in a Lean Six

Sigma project, they are often overlooked; as root cause verification is such a prevalent mindset for the LSS practitioner. Furthermore, Lean Six Sigma has fallen under some criticism in organizations because it can take several months to identify and implement solutions. Some businesses simply do not believe they can afford to wait months to address their important business challenges. Finally, the LSS DMAIC process is critically dependent upon the availability of data. Most organizations don't collect all the requisite data that a LSS practitioner will need to successfully identify and verify suspected root causes. The data collection planning and compilation can be another reason for the extended duration of a Lean Six Sigma project.

As previously stated, the deductive, data-based problem-solving approach is a key strength of the DMAIC methodology. It is important to recognize that this approach; while it results in root cause verification when done properly, the Improve phase involves a divergent thinking approach that attempts to generate potential solutions to address these confirmed root causes. Of course, criteria-based selection methods are employed to more objectively evaluate and select top improvement actions. Figure 3 illustrates a solution selection matrix commonly used during the Improve phase. The challenge here is that this important selection process faces a fair degree of subjectivity and ambiguity that surrounds certain selection criteria. For example, "Feasibility" or "Organizational Fit" can often be very difficult for LSS improvement teams to predict for each of their recommended improvements. Some degree of confirmation bias can also exist, where the feasibility and anticipated adoption of new ideas can be overestimated where LSS teams are overly optimistic about their own ideas.

In the Improve phase, the DMAIC process naturally shifts from deductive to intuitive reasoning; wherein inductive reasoning tends to dominate the decision processes. This paper recommends the inclusion of Design Thinking's abductive reasoning approach to the DMAIC methods to gain more empirical evidence of recommended solutions. Furthermore, the key strength of Design Thinking is its strong focus on identifying the 'real' problems faced by end-users/customers; as well as its ability to promote more creative, 'outside the box' solutions for addressing the needs of end-users.

3. Recommended Solution

To address the many challenges associated with sustaining a Lean Six Sigma initiative, the authors recommendation is to combine the strengths of Design Thinking with the key practices of Lean Six Sigma. This combination provides a problem-solving approach that selectively merges practices that take advantage of the three distinct forms of reasoning – deductive, inductive and abductive; resulting in a more holistic change management process. The key strengths of the two problem solving approaches, Lean Six Sigma and Design Thinking, are outlined in Table II. These strengths are realized by way of their unique methodologies and practices. The combination of key practices also addresses some of the short-comings associated with Lean Six Sigma. By empathizing with end-user through direct observation, prior to 'Defining' the problem, this new approach allows problem-solvers an opportunity to reframe problems ensuring that the end-user experience is ultimately improved. In LSS DMAIC, the Define phase is the first phase, wherein a specific, measurable and objective problem statement is agreed upon by the project team. While Lean Six Sigma encourages direct observation of the problem space by advising team members to "Go-See" and walk the Gemba – the place where the actual work is performed, this activity usually takes place during the Measure phase where most of the process analysis is performed. The authors recommend that LSS teams first "Empathize" with end-users prior to "Defining" the problem statement allowing for a stronger perspective of the problem from the users' point of view.

Table 2. The Strengths of Lean Six Sigma and Design Thinking

STRENGTHS	
Lean Six Sigma	**Design Thinking**
Analytical Problem Solving	Intuitive Problem Solving
Self-directed Teams	Self-directed Teams
Customer Focused	End-user Focused
Data-driven	Experiment-driven
Waste & Variation Reduction	Solution-centric
Methodical	Iterative
Management Framework (DMAIC)	Management Framework (EDIPT)

There are several Design Thinking practices that can be integrated into the LSS Define phase and should be performed prior to development the project's problem statement. These practices include: A persona worksheet, Empathy Map, As-Is Scenario Map and/or Journey Map. In Design Thinking, empathizing with end-users means that project team must gain a clear understanding of not only what the end-user 'do' (typically of a Value Stream Map or Functional Deployment Map where activities and tasks are documented), in addition they delve into their feelings and emotions. Once a project team understands why end-users feel the way they feel, they have gained valuable insights into ways they can improve their customers' product or service experience (and not just improve the process through waste and variation reduction) The inclusion of these practices now places the emphasis on the key focus of the change effort; which is to improve the experience of end-users and customers.

Another way that Design Thinking can help with the DMAIC methodology is during the Improve phase. During this phase, potential solutions are identified that are aimed at addressing the root causes that were identified and statistically verified during the Analyze phase. As previously stated, these recommended solutions often speculate on important adoption issues; such as, the ease of implementation and organizational fit. It is not uncommon for LSS project teams to experience push back or resistance to change from the organization when implementing solutions. In Design Thinking, solutions are evaluated by way of low-fidelity (quick and cheap) prototypes. The iterative Prototype and Evaluate phases in Design Thinking is truly where the abductive reasoning takes place by of way experimentation. It is this "Make Fast to Learn Fast" approach that allows project teams to test proposed solutions in a very rapid and low-cost manner; while at the same time receiving extremely valuable feedback from end-users. There is a profound impact by providing end-users something tangible to relate with and react to, versus simply telling end-users about the solutions you are planning. Like during the Empathize phase, when project teams test prototypes, there is a strong reliance on engaging all the senses of end-users so that a realistic experience is evaluated. The early and frequent feedback through multiple iterations helps project teams validate their improvement ideas prior to making more time consuming and costly investments in solution implementation.

To further enhance the effectiveness of LSS projects, Agile project management practices should also be employed during the Improve phase. Design Thinking and Agile practices are often used in conjunction with one another to shorten the time-to-value for new design and development projects. Design Thinking is commonly used to validate new product or service concepts with end-users, and once a design is confirmed, the development team readies the deliverables for release to market using Agile development practices. These deliverables for the overall release are broken down into smaller customer requirements and development teams release their solutions to end-users at the completion of time-box iterations, or sprints, ranging from 1 to 4 weeks in duration. These sprints can be employed during the DMAIC Improve phase to incrementally deliver value to end-users. As previously mentioned, one of the keys to successful change management is the early and frequent recognition of success; wherein the agile delivery methods enable the continuous delivery of value across the life of the project. It is often common for LSS projects to include many improvement actions of varying complexity and cost; so, it is quite plausible for project teams to deliver these solutions across multiple sprints where simpler actions are delivered early and more complex solutions follow in later sprints. By shortening the time-to-value for end-user through sprints, the project team is better able to demonstrate their effectiveness.

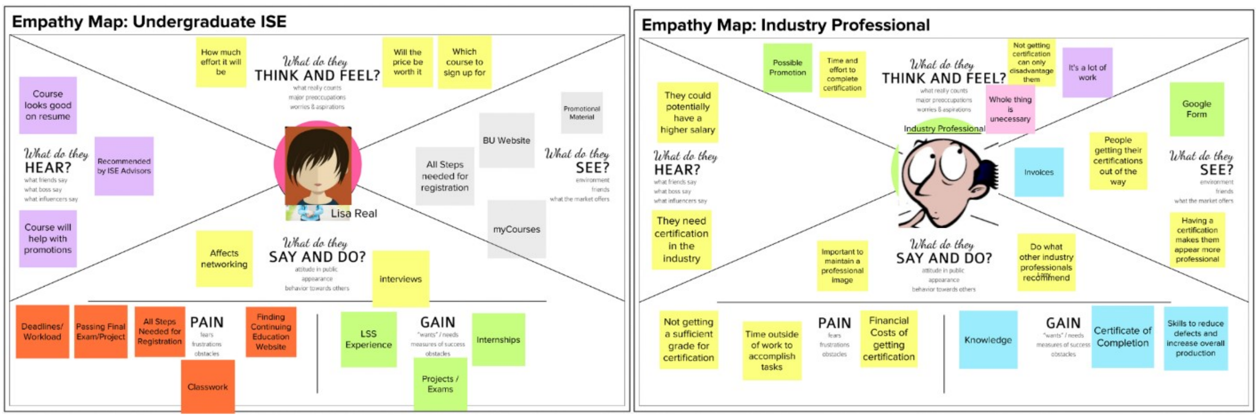
4. Results

In this section, a case study of a learning management system (LMS) redesign project will be briefly outlined. The project combined LSS, Design Thinking problem solving methods along with Agile project management practices. The DMAIC framework was followed; wherein Design Thinking practices were integrated. The system design challenge, or problem statement, and goal are listed in Table 3.

Table 3. Learning Management System (LMS) Problem and Goal Statements

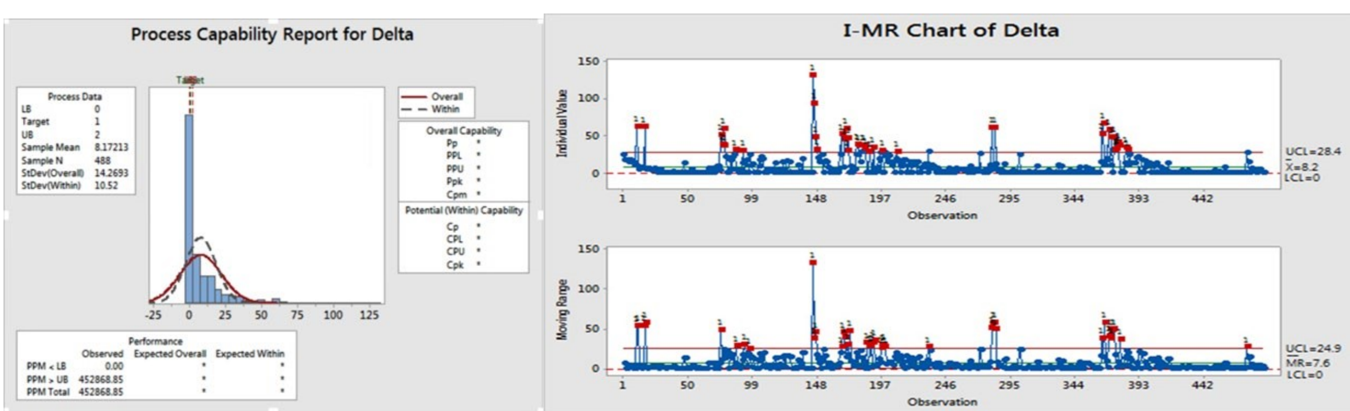
Problem Statement (Design Challenge) – What problem are we trying to solve?	The current state of the LMS registration process requires excessive manual labor, end-user ambiguity, slow responsiveness, and a lack of accessibility: which leads to the inability to scale and grow.
Goal Statement (Desired end-state) – What does a successful redesign look like?	The goal of this project is to identify and implement design changes for the LMS registration process to make it easier to use for both registrants and system administrators. (System functional and user non-functional requirements to be quantified and evaluated)

During the Define phase, personas were identified using stakeholder mapping and stakeholder analysis followed by creating Empathy Maps for key personas. In Figures 1 and 2, the Empathy Maps for two key stakeholders are identified; who are the main end-users of the system. The primary end-users of the system are university students and industry professionals; although an Empathy Map was also created for the system administrator. The Empathy Map is a powerful Design Thinking technique for placing problem solvers in the 'shoes' of the end-users to help them better appreciate their experience with a product or service (the LMS in this case) Not only are observable behaviors documented, but thoughts and feelings are also identified so that the source of poor and/or exceptional experiences are known to the improvement team. The end-user experience becomes a key and critical input the root cause analysis (Analyze phase) and improvement ideation activities (Improve phase)



Figures 1 and 2. Empathy Maps for end-users (registrants/students) of the Learning Management System

In addition, during the Measure and Analyze phase, traditional LSS techniques are used to evaluate the current process or system performance, and commonly process capability and stability are assessed. Where process performance criteria (non-functional system requirements performance, for example) is not meeting expectations, correlates, or critical x's, are identified by way of root cause analysis that is preferably quantitative and statistical in nature. In Figures 3 and 4, the process capability (Cp, CpK) and stability (SPC) was performed for key system performance measurements. It can be observed from the capability study that the process is not capable of meeting its performance targets; wherein dramatic improvement is required. For the stability study, an individual-moving range (I-MR) chart was used to analyze the same key performance indicator; wherein the analysis showed several points where special cause variation was likely evident as there were many points above the upper control limit (UCL). The out of control points became of source for root cause investigation and identification the improvement team.



Figures 3 and 4. Capability (Cp/Cpk) and Stability (I-MR) studies for system non-functional requirements (NFR)

Combining the qualitative insights derived from the Empathy Maps with the quantitative insights from statistically validated root cause analysis, the process improvement team is better informed to make more holistic decisions concerning required improvement actions (Improve phase). Of course, during the Improve phase, the creative thinking practices employed in Design Thinking can help to bolster the team's ideation processes as well.

Finally, solutions can be deployed using Agile project management methods. LSS, Design Thinking and Agile are all very compatible in that their principles empower self-directed teams to focus on providing superior value to end-users and customers. In Agile, the project team prioritizes the project deliverables from the highest value, lowest risk down to the lowest value, highest risk activities. In Agile, risk is the likelihood of not successful completing a deliverable on time. The project team's "Wall of Work" or project activities using the Trello® application (UNC, 2019). Using Agile visual management practices, the entire organize is aware of the project deployment status at any given point in time, and by delivering the highest value items quickly, the organization gains valuable momentum that enables the sustainability of the change effort; as per Kotter's change management model (Balestracci, D., 2009) The results for this project are summarized in Table IV. For the new and improved system and supporting processes, the time in the system for the end-user was reduced by more than 50%, and the process capability (Cp/Cpk) for a key performance metric was improved dramatically resulting in a process sigma performance far greater than 6sigma (from 1.62 sigma, originally).

Table 4. Summary of the results of combine Lean Six Sigma and Design Thinking Methods

System Performance Metric	**Before Condition (As-Is)**	**After Condition (To-Be)**
Avg. Time in System (Days)	2.5 Days	1.2 Days
Process Cycle Efficiency (PCE)	35.9 %	47.2 %
Cp/Cpk	.03 / - 0.20	Infinity / Infinity
PPM (DPMO)	45,269 Defect per Million	0 Defects per Million
Process Sigma	1.62 Sigma	>>>6 Sigma (Infinity)

5. Conclusions:

The effectiveness and benefits of combining these methodologies has become apparent to the authors by way of this project, and several subsequent projects to follow. A summary of the results for this project can be observed in Table IV show that the quantifiable system performance measurements improved significantly. These results are dramatic; although not uncommon for a Lean Six Sigma project. The addition of the Design Thinking and Agile deployment practices help deliver value to the end-users in a more thoughtful and timely fashion; resulting in delighted end-users and very satisfied business process owners.

In addition to the results demonstrated in Table IV, end-user satisfaction improved wherein complaints dropped from several per month to zero after implementation of recommendations. Furthermore, this project was started delivering results to end-users and the sponsoring organization in a matter of a few weeks, compared with several months for traditional projects.

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