Application of Six Sigma Model in Library Management System for Process Improvement

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ABSTRACT

Six Sigma is a set of strategies and principles for the process improvement and to produce quality products while reducing the waste substantially. Six Sigma is applied to produce near zero-defect products and services and it also ensures to meets all the quality and customer specifications. In this paper we will show how Six Sigma can be implemented in a college Library Management System for further improvement of the existing automated process. We will follow the basic Six Sigma methodologies (DMIAC) to identify the scopes of further improvement and to implement the new tool.

Key Words: SDLC, Six Sigma, Library Management System.

INTRODUCTION

Six Sigma can be defined as a philosophy aiming to produce near zero-defect services and products. The focus of Six Sigma is to minimize the amount of resources, money and time invested to produce a quality product that meets all the customer's requirements. Another way of defining Six Sigma is to measure the amount of deviation a business process experiences from perfection.

In 1920, Walter Shewhart showed that when business process suffers from three standard deviations away from the average then there is need for some corrections in the production process otherwise product will fail quality inspection test. This idea was later implemented by the Motorola engineer Bill Smith. Initially Six Sigma was a quality metric used to reduce defects in production unit. In 1980 Motorola's CEO Bob Galvin and Motorola's engineers wanted to measure the defects per million opportunities and improve the product quality to increase the profit. Motorola developed a methodology that helped to increase the quality and profits in their organization by using Six Sigma which yielded $16 billion profits for them. Many companies got attracted by this successful methodology and soon started to implement and thus Six Sigma made faster and greater results in GE (General Electric) and in most of the manufacturing companies in 1985. In statistics, Six Sigma is known as the process capability and it is referred as the ability of the manufacturing process to produce more quality products. 'Sigma' measures the deviation of

process from perfection. Any process that is made using Six Sigma methodology is assumed to have less than 3.5 defects per a million opportunities.

Motorola defined Six Sigma as a metric, methodology and a management system. Metric in the sense that Sigma is used as a scale of quality and using this scale, Six Sigma reduces defects as 3.5 defects per million opportunities. As a methodology it has the capability of understanding and managing customers' requirements and aligning the key business process to achieve the goal and utilizing the rigorous data analysis to minimize variation for the business process and to obtain rapid improvements in business process.

According to General Electric, Six Sigma is a highly disciplined process to focus on developing and delivering near-perfect products. It consists of few key concepts such as: critical to quality, process capability, stable operations, defects, variation and design.

Over the time, Six Sigma has evolved as a generic tool for set of concepts that many organizations have used for quality and performance improvement. Six Sigma is a flexible and highly customizable concept that fits to be implemented in any industry, to the production quality metric and to the customer service team and a successful implementation of six sigma methodologies represent the corporate culture.

The organization of this paper is as follows: first basic *Introduction* is followed by *Related Work* which provides a comprehensive study of several existing research works on Six Sigma. Thereafter *Six Sigma Management Roles and Hierarchy* explains the managerial hierarchy of Six Sigma and *Six Sigma Belt Systems* discusses different existing belt systems in Six Sigma methodology. Further, *Six Sigma in Software Development Life Cycle* (SDLC) covers implementation of Six Sigma in SDLC. Next, *Our Proposed Solution* gives a detailed insight of our design and Six Sigma based application in Library Management System. Further, *Details of Deliverables – Automatic Alert Generation Tool* section elucidates technical details of our application. Finally *Conclusion* section provides conclusions to our paper.

RELATED WORK:

Six Sigma methodologies have been adapted to software industries also, and its relationship to the standard software development life cycle process needs to be rationalized [1]. Both manufacturing and service operations are now calibrated in terms of "sigma level", and industries have begun to label themselves "six sigma organizations" for process improvement [8]. Richard E. Biehl [9] discussed a better understanding of Six Sigma movement by looking back at its predecessor – 'Total Quality Management'. A detailed discussion on success of Six Sigma in productivity and quality has been discussed by Bernie Gollomp [10]. A study on Understanding the key features, obstacles and shortcomings of the six sigma method has been carried out by Young Hoon Kwak et al. [11]. Michael VanHilst et al [12] proposed to apply artifact mining in global development environment. Their approach was to identify sources of wastes in Six Sigma DMAIC approach and to improve the process and quality accordingly. An approach to the improvement of software verification process based upon the application of Six Sigma methodology along with change management, and statistical tools was proposed by Tihana Galinac et al [13]. Florian Johannsen et al [14] presented an approach to develop Six Sigma model for integrated solutions of goods and service. The proposed approach was tested in

the context of a financial services company in automotive industries that reveals considerable benefits. Security can be a major concern to be considered while integrating Six Sigma model with the existing industrial process model. V. Anand et al [15] represented policy creation tools and management process to map security policy management with Six Sigma model. In this paper we will consider the Six Sigma methodologies to address the scope of enhancement in an existing college library management system for further process improvement.

SIX SIGMA MANAGEMENT ROLES AND HIERARCHY

A hierarchy of Six Sigma Management Roles is established to provide Six Sigma Training and Certificate to a professional for better understanding of roles and responsibilities within an organization. Hierarchy includes levels such as CEO, Six Sigma Champion, Six Sigma Master Black Belt, Six Sigma Black Belt, Sigma Green Belt, Six Sigma yellow Belt. Various levels of Six Sigma hierarchy differentiate among individuals on the basis of their knowledge and skills with highly trained individuals at the top and those having basic knowledge at the bottom.

SIX SIGMA BELT SYSTEMS

Belt system of Six Sigma has been designed as per the hierarchy levels. Yellow Belt provides an overall insight into the basic tools of Six Sigma and process management. Green Belt provides training emphasizing on DMAIC (Define, Measure, Analyze, Improve and Control) method so that problem solving skills of employees are improved. Green Belt performs two primary tasks, like: successfully deploying six Sigma techniques and leading small scale improvement projects within their respective areas. Individuals in Black Belt are trained to have good leadership qualities and providing them with complete knowledge of DMAIC/DMADV models in accordance with Six Sigma principles.

SIX SIGMA IN SOFTWARE DEVELOPMENT LIFE CYCLE (SDLC)

At the conceptual level both SDLC and DFS (Design for Six Sigma) are same as both of them are used for developing products. So they can be potentially merged into single framework. Involving Six Sigma tools during ‘requirement analysis’ stage and quality function deployment during ‘design’ stage have shown to produce several benefits. This method of mapping Six Sigma tools on specific phases of SDLC can be one way of rationalizing the relationship of Six Sigma to SDLC.

Although mapping of Six Sigma to SDLC brings improvement in the process of development of software products but the full potentials of Six Sigma are still not utilized. Six Sigma is a business management system and can bring an improvement in every area of business due to its ability to identify typical pitfalls in existing problem solving behavior. Also Six sigma provides a platform for fact based conversation among all areas of a business organization by establishing a common language. Also SDLC scope is restricted to system and software engineering as opposed to Six Sigma which spans over various departments such as sales, system engineering, finance, marketing etc.

With respect to Software development process Six Sigma has more benefits that any SDLC can have. It bridges the gap between software and business team by providing proper interaction between various financial decisions related to software development and business products. Achieving maximum benefits of mapping Six Sigma tools to SDLC requires the involvement of

software organizations in every area of business and learning a common language so that financial benefits are maximized.

OUR PROPOSED SOLUTION

In this paper we will discuss implementation of Six Sigma concept in a college Library Management System for process improvement. We will align the software developed by us to the existing Library Management System to get efficient outcome from the improved system.

A. **Study of project phases**

- A brief summary was made to identify the area of possible improvements. A typical format has been shown in TABLE 1:

Table 1: PROJECT SUMMARY

Area/Location	College Library
Description	Automatic alert sending system to library users as per due dates
Project Driver	Business Y: User satisfaction and effective resource management
Objective	Reduction of late fine given by library users by sending timely alerts and hence quick and effective movement of resources
Project Y	Frequency of late fine, fine amount, resource movement

B. **Define Stage**

- **Voice of the Customers**: In this section some brief aspects from customer's point of view get discussed. It indicates the requirement of implementing new methodology in the existing system Units (Refer TABLE 2).

Table 2: CTQS SUMMARY

Customer	**Sample VOC**	**CTQs (Critical to Quality)**
Library users	Often due dates are missed because users are unable to remember it for each individual book and it results paying fine amount	Money
Library users	Some specific text books, being a limited resource, are sometimes not available in library	Resource
Librarian	Text books which are not returned by users on time (due dates) are not available for other users to issue.	Resource

- **Alignment to business Big Y:**

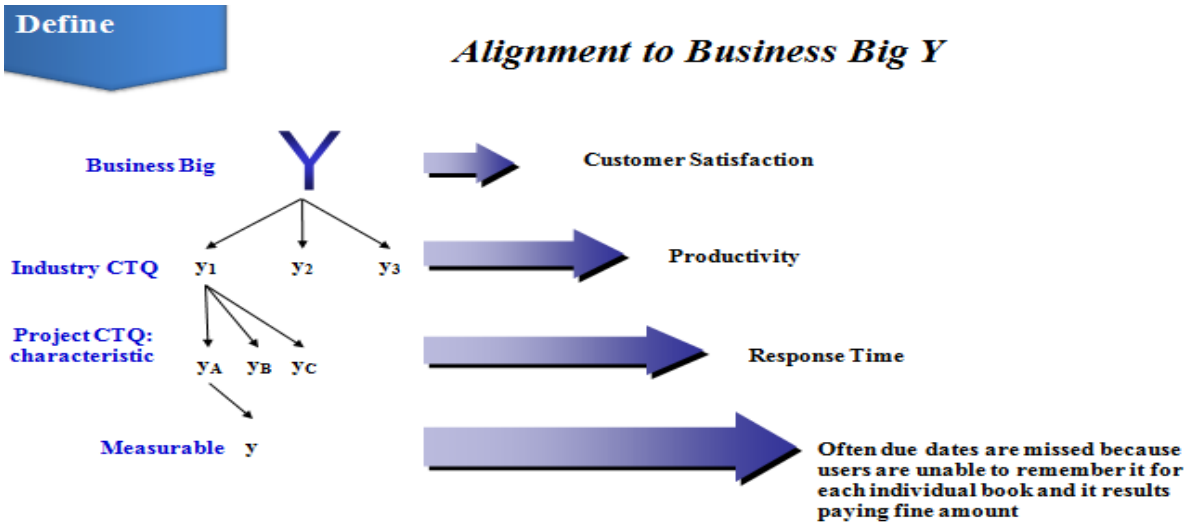

Fig. 1. Alignment to Business Y

Business Case (High level benefit analysis): College Library collects fines from users if books are returned after the due date. Fine amount/day increases in every week and it may reach up to the whole price of the book. Users often forget to return the books on time because they are unable to remember the due date for each individual book they borrow. Also if the resource (book) is not returned on time it cannot be issued to other user and thus effective resource movement is affected. If an automatic alert system sends alerts to users, the process can be improved in the system.

In scope: To alert users about the due date.

Out of Scope: Any other library management activity.

Specific Goal Statement: To incorporate an automatic alert generating system in library management system.

Specific Problem Statement: Late fine, resource usage.

C. **Measure Stage**

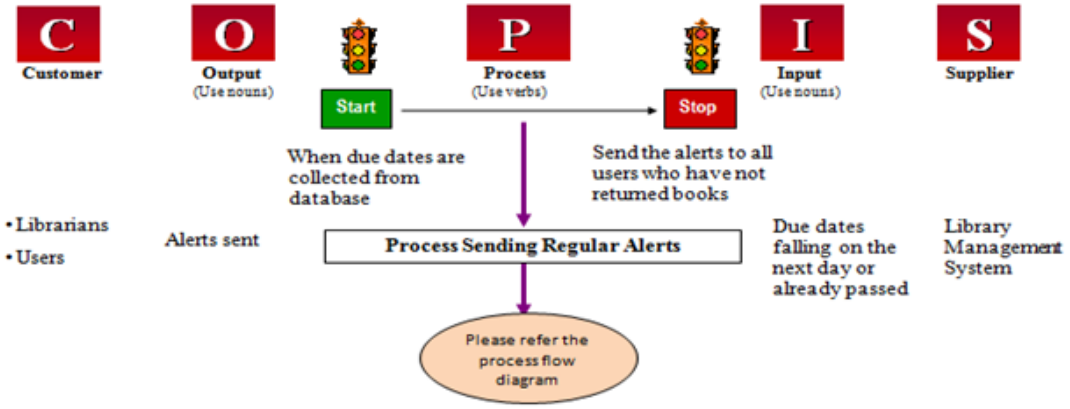

Fig. 2. COPIS Measurement

Expected performance standard of the project has been shown in TABLE 3:

Table 3: PERFORMANCE STANDARD

CTQ	Project Y Metric	Tolerance	Unit	Opportunity	Defect Definition
Frequency and amount of late fine amount	Automatic alert sending system to library users as per due dates	None	Per User	1	When fine amount is much and resource (book) is not available

Data Collection Plan: In this sub phase of 'Measure' phase we will gather necessary information for further process improvement.

- *Data Collection purpose:* To analyze amount taken as late fine while returning books.
- *What to measure:* Total fine amount paid by users and frequency of payment
- *How to measure:* Data collected from library database.
- *Sampling plan (Scheme, Frequency, Size):* In a complete academic year.

We collected the data (fine amount) of past 16 weeks from a typical college library management system and performed normality test on it.

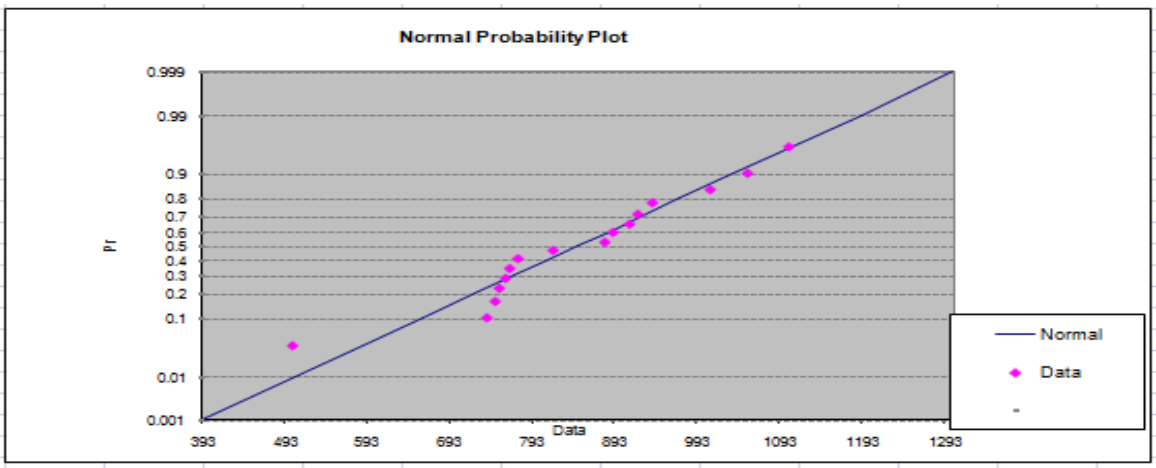

Fig. 3. Before Improvement

P-value = 0.3799 > 0.05 implies data is normal.
Mean value = 848.438
Standard Deviation = 147.325
Z st = 1.21

D. **Analyze Stage**

After the problem identification and measure, the result of brainstorming session is given in the TABLE 4:

Table 4: **SOLUTION ANALYSIS**

#	**Root Cause for Efforts**	**Proposed Action**	**Solution**
1	Due dates are often missed by users for reissue or return	Create a tool which may send auto generated alerts to users	An auto alert generation system will fetch data from library database to check which users are having due date in the very next day or already overdue and will start sending alert mails/sms to users
2	If resource is booked by some user and not returned on time, resource movement is not possible	If users get alerts they may return resources on time	

The process sigma measure before and after improvement can easily be calculated once the software is installed.

E. **Improve Stage:**

Improved process model has been shown in Fig. 4:

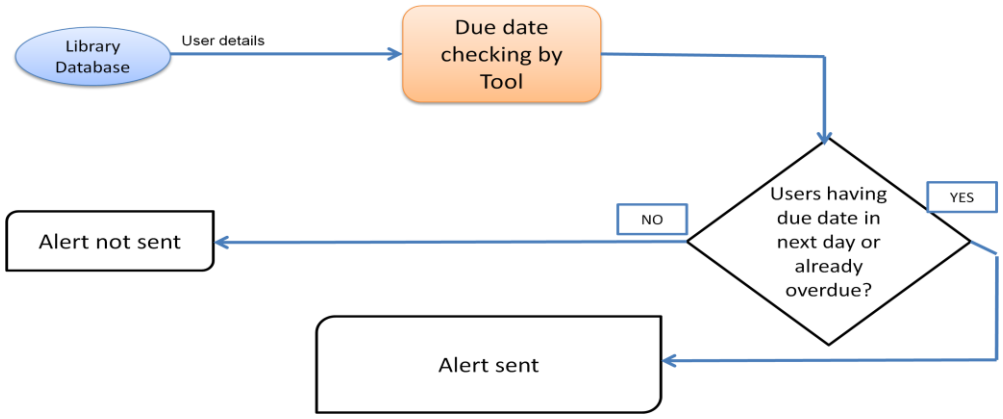

Fig. 4. New proposed model

Normal probability plot after improvement is shown below:

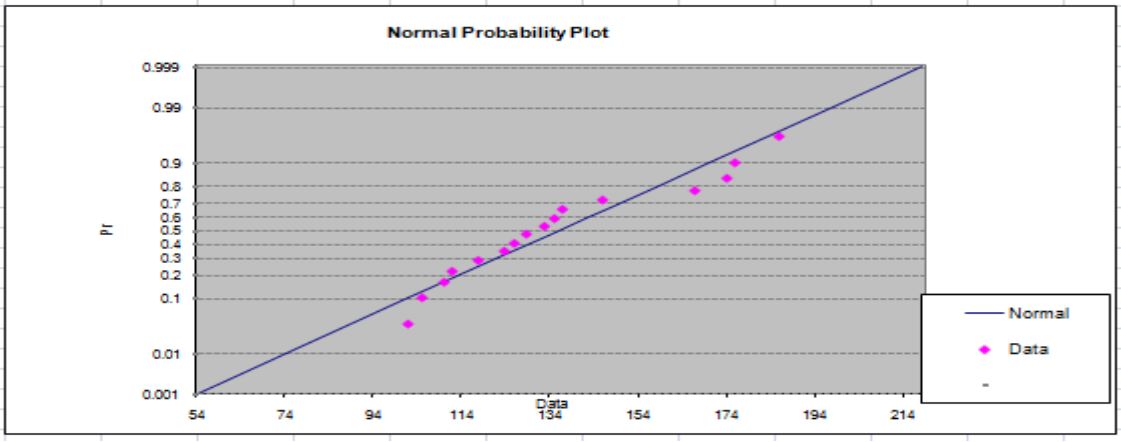

Fig. 5. After Improvement

P-value = 0.1585 > 0.05 implies data is normal.
Mean value = 136.25
Standard Deviation = 26.58
Z st = 2.25

F. **Control Stage:**

The frequency of paying fine amount will be reduced by this tool. Also proper movement of resources will also be achieved.

Statistic	Before	After
Z st (Short Term Sigma)	1.21	2.25
Z lt (Long Term Sigma)	-0.29	0.75

Fig. 6. Sigma Levels/Improvement

DETAILS OF DELIVERABLES – AUTOMATIC ALERT GENERATION TOOL

Tool definition

- As part of the improvement, a new alert generation tool has been developed in C# to be aligned with existing Library Management System.

Technology

- C#.Net.

Inputs

- Users having due dates in the very next day or already overdue.
- Data (users mail ID or phone number) will be fetched from library database to send mail/sms alerts.

Features

- Sending auto generated alerts with minimal effort using mobile number or mail id.
- Sum of fine amount can also be provided.
- Can be run as a job at some prescheduled time every day.

Output

- Users will get alerts in their mail ID or mobile number.
- Users may get the fine amount.

We have implemented the prototype software in a real world library management system in order to test the effectiveness of the tool and detailed data analysis shows substantial decrement of fine amount and more availability of resources and thus it improves process sigma.

CONCLUSION

Mapping of Six Sigma to SDLC brings improvement in the process of development and implementation of software products. In this paper we have shown how Six Sigma principles can be implemented to develop new software tool aiming to be aligned with existing college Library Management System for further process improvement. We followed the basic Six Sigma methodologies (DMIAC) to identify the area of improvement and implemented the new tool in the existing system.

REFERENCES

[1] Gary A.Gack, "Six Sigma and software development life cycle" Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955.

[2] Clyde M.Creveling, Lynne Hambleton, Burke McCarthy "Six Sigma for Marketing Process: An Overview for Marketing Executives, Leaders and Managers", Pearson Education, 2006.

[3] I. S. Jacobs and C. P. Bean, "The history of Six Sigma", vol. III, Eds. New York: Academic, 1963.

[4] Michael L. George, "Lean Six SIGMA", McGraw Hill Professional, 2002.

[5] George Eckes, "Six Sigma for everyone", John Wiley & Sons, 2003.

[6] T.M kubiak, "The certified SIX SIGMA Black belt Hand book", ASQ Quality Press, 2012.

[7] Stephen A. Zinkgraf, "Six Sigma –The First 90 days", Pearson Education, 2006.

[8] T. N. Goh, M. Xie, "Improving on the six sigma paradigm", The TQM Magazine, Volume – 16, Number – 4, 2004, pp. 235-240.

[9] Richard E. Biehl, "Six Sigma for Software", IEEE Software, Volume 21 Issue 2, March 2004, pp. 68-70.

[10] Bernie Gollomp, "ZERO DEFECTS TO SIX-SIGMA- MORE THAN PAPER TO ELECTRONIC DATA [A LOOK BACK]", Instrumentation & Measurement Magazine, IEEE, Volume 8, Issue 2, Jun 2005, pp. 70-71.

[11] Young Hoon Kwak, Frank T. Anbari, "Benefits, obstacles, and future of six sigma approach", Technovation, Jun 2006, Volume: 26 Issue: 5, pp.708-715.

[12] Michael VanHilst, Pankaj K. Garg, Christopher Lo, "Repository Mining and Six Sigma for Process Improvement", MSR '05 Proceedings of the 2005 international workshop on Mining software repositories, ACM New York, pp. 1-4.

[13] Tihana Galinac, Zeljka Car, "Software Verification Process Improvement Proposal Using Six Sigma", Proceedings of 8th International Conference PROFES 2007, Riga, July 2-4, 2007, pp. 51-64.

[14] Florian Johannsen, Susanne Leist, (2009) "A Six Sigma approach for integrated solutions", Managing Service Quality, Vol. 19 Issue: 5, pp.558 – 580.

[15] V. Anand, J. Saniie and E. Oruklu, "Security Policy Management Process within Six Sigma Framework," Journal of Information Security, Vol. 3 No. 1, 2012, pp. 49-58.