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Six Sigma: Literature Review and Methodologies to Improve Implementation

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Abstract
There were plethora of research done and journal papers published in relate to Six Sigma. Ironically, there are few research and papers were published on reviewing the literature on Six Sigma in all the sectors like Engineering, Healthcare, IT Industry, education etc. Six Sigma is not only about the statistics but also it is a process of defect reduction, improvement and customer satisfaction. The goal of this study is to look at prosperity of improving methodologies and deepen the knowledge of various research and coclude the process Six Sigma. In this paper, a survey of Six Sigma literatures is presented through various research papers to illustrate the broad scope of the application of Six Sigma. Lean Six sigma can also be implemented in the financial services and the with significant results and improvements which was shown with the help of case study.

Keywords: *Six Sigma, Literature, Classification, Research methodology, Lean manufacturing, Financial services.*

1. Introduction

What is Six Sigma?

Six Sigma is a careful, focused, and highly effective implementation of quality principles and techniques. Sigma (σ) is a letter in the Greek alphabet which is used by statisticians to measure the variability in any process of error. Most of the organizations were accepting three or four sigma performance levels because the norm, despite the actual fact that these processes created between 6,200 and 67,000 problems per million opportunities. At the basic definition, Six Sigma is a statistical measure for what many technicians and researchers call as perfect methodology. Some of the methods of Six Sigma uses highly advanced, including up-to-date computer technology. Moreover the tools which are applied within a simple performance improvement model known as Define-Measure-Analyze-Improve-Control, or DMAIC. DMAIC is described briefly as follows:

D Define the goals of the improvement activity.

M Measure the existing system.

A Analyzing the system to identify various ways to eliminate the gap between the current performance of

System or process and the desired goal.

I improve the system.

C Control the new system.

I will say that Lean Six Sigma can be fast, affordable, flawless, maximizing results while minimizing costs. Six Sigma is about learning how to eliminate the three silent killers of productivity and profitability; delay, defects and deviation. Eliminating defects and deviation reduces costs so that products and services

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become more affordable. Fig. 1.1 shows basic definition of Six Sigma. It also shows the relationship between errors and sigma levels as the error rate drops exponentially, the sigma level goes up.

To understand the statistical meaning of Six Sigma let us take an example of time taken by an airplane in one month to travel from America to India. Some of the day in month will take less time or more time depending upon various criteria. If the data is plotted on a graph taking time on X-axis and distance on Y-axis and a smooth curve is drawn, its shape will look like bell shape i.e. normal distribution curve.

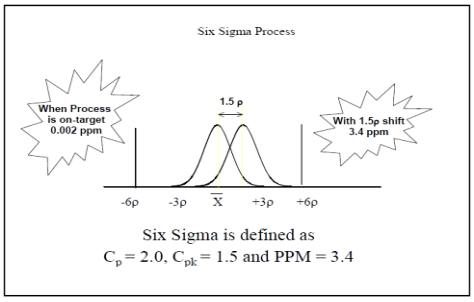

Figure 1. Process of Six Sigma by Normal Distribution Curve

Why Six Sigma?

Market is changing drastically and new technique has to be adopted by a growing majority of fortune companies, as well as small and mid organizations. Customers are very conscious of quality despite of cost of the product. Demand for high quality products and also at competitive economy has augmented. Motorola was the first company to introduce the Six Sigma technique for process improvement. When a Japanese organization took over a Motorola company that manufactured television sets in the United States in the 1970s, they set about making drastic changes in the way the factory operated.

Under the Japanese management, the factory was soon producing TV sets with 1/20th as many defects as they had produced under Motorola's management. It took nearly the mid-1980s before Motorola figured out what to do about it. CEO of the Motorola company has started the corporate on the quality and standard path referred to as Six Sigma and have became a business icon largely as a results of what he accomplished in quality at Motorola. Motorola was only the one organization to won the Malcolm Baldrige National Quality Award in 1988 and the secret of their success became public knowledge, The Six Sigma revolution was started from here. Six Sigma is not just about the quality and little to do with that. Six Sigma completely focuses on helping the organization to make economy and productivity by improving the customer value and efficiency. It sheds light on customer requirements, defect prevention, cycle time reduction, and cost savings.

The goal of Six Sigma is to reduce the defects near to zero. It generates demonstrable results which are linked to ambitious achievements of reducing defects and economy near to zero by setting target. This technique is applicable for all the processes held in industries such as from production, quality checking to the servicing.

Implementation of Six Sigma

- ***Focus on the Customers*** **–** Customers is on the top priority in the Six Sigma technique. Defects are the failed products which not met measurable customer requirements.
- ***Fact Driven System*** **–** It includes collecting the data and analyzing it thoroughly to understand key variables and process drivers.
- ***Focus on Process*** **–** This step focuses on the various processes ongoing in industries to ensure the customer requirements.
- ***Proactive Management*** **–** To opposite of being reactive we have to be proactive; means to act ahead of event and to be behind the curve. In this step we set the goals and priorities.
- ***Smash the Barriers*** – It includes the collaborations that smash the barriers which blocks the flow of new ideas and action up across the organization.
- ***Drive for Perfection*** **–** It is very important to drive for the perfection and make sustainable results happen within an industry.

The fig shows difference between Lean and Six Sigma approach. Lean is not only about mitigating wastes and reducing it but it also can be applied in the continuous form for years. Whereas Six Sigma

reduces the problems, which concludes in terms mitigate the defects.

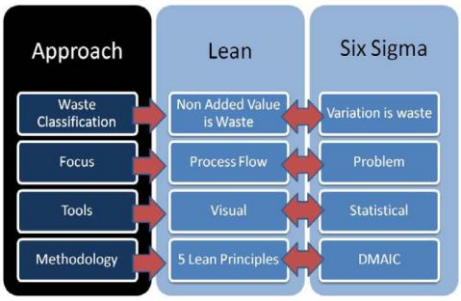

Figure 2. Difference between Lean and Six Sigma

2. Literature Review

Literature review in the paper focuses on the reviewing part of the Six Sigma. Literature review is indeed a very important research effort, which not only reviews the previous writings but also it answers in the affirmative way to specific research questions. It also evaluates, analyze and synthesizes the comprehend data and reports the evidence in such a way that it possibly draw a reasonable conclusions. In this section studies of various prospects regarding Six Sigma were carried out in terms to help to put the current state of literature.

Viender and Sandeep [1]: The purpose of this paper is to establish and capture the current state of Six Sigma as well as to report the current practices of Six Sigma. This paper answered about "what is Six Sigma?", "what will be the various uses of the Six Sigma?", "what will be the most of enablers and barriers to its implementation?" and "what are the rising trends?" Seven key findings the topics on which the views of the authors converged and two issues of the topics on which authors had differing views are established. These include the understanding of Six Sigma tools and techniques, implementation of Six Sigma, profit, espousal, low cost and links to other disciplines. The systematic literature review approach utilized in this paper allows rising trends and issues in Six Sigma to be highlighted during a structured and conclusive manner, enabling the longer term work to progress as Six Sigma continues to develop and evolve. The findings also open up new opportunities to use Six Sigma within the plethora of fields that aren't widely explored and at lowest possible cost before example as sustainability and product-service systems.

Rodney McAdam et al. [2]: The business improvement approaching the technique Six Sigma with wide potential to increase its competitiveness and productivity as well. And this technique is emerging very rapidly in the various sectors in both practitioner and academic literature. However there are very few papers published on practical basis with respect the theory of Six Sigma. There is a rising theoretical reinforcement in relation to Six Sigma borrowing from assorted range of organizational theory. Six Sigma can be developed in the practice by expanding mainly through more meticulous studies and applications in various sectors. This paper tells us that Six Sigma is both strategic and an operational issue as well which focuses solely on Define, Measure, Analyze, Improve and Control. The main agenda of this research paper is to relate both theory and practical and have established in relation to each dimension of the absorptive capacity framework.

Shruti J. Raval et al. [3]: The purpose of this research paper is to introduce insights in the field of the Lean Six Sigma (LSS) and also examining and identifying research gap. It was assessed by the examining the field with time horizon, research and publisher, university and geographic analysis etc. Authors of this published paper reveals noticeable emerge in the attention of LSS research. Most of the research shows that, the empirical relation and the research holds at greater credibility. Statistics has proven that the research study method scores the highest among all the research methods used in the regulation. LSS uses a plethora of tools, techniques and methodologies. All the sectors including manufacturing and healthcare focused on the LSS research. Most of the organizations which are following the LSS technique have improved the results, growth and profitability of the company. These results also enhanced customer satisfaction. However there are still lack of the standards in the LSS accomplishment framework. This study reveals to understand about the current state of the research on LSS. Its various trends in this field and its

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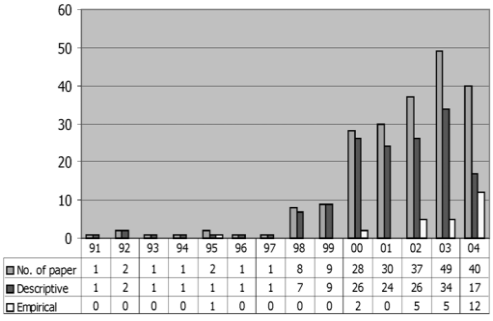
application has got future prospective of investigation in this field.

P. Nonthaleerak and L.C. Hendry [4]: This research paper has reviewed more than 200 Six Sigma literature reviews and classified there content according to their research. This paper has organized in the five sections. In the first section they briefly described about the key characteristics and some of the assumptions. They have mentioned about the example of Motorola who implemented the Six Sigma in there company, which helped them about with a greatest achievement. According to them the Six Sigma exploitation process focuses on the continuous implementation by the top level management. They also described about the methodologies used in the Six Sigma i.e. DMAIC, DMAIV and DFSS (Design For Six Sigma). In another section they have categorized the plethora of literatures and also shown how the number of publications approached to LSS and increased in recent years. While reviewing the papers they have gone through various websites like isixsigma.com, googlescholars.com etc. They also have included the industrial peer reviewed journals because its essential to be get acquainted with the industrial knowledge and various practical. There were two categories identified with the methodology focus and the implementation focus. And most of the research papers were discussed in detail in sections 4 and 5 which identified the research gap throughout the discussion.



	91	92	93	94	95	96	97	98	99	00	01	02	03	04
No. of paper	1	2	1	1	2	1	1	8	9	28	30	37	49	40
Descriptive	1	2	1	1	1	1	1	7	9	26	24	26	34	17
Empirical	0	0	0	0	1	0	0	0	0	2	0	5	5	12

Figure 3. Various Journal Papers Publications from 1991 to 2004

They also have researched and found number of papers published on Six Sigma upto year 2004, which was strated in the year !991. Fig 3. shows the papers publused form year 1991 to 2004 and with the statistics of types of published journals.

Walter et al. [5]: This paper is based on the goal of cleaner production for achievement of sustainable development with the use of Six Sigma methodology. Most of the literature review has discussed about the theoretical concepts. However this literature described on the practical implementation of Six Sigma and also analyzed the literature reviews on the Lean Six Sigma article. They also explicated the difference between the Lean Production (LP) and Six Sigma (SS). Over integrating them both i. e. Lean Six Sigma (LSS) has helped out with most of all the organization with its plethora of advantages and augmenting technologies. They mentioned a new technique Lean Six Sigma and Sustainability (LSSS) in which they discussed about the limitations and sustainability and enhancing the effectiveness of lean initiatives. They suggested over the LSSS to be analyzed for the future studies and draft a model according to current aspects. This article has also verified and analyzed the method LSSS and described about how to implement the LSSS technique.

Adan Valles et al. [6]: This paper has presented the methodology of Six Sigma used in the project at a semiconductor company, which was devoted to the manufacturing of the cartridge for inkjet printers. They tested the cartridge electrically at the final stage of the manufacturing process and after measuring the electrical characteristics making sure to accept it or reject. The electrical failures happened at 50% of the entire defect. So they established and found out the main problems, causes and acted with the better results to reduce the level of defects. According o them, with the implementation of Six Sigma technique they were able to find the key characteristics and problems. After the design experiment held with help of Six Sigma they found three factors abrasive pressure (90 to 95 psi), height of tool (0.05 to 0.06), and cycle time (7000 to 8000 millisecond).

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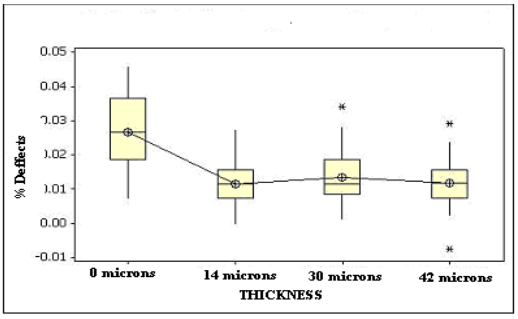

Figure 4. Boxplot Diagrams of the Percentage of Electrical Faults vs. the Thickness of the Procoat Layer

The main cause of this experiment was the quantity of wash cycle, the thickness of the procoat layer and the operational differnce between them.

Nilesh Fursule et al. [7]: This paper has discussed over the various advantages and limitation of the Six Sigma while implementing this technique. Six Sigma technique imroves the quality of prduct by reducing the waste while manufacturing process. However there is not sufficient informantion provided over the implementation and due to this most of the companies were failing to implement the Six Sigma technique. Author of this apper has investigated the role and issues over implementing the Six Sigma and also reviewed both sides of this technique i.e. quality management and and Six Sigma literatures. The paper is a small aprt of broaden and critical research project work which aimed of exploring the data and analyzing the startegies ued in the Six Sigma technique. The next part of paper shades light on the methododlgies of Six Sigma. And they also elaborated the future scope of this technique and the future woeks requiered to be done by professionals in this field. The main aim is to broaden the knowledge of scholars to think deeply and bolster there knowledge in this technique. According to them Six Sigma is a traditional approach, where we create internal teams and reduce the waste. It also ansers the questions like How internal and external systems will affect the Six Sigma technique?, How should company invest in the inventory control and manage the Six Sigma methodolies and its implemntations? They also suggested that for furhter work, study and research how Six Sigma could be improved by combining with the Lean Manufacturing.

Faust et al. [8]: Six Sigma is a technique which reduces defects of the product by the customer requirements. It uses the DMAIC methodology to reduce the waste. The main purpose of this paper was to improve the customer's requirement and satisfying their needs. And it also focused on the reducing variations in the processes and product quality characteristics. Yhis paper was researched under the paint company and processes covered under the painting. They used a standard deviation which is mathematical function and it gives prospective set data. Standard deviation is a square root of the variance and the variability in the process is calculated. Large standard deviaiton values leads to spreding the data with respect to mean and small standard deviation leads to the closer the data with respect to the mean. They applied the Six Sigma technique by upper and lower control limits within the standard deviations. By the use of this the bar chart has drawn and by plotting the ponits and results can be concluded to fix the problem. It was performed to gather the information on customer needs and to improve the quaity by focusing on the DMAIC process.

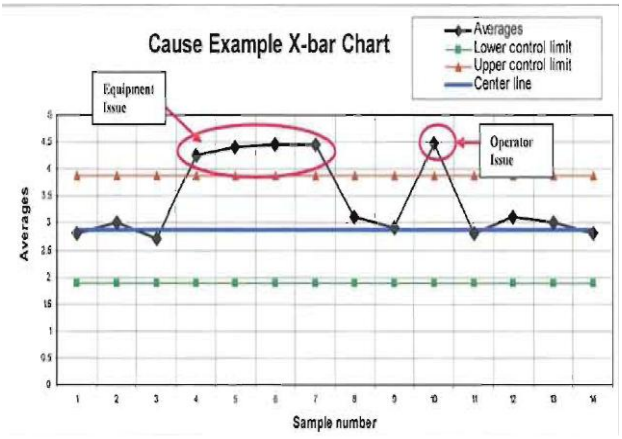

Figure 5. X Bar Chart Showing Limits within Standard Deviation

Raveen Rathilall et al. [9]: In this competitive world all the companies has necessarily to improve the economy they have to improve their operations and enhance the processing quality. Literatures found out that by use o Lean Six Sigma tool one can compete to the rest of the world by their productivity, quality, environment etc. Author has investigated the incorporation of the Lean and Six Sigma to approach

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the continuous improvement and develop a combined tool to assist the organization to compete with the world. The quantitative analysis was adopted and the empirical study was conducted to by questionnaires. They analyzed the automotive component manufacturing company in South Africa. With their research figures South Africa has appeared to be 20% more expensive than other countries such as Western Europe, China and India as an automobile manufacturing base. It has appeared through the research that South Africa adopting various technique by using the government funds, consultants and support from the global sister organizations. They mentioned about the key differences and various advantages of Lean and Six Sigma.

Qun Zhang et al. [10]: This paper has reviewed near about 116 journal papers related to the Lean Six Sigma from the websites like Science direct, Google Scholar etc. This paper has also included the implementation results from the various organizations which applied the Six Sigma methodology. According to the author Six Sigma process has mostly implemented in the Heath Sector. Lean Six Sigma is a combined method of waste mitigation and the process improvement technique.

The fig. shows journal papers which are reviewed in plethora of sectors by author. Organization implements the Six Sigma process either to improve the manufacturing process or to modify the process to augment the efficiency and productivity as well. Most of the organizations were failed to implement the Six Sigma methodology due to lack of practicality and other prospective such as ERP (Enterprise Resource Planning), Data mining, Simulation, Risk Management etc. Lean Six Sigma is equally beneficial for not only the large scale industries but also for the small scale industries for both manufacturing and servicing.

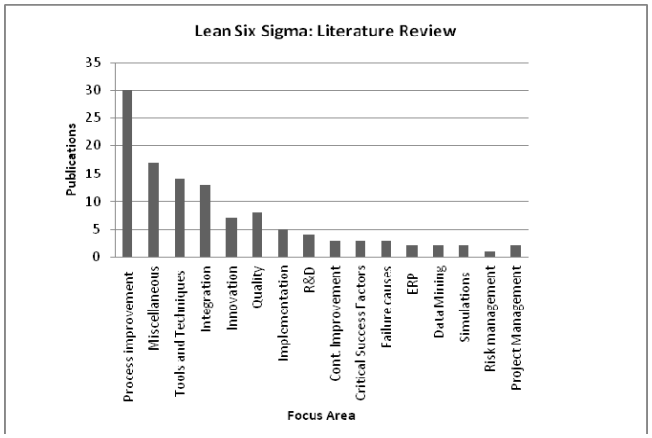

Fig. 6. Bar Chart on Various Literature Reviews in Different Focused Areas

3. Case Study

When we call our bank regarding any issues then you can get an option regarding blocking the Debit/Credit cards, when ATM machine makes a sound when you forgot to remove the card after use, when you receive messages saying 'services will be delivered within X days', then we have to think about Six Sigma. We all know that Six Sigma was developed and implemented in the manufacturing environment. However most of us have the questions 'How Six Sigma can be implemented in the non manufacturing sectors'? Different organizations such as Financial Sectors, Healthcare services, Educational sectors etc. are having mindset of, we are service sector, a human driven association and there is no defect to measure. On the other hand no matter which product your organization offering, all sectors driven in the same cycle of Input-Process-Output.

Below are the some use cases where Six Sigma can be applied in the Financial Industry:

- Improving customer understanding by identifying troubles that normally occurs.
- Solving the problems related to the delays or queuing.
- Managing employees, quality of work and productivity of employees and building the team
- Improving the internal process in the financial sector by mitigating irrelevant processes that cause delay such as manual detail filing by making it online and friendly.

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- Design new products and services in the financial applications that customers got acquainted and provide a hassle-free experience for financial management

Financial services are facing more competition because of globalization. Thus to compete on the global level it is obligatory to improve operational effectiveness and efficiency. Lean Six Sigma can bring significant results and improvements in the financial services. We can implement Six Sigma in financial sectors by improving operational efficiency and effectiveness which includes quality improvement, cycle time reduction, productivity improvement, waste reduction and the elimination of rework

Banks providing a broad range of financial services, including retail banking, loans and money transmissions have implemented the Six Sigma methodology. Suntrust Bank, Citigroup and JPMorgan Chase & Co. are few examples who have implemented Six Sigma successfully in banks. One of the bank form US which is holding 2nd position in the financial services named JPMorgan Chase and Co. has generated wonderful results through expense reduction, revenue, service etc. Dr. Alex Balbontin, Vice President of Productivity and Quality and Master Black Belt at JPMorgan Chase spoke at the IXPERION Six Sigma in Financial Services Conference in New York. He presented an excellent overview of the evolution of Six Sigma at JPMorgan Chase. In JPMorgan a unique addition to the traditional DMAIC steps included another "I" into the methodology, creating "DMAIIC", which stands for Define, Measure, Analyze, Improve, Implement, and Control.

Six Sigma Results

Company	Annual Savings
General Electric	$2.0+ billion
JP Morgan Chase	*$1.5 billion (*since inception in 1998)
Motorola	$ 16 billion (*since inception in 1980s)
Johnson & Johnson	$500 million
Honeywell	$600 million

Six Sigma Savings as % of revenue vary from **1.2 to 4.5 %**

For $ 30 million/yr sales – Savings potential $ 360,000 to $ 1.35 million.

Investment: salary of in house experts, training, process redesign.

Figure 7. Six Sigma Implementation Results from Various Sectors

Figure 8 below sheds light on the revenue and the annual saving figures achieved by the bank JPMorgan and co. with the use of Six Sigma technique.

In the Annual report of 2001 they affirmed, 45 million in savings achieved through restructuring, productivity and quality programs, including an organization-wide Six Sigma effort and the firm's clients and shareholders were benefited from Six Sigma. In the year 2002 they nearly doubled the number of employees who are having Six Sigma certification and to realize the full power of business in finance sector.

Another figure elaborates the profit made by the JPMorgan and co. with comparison to the other banks with implemented Six Sigma technique.

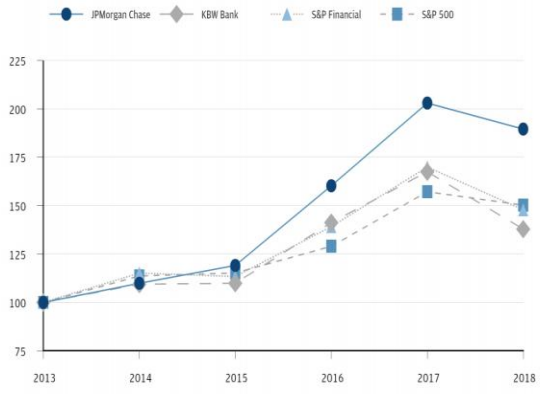

Figure 8. Revenue after Implementation of Six Sigma

An International bank in the Germany and near about 300 employees decided to implement the Six Sigma in the bank in all its business units in Europe in the year 2003. To pre analyze the process of the car loan the cross functional team has formed with expertise from

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different sections like sales, marketing and operations to investigated the key roles in the car loan. The team created the high map through research and practical's and identified the relevant influence factors.

The tam contacted with the near about 130 car dealers and developed the client satisfaction survey conducted by the telephonic process.

Near About 60 percent of the car dealers affirmed non-existing or poor communication with the bank as the biggest driver for dissatisfaction.

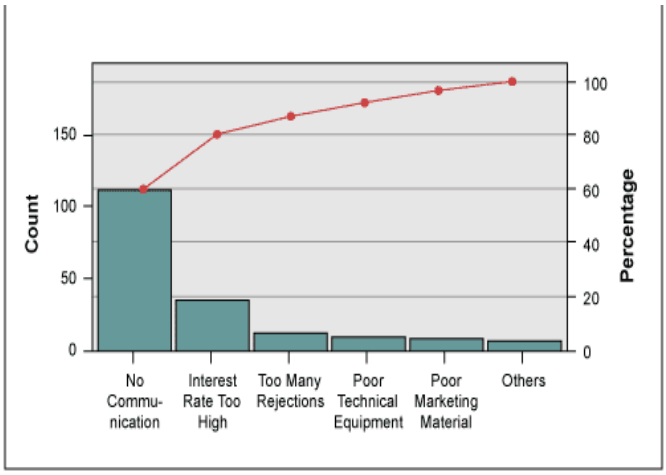

Figure 9. Different Reasons for Dissatisfaction of Customers

Thus during the analysis with the Six Sigma technique the team has focused on this issue as the important influencing factor. The team has decided o check the communication process between the sales team and rhe clients. But surprisingly they found there was no any communication. Because sales representatives kept their days busy with reports and the paperwork. After the market research the team has contacted with the car dealers and persuaded them to make them as priority and they have successfully implemented the Six Sigma.

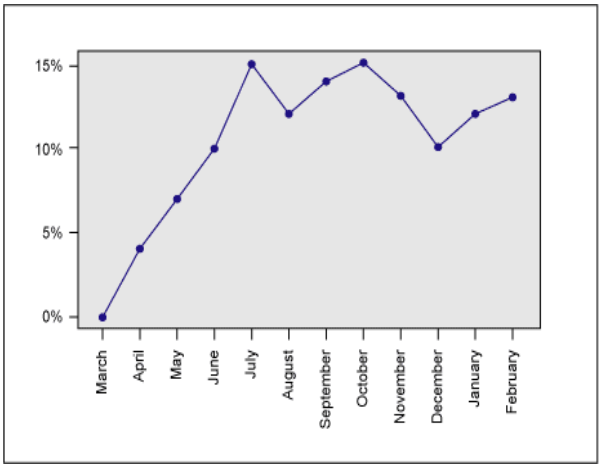

Figure 10. Results after Implementation of Six Sigma in Bank

The banking team has developed the solution for growing the car loan revenue and made transparent system between the car dealers and sales representative.

4. Discussion

Most of the review papers published based on the theories made by Six Sigma process but there are least papers existing in the market which will show practical and conversant knowledge on Six Sigma. Methododlgies implemented in this process like DMAIV, DMAIC etc are making the manufacturing processes improved and with increased efficiency. Si Sigma minimizes the defects and variations in the flow process. It eliminates the causes of errores by using different methodologies. It also determines measurement sysytems producing reaibility estimated by the quantity. Now a days customers are aware of the quality and they are ready to spend much penny on the good quality product. Hence to develop a better quallity product we needed the method which will improve the varaitions and reduce the defects. Demand for the high quality products is also increasig ad this is is the another most improtant reson fo the implementation of Six Sigma as to increase the production. Most of the orgaizations are shroting up there defective products by implementing this process and cutting down the waste ecocnomy. Six Sigma is not only the philosophy but the methodldogy which improves the quality by analyzing the data, solving the data statisitically and implementing it technically. From case study we can get to know about the

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addressin the main root cause of the problem with the help of Six Sigma technique. With an example developing communication between sales reresentitive and clients by redefining the internal interference etc.

5. Conclusion

Six Sigma methodology can be used in the various sectors such as automotive, healthcare, IT industry, casting industries, plastics industries etc. Thus there is very much scope to implenemt the Six Sigma as a process tomimprive the quality and productivity. There has considerable research on Six Sigma by more focusing on how to integrate the process instead of discussing on the basics and comaprisons. Lean Six Sigma (LSI) has known as considerably from its multiple paths of Taylor's time and motion, Statistical process Control (SPC), Total Quality Management (TQM) etc. Six Sigma is a process which mitigates the defects in the areas by focusing on the data which is collected and analyzed.By the use of Define, Measure, Analyze, Improve, and Control (DMAIC). Most of the banks have cut waste and streamlined various processes which resulted in shorter waiting queues for our customers, with less staff. People no longer needed at tellers were retrained into commercial profiles, stimulating sales and they can be fulfilled with their works with online services with the help of Six Sigma management.

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