International Journal of Latest Engineering and Management Research (IJLEMR)
ISSN: 2455-4847
www.ijlemr.com || Volume 06 - Issue 09 || September 2021 || PP. 14-21

Lean Six Sigma application in engineering outsourcing

Mehrshad Ketabdar[1], Milad Ketabdar[2], Valerie TSAO[1]
[1]*(SoCalGas, Los Angeles, USA)*
[2]*(Parsons/ Bakersfield, USA)*

Abstract: The Six Sigma was developed by Bill Smith in 1986 while he was working at Motorola. During 2000s the lean ideas by Toyota was added to Six Sigma techniques and Lean Six Sigma (LSS) was finally developed. Since then, it has been used in manufacturing, service, healthcare and so many other different industries. In this study, we carry out this technique in order to evaluate and assess engineering consultants for outsourcing purposes. Many businesses and government agencies such as those in the oil and gas, or water and wastewater industries hire consultants to conduct engineering design activities. In order to receive higher quality work in a shorter time frame with cheaper costs, Project Mangers (PMs) are constantly trying to implement different techniques and methodologies, one of which is LSS. In this study, we apply the LSS method to improve the caliber of outsourced work and reduce the review process time including approval process and associated cost of review. Statistical tools such as process map, Pareto diagram, scatter chart, histogram, plot box, control charts, Regression analysis, root cause analysis, design of experiment technique etc. are used to comprehensively evaluate all scenarios and make effective recommendations. Finally, we suggest a major decision-making factor that can be used to appraise engineering firms.

Keywords: Lean Six Sigma, Outsourcing, Cost and Schedule, Optimization, Engineering

Introduction

Bill Smith introduced the Lean Six Sigma (LSS) technique to improve the quality of products and services in 1986. Car manufacturers [1] such as Toyota, cell phone providers such as Motorola, and even healthcare providers such as Kaiser Permanente have been using this approach since it has been established [2]. [3]utilized the integration of the lean approach and six sigma to measure the efficiency of light in the operation rooms. MSA and Gage Control were proposed to measure the operation room light. [4] utilized the empirical data from 256 lean sigma projects to develop a model for determining the significant factors for Lean Six Sigma implementation success. Based upon the model analysis, the competency of blackbelt team and the management support to the project were found as two main factors. Even more, engineering design firms have utilized LSS methodologies to improve the quality of their designs. To illustrate, [5] utilized LSS techniques such as fishbone, control chart, and road map to measure safety performance in the aviation industry. Additionally, [6]developed an innovative LSS approach for engineering design projects. Other researchers such as [7] used LSS in their engineering studies to better understand how to optimize models of feasibility robustness. On the other hand, [8] coalesced principles of Lean and Six Sigma to provide a more malleable framework for system engineering design and [9] used a new concept of engineering design targeting Six Sigma in his analysis.

To forward the prevalence of LSS, there are a myriad of research projects that have been conducted determining the benefit of using LSS for outsourcing both products and work processes [10]. In this regard, LSS remains a highly powerful tool that can assist with decision making for outsourcing issues [11]. [12] provide a great example of this in their case study, which involves utilizing Lean Six Sigma application in Malaysian automotive suppliers. Their experiments proved the validity of LSS as an efficient and successful procedure for establishing organizational performance.

In this study, we hope to identify a means to make outsourcing processes swift and develop an engineering governance protocol for decision makers and stakeholders alike. Overall, project management has three major elements: schedule, cost, and quality [13]. As a team, we are trying to understand what parameters would constitute the most important factors regarding the three primary elements stated earlier (quality, schedule, and cost), especially when we are hiring as an engineering firm. Through our work, we endeavor to maximize the satisfaction score, scored from 1 to 10, which is reviewed by owner engineers. Also, we are striving to minimize the cost of review, the time required for review by owner engineers, and the time required for consultants to address all comments and questions. We predominantly want to focus on the review process and how we can improve or enhance upon it. Utilizing the LSS technique through blackbelt training, we plan to issue a general recommendation for future engineering outsourcing projects based on statistical data [14]. [15] studied the criteria for outsourcing projects during design and engineering phases. We will instead focus on statistical data to give our recommendations and evaluate their efficacy.

The first step to any project is a definition of the project charter. The main goal of this project is to minimize the review process time since it can be painstaking, which causes delays and capital loss. To quantify these goals, we will make an effort to expedite the review process from 4 months to 4 weeks as well as improve the satisfaction score from 6 to 8. The reduction in review time will directly impact the associated time each employee will have to work on the project, and in turn a million dollars could be saved through the blackbelt project. Specifically, this study has been conducted on civil and structural engineering work on a natural gas project. The current process map for review and approval are shown below in Figure 1:

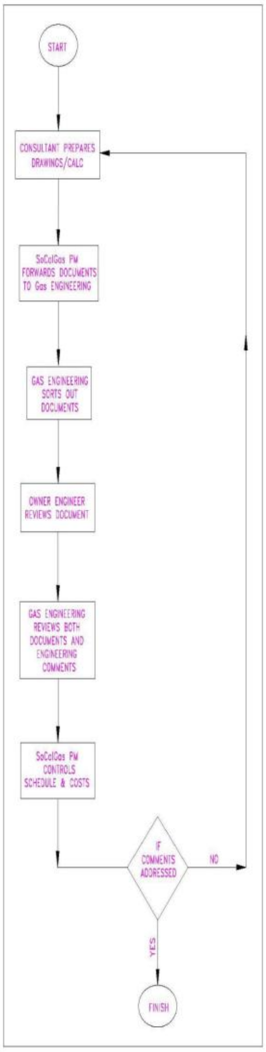

Figure 1 Process map

Data Collection and Normalizing the Data

For data collection we measured several factors for each task: level of expertise, time it takes for consultant to respond and resolve all questions, time it takes for overseeing owner engineers to review all drawings and calculations, cost, and assigned satisfaction score. Level of expertise was based on three elements: education, years of experience, and whether the individual held a civil or structural license. These elements combined allowed us to give a rating from 1 to 5, where 1 corresponds to the lowest and 5 corresponds to the highest. The time parameters for the consultant and owner engineers were both measured in number of weeks. Cost was given in monetary value and satisfaction scores were appointed by the client representative, with 1 being the lowest and 10 being the highest. Due to simplicity and privacy issues, we used the task number and an appropriate letter to identify the engineer. Table 1 below summarizes the data collection succinctly:

Table 1 A sample of data collection

Task	Engineer	Level of expertise	Consultant's time to update and respond (weeks)	Owner engineers time to review (weeks)	Cost of process	Satisfaction score
1	H	5	8	4	$85,600	6
2	M	3	9	2	$79,200	6
3	P	5	9	4	$92,000	6
4	M	3	9	2	$79,200	6
5	M	3	10	2	$85,600	6
6	M	3	10	2	$85,600	7
7	H	5	5	2	$53,600	8
8	M	3	8	2	$72,800	7
9	M	3	8	2	$72,800	7
10	R	5	14	4	$124,000	9
11	C	3	13	2	$104,800	7
12	M	3	14	2	$111,200	7
13	E	2	5	2	$53,600	7
14	H	5	5	2	$53,600	7
15	C	3	5	2	$53,600	7
16	C	3	5	2	$53,600	7
17	R	5	9	3	$85,600	8
18	C	3	8	2	$72,800	7
19	C	3	9	2	$79,200	7
20	C	3	8	2	$72,800	7
21	E	2	5	2	$53,600	7
22	E	2	5	2	$53,600	7
23	M	3	10	2	$85,600	7
24	H	5	5	2	$53,600	7
25	H	5	5	2	$53,600	7
26	C	3	8	2	$72,800	6
27	C	3	40	2	$277,600	7
28	C	3	14	2	$111,200	7
29	C	3	16	2	$124,000	7
30	C	3	40	2	$277,600	7
31	C	3	8	2	$72,800	7
32	E	2	27	2	$194,400	3
33	E	2	27	2	$194,400	3
34	E	2	21	2	$156,000	3
35	E	2	21	2	$156,000	3
36	E	2	18	2	$136,800	3
37	E	2	18	2	$136,800	3
38	E	2	16	2	$124,000	3
39	E	2	16	2	$124,000	3
40	E	2	5	2	$53,600	4
41	E	2	5	2	$53,600	4
42	H	5	22	2	$162,400	8
43	J	3	17	4	$143,200	6
44	C	3	2	2	$34,400	6
45	C	3	24	2	$175,200	6
46	C	3	2	2	$34,400	6
47	D	4	10	2	$85,600	7

To visually depict and analyze the raw data, we created a histogram and pareto diagram which are shown below:

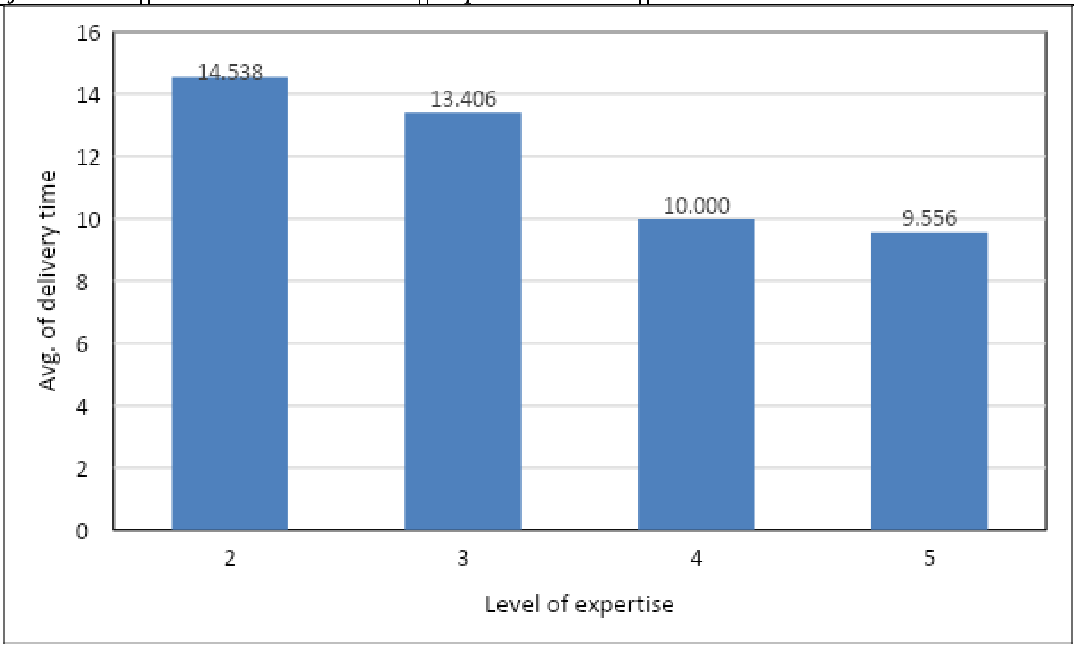

Figure 2 Histogram depicting the level of expertise vs. response time (weeks)

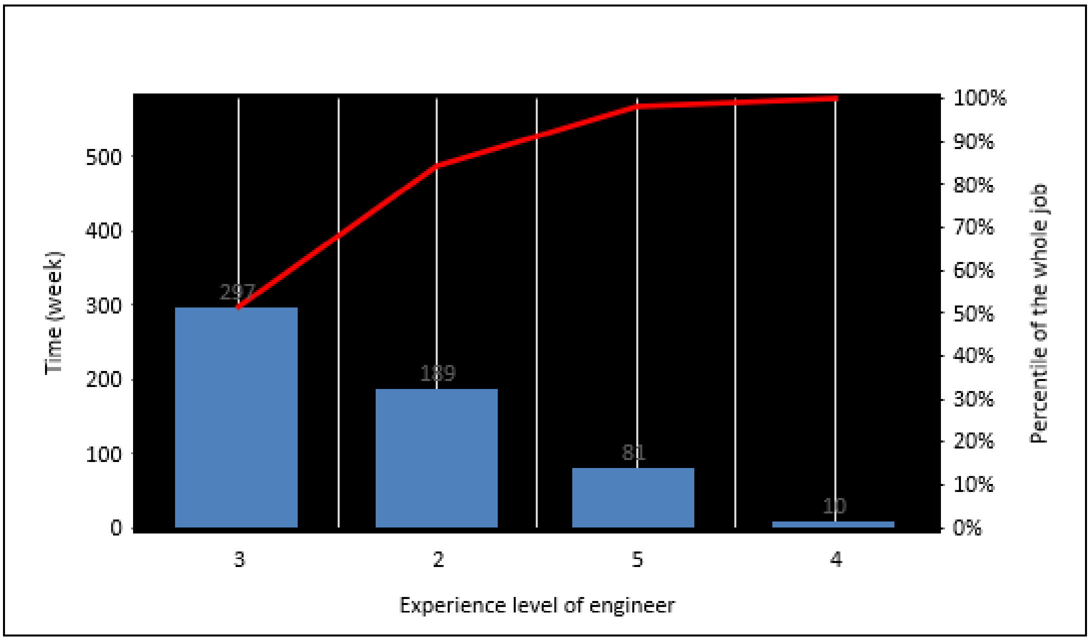

Figure 3 Pareto diagram for response time(weeks) based on varying levels of experience level

Based on the Pareto diagram in Figure 3, over 80% of delays originated from engineers categorized with expertise in levels 2 and 3. This demonstrates how, like we'd expect engineers with more experience typically address issues much more efficiently and that experience should continue to be a major criterion for hiring consultant firms in the future. Using the SPC XL [15] software, we learned that the data was not normal. To rectify this, the square root of cost was taken to normalize that variable. A histogram analysis was conducted, and Kolmogorov-Smirnov value (KS test) was calculated to evaluate the compare the sample with a reference probability distribution. Even more, charts such as box plot were used, and median was taken rather than the mean to account for the highly skewed data. The skewed data is a direct result of the gap between skilled and non-skilled workers and how they perform differently. Since the data was not normal, we categorized it into groups of low-skilled or high-skilled and re-ran the histogram analysis. These are represented in Figures 4 and 5, whose data are now normally distributed for each category.

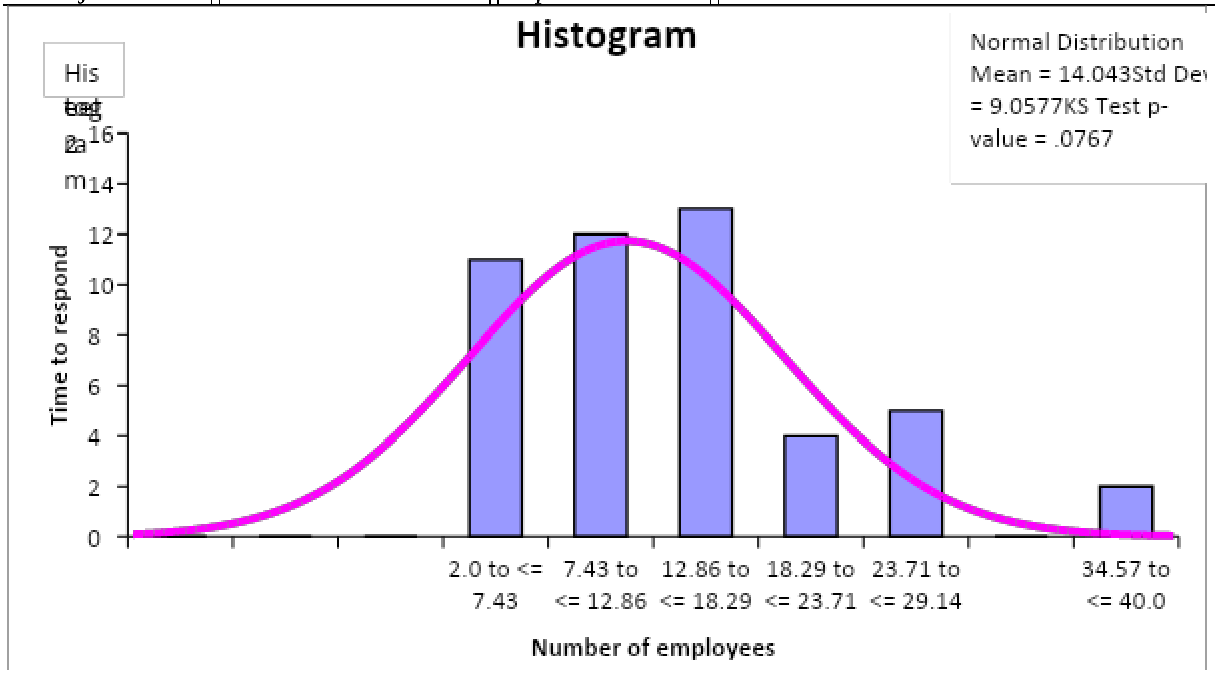

Figure 4: KS test for low-skilled employees and time to respond to comments

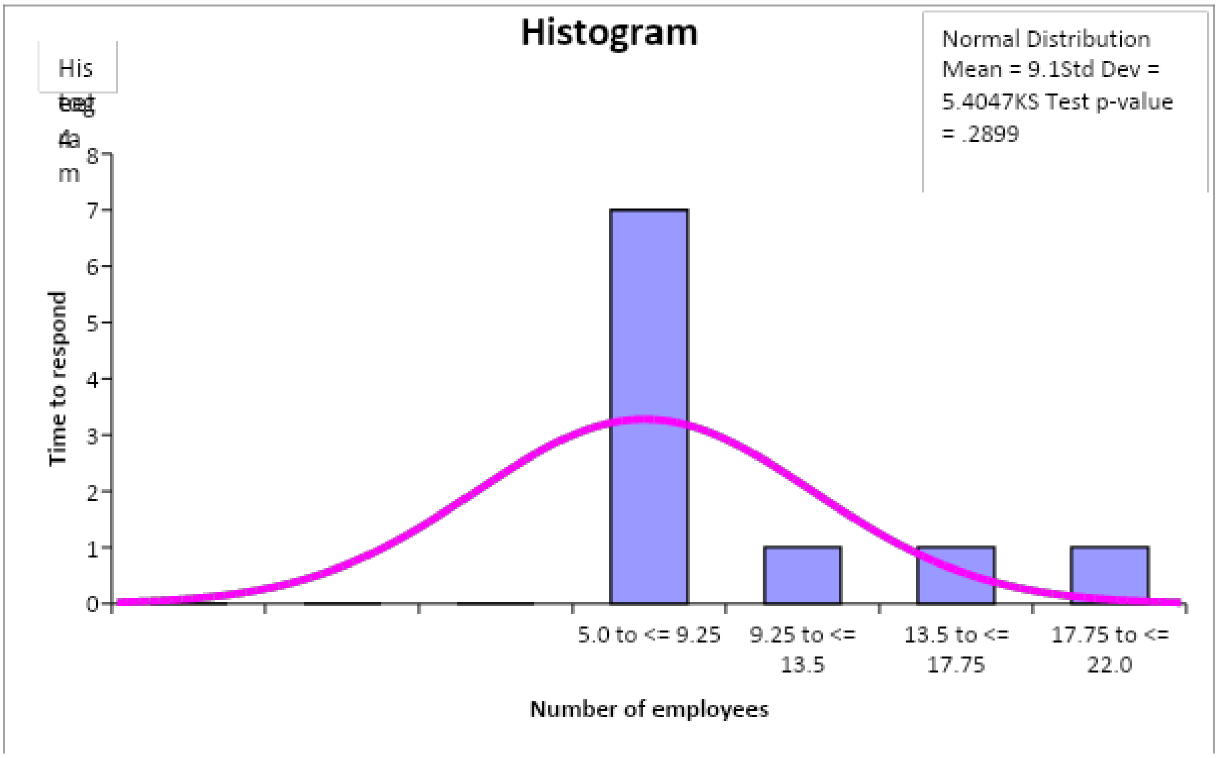

Figure 5 KS test for high-skilled employees and time to respond to comments

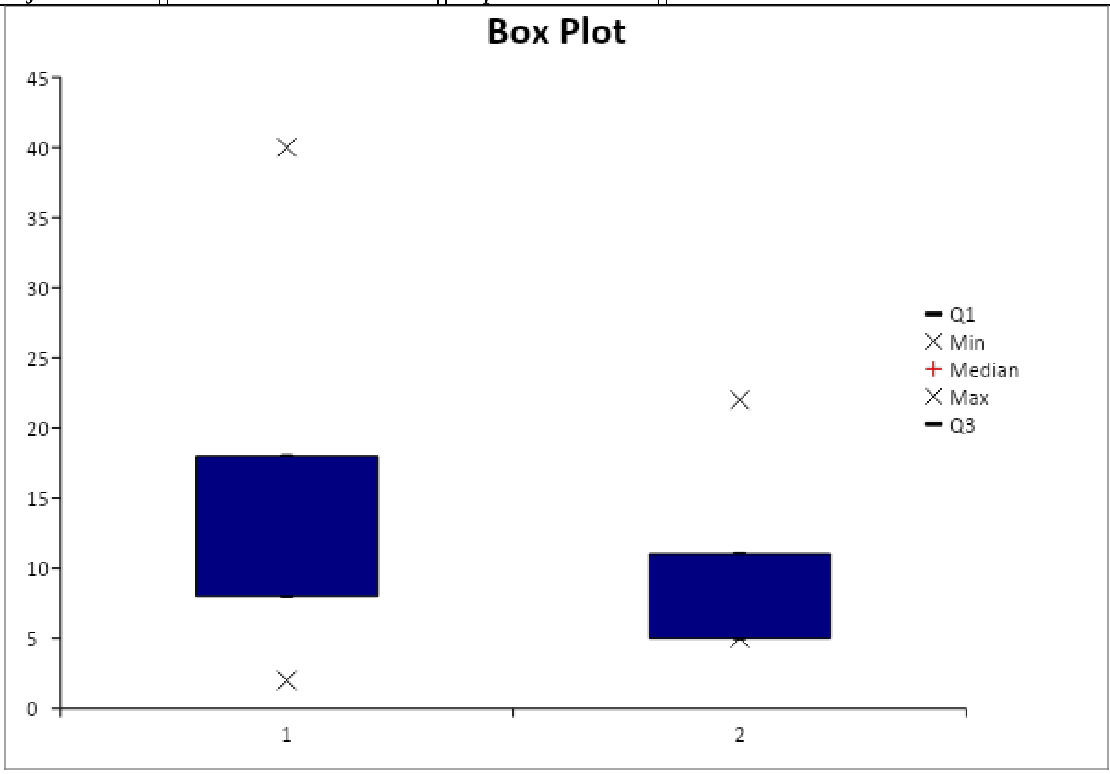

Figure 6 Box plot diagram of experienced employee vs. inexperienced employee and time to respond (weeks) Time to respond (Y axis) and years of experience X axis

The box plot above shows how the typical low-skilled engineer needs 8 to 18 weeks to respond to the comments with a median of 13 weeks. On the other hand, the skilled engineer typically needs 5 to 11 weeks with a median value of 8 weeks. This supports our observation earlier, that skilled engineers respond faster with higher confidence and lower deviation and thus signify how an engineer's level of skill is a highly important factor in engineering projects. Next, the C charts were generated to visualize the results of our findings. These are shown in Figures 7 and 8.

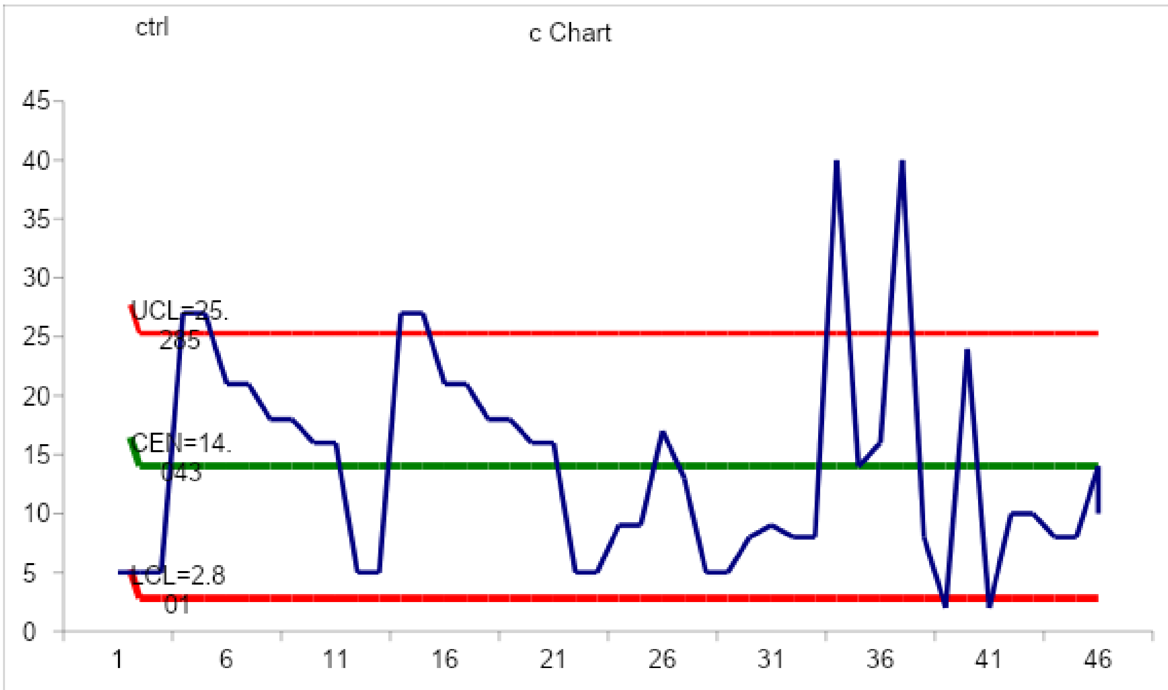

Figure 7 C chart for time to respond for low experienced engineers

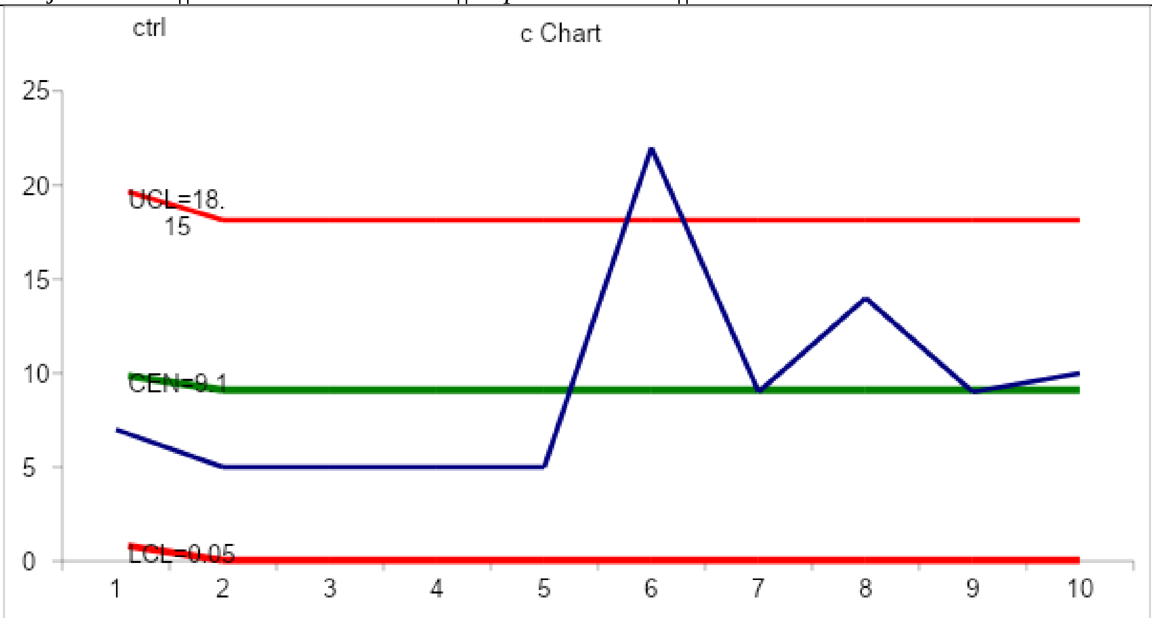

Figure 8 C chart for time to respond for high experienced engineers

Figures 7 and 8 show the time that is required for low-skilled and high-skilled employees to respond to comments through the C charts respectively. More irregularities and unacceptable time frames were observed for inexperienced employees. The Design of Experience (DOE) technique [14] was also used to elaborate and build upon these findings. We ran a historical analysis for three parameters which further supports that quality improves when we are using high-skilled employees.

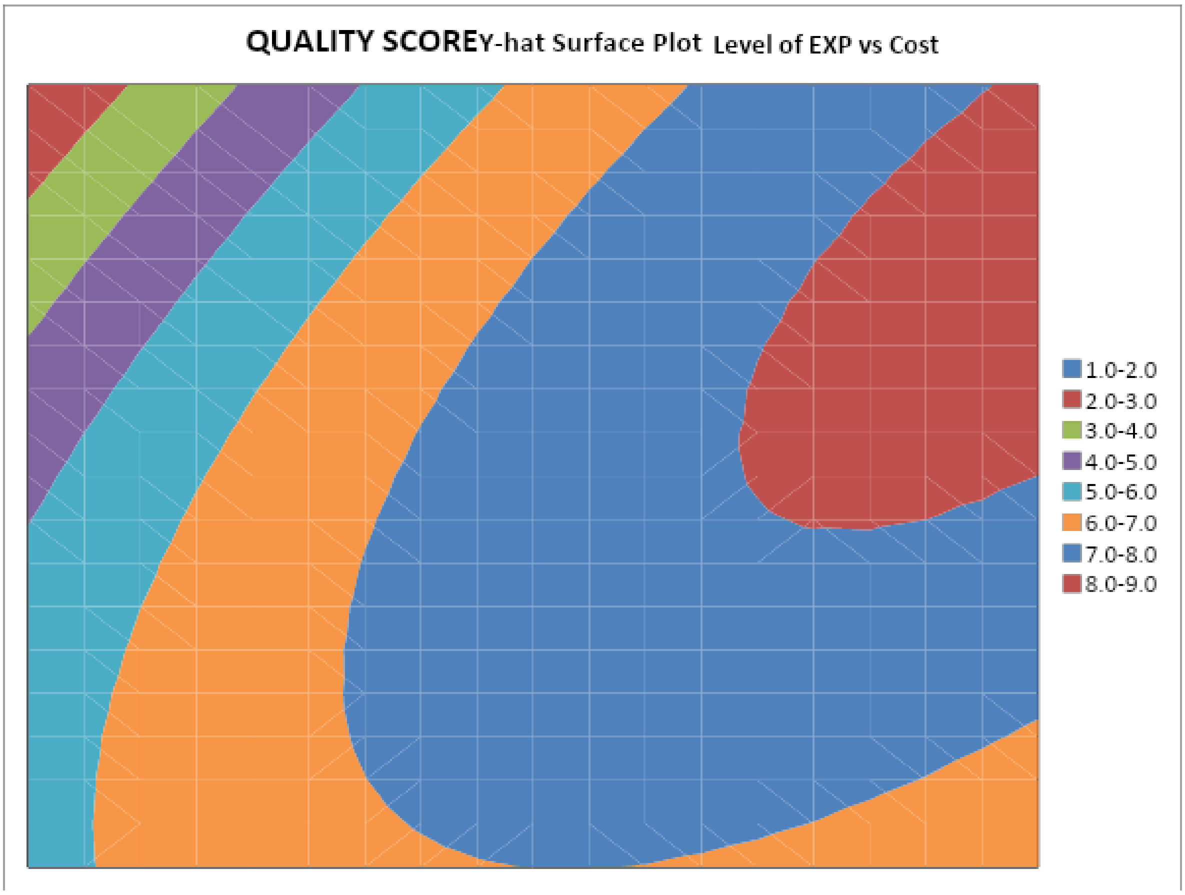

Figure 9 Historical analysis of satisfaction score vs. response time, level of expertise and cost

Improvements and Monitoring

Based on statistical analysis, it is proven that the level of expertise of engineers who work for consultants is the main driving force in improving the quality of work, while minimizing the review time for review process, and reducing the associated cost of review. The team suggests that a consultant's experience during the bidding process should be reviewed to ensure it is well established as a governance criterion during the outsourcing process by supply management. Providing a thorough Terms and Conditions section in the contract will also make sure consultants can maintain experienced engineers throughout projects, who can then contribute to its success. In addition, during the Kaizen events, the team suggested that having good communication tools in place would prove to be highly beneficial for the success of future engineering projects. It is recommended the client's requirements, specifications, ad applicable codes and guidelines are discussed prior to the first meeting with the consulting firm. These improvement suggestions are to be implemented and monitored in the next 4 years in case there is any need for future proposals or continued refinement.

Summary

Lean Six Sigma (LSS) is a powerful tool that is heavily used in diverse industries such as healthcare and manufacturing. However, it can also be useful when applied to engineering projects, specifically outsourcing and supply management planning. In this study, we found the experience of engineers to be a major criterion for hiring at engineering consultant firms. We suggest also evaluating other factors such as history of consulting firms, cultures and ethics on the quality of the engineering products, as well as the associated cost and effect on the schedules.

References

This heading is not assigned a number.

[1]. H. Panjari, S. N. Teli and L. Gaikwad, "Lean Six Sigma Applications," in 3rd International Conference on Engineering Confluence, TEC, NaviMumbai, 2017.
[2]. Q. Zhang, M. Irfan, M. A. O. Khattak and X. Zhu, "Lean Six Sigma: a literature review," Interdisciplinary Journal of Contemporary research in business, Vol 3, No10, pp. 599-605, 2012.
[3]. Y. Ozturkoglu, Y. Kazancoglu, M. Sagnak and J. A. Garza-Reyes, "Quality Assurance for Operating Room Illumination through Lean Six Sigma," International Journal of Mathematical, Engineering and Management Sciences, pp. 752-770, 2021.
[4]. L. Papic, M. Mladjenovic, A. C. Garcia and D. Aggrawal, "Significant Factors of the Successful Lean Six-Sigma Implementation," International Journal of Mathematical, Engineering and Management Sciences, pp. 85-109, 2017.
[5]. I. Panagopoulos, C. Atkin and I. Sikora, "Developing a performance indicators lean-sigma framework for measuring aviation system's safety performance," Transportation Research Procedia, Volume22, pp. 35-44, 2017.
[6]. P. Subramaniyam, K. Srinivasan and M. Prabaharan, "An Innovative Lean Six Sigma Approach for Engineering," International Journal of Innovation, Management and Technology, Vol. 2, No. 2, p. 166, 2011.
[7]. X. Du and W. Chen, "Towards a Better Understanding of Modeling Feasibility Robustness in Engineering Design," Journal of Mechanical Design, 122 (4), pp. 385-394, 2000.
[8]. T. Sreeram and A. Thondiyath, "Combining Lean and Six Sigma in the context of Systems Engineering design," International Journal of Lean Six Sigma Volume 6 Issue 4, 2015.
[9]. T. Hasenkamp, "Engineering Design for Six Sigma—a systematic approach," Quality and Reliability Engineering International 26, no. 4, pp. 317-324, 2010.
[10]. R. D. Snee, "Lean Six Sigma and Outsourcing: Don't outsource a process you don't understand.," Contract Pharma 8, no. 8, pp. 4-10, 2006.
[11]. M. Uluskan, J. A. Joines and A. B. Godfrey, "Comprehensive insight into supplier quality and the impact of quality strategies of suppliers on outsourcing decisions," Supply Chain Management: An International Journal, 2016.
[12]. N. F. Habidin, S. M. Yusof and N. M. Fuzi, "Lean Six Sigma, strategic control systems, and organizational performance for automotive suppliers," International Journal of Lean Six Sigma, 2016.
[13]. E. W. Larson, "Project management: the managerial process I Erik W," Management 16, no. 4, pp. 25-30, 2002.
[14]. "www.sgigmazone.com," [Online]. Available: www.sgigmazone.com.
[15]. S. Shishank and R. Dekkers, "Outsourcing: decision-making methods and criteria during design and engineering," Production Planning & Control, Volume 24, 2013.