sciendo

PRODUCTION ENGINEERING ARCHIVES 19 (2018) 10-15

PRODUCTION ENGINEERING ARCHIVES

ISSN 2353-5156 (print)
ISSN2353-7779 (online)

Exist since 4th quarter 2013
Available online at www.qpij.pl/production-engineering-archives

Six Sigma as a method of improving the quality of service process

Kamila Kowalik[1]

[1] Częstochowa University of Technology, Faculty of Management, Armii Krajowej 19B, Poland, e-mail: kamilakowalik93@gmail.com

Article history
Received 15.05.2018
Accepted 28.06.2018
Available online 15.07.2018

Keywords
DMAIC cycle
improvement
quality
service process
Six Sigma

Abstract
The objective of the analysis conducted and described in this paper has been to present the practical application of the Six Sigma method based on the DMAIC cycle in improving the quality of the service process. The first part of the article contains the theoretical framework of six sigma and the issue of using its tools in the aspect of services. Afterwards, there has been calculated the initial sigma value which indicated the need for improvement. Measurement phase has been developed by the value stream mapping, process FMEA and customer survey which results have been analyzed in Pareto chart and fishbone diagram. Improve phase includes the Impact&Effort Matrix and target sigma level that can be achieved as a result of failures reducing and service quality improvement.

DOI: 10.30657/pea.2018.19.03 JEL: L23, M11

1. Introduction

Service quality has become an increasingly valid aspect of functioning for companies that aspire to achieve market success in environment characterized by high competition and instability. The two main trends in this area are being observed. First of them, the service sector has been perceived as a dominant one in the most developed countries. What is more, changing customers' needs and the necessity of adapting to them resulted in offering products as packages of goods and services which additionally strengthened the importance of services in modern economy (NAKHAI, B., NEVES, J. 2009, KOWALIK, K. KLIMECKA-TATAR, D. 2018, INGALDI, M. 2018).

Due to being a continuous stimulant, issues concerning the quality of services are included in many different theoretical and practical studies. One of them is the possibility of practical implementation of production improvement methods and tools in aspect of services. The six sigma method is worth particular attention (ULUSKAN, M. 2016, ALHURAISH, I., ROBLEDO, C., KOBI, A. 2017).

The six sigma, perceived not only as a statistical tool but also as a perspective of business strategy in literature is defined as a method of improving companies' profitability by driving out waste, reducing costs and increasing the efficiency and effectiveness to achieve the goal of meeting customers' expectations (ANTONY, R., BANUELAS, R. 2001).

Six Sigma has been considered as organized and systematic way of improving processes or developing the products or services. It is based on the statistical and scientific approach to reduce defects indicated by customers.

In technical aspect six sigma by the term of sigma, meant as a variation of the process, aims to reduce a defect level to be lower than 3.4 DPMO (defects per million opportunities) (LINDERMAN, K., SCHROEDER, R.G., ZAHEER, S., CHOO, A.S. 2003).

The six sigma methodology is mainly based on the DMAIC cycle which phases can be explained as follows (HENSLEY, R.L., DOBIE, K. 2005, KWAK, Y.H., ANBARI, F.T. 2006, SMĘTOWSKA, M., MRUGALSKA, B. 2018):

- Define – identifying the goals depended on the VOC (voice of customer or theirs expectations) and the CTQ (service features that are critical to the customers' view of quality);
- Measure - measuring the actual performance of the process, data collection and determining key characteristics and parameters;
- Analyze – analyzing the collected data to determine the causes of the problem that most likely affect the lack of process stability;
- Improve – finding and implementing the solution of identified problems as a result of a selection and choice the one most valuable one to be applied to reduce the process variability;
- Control – guarantying continuous process monitoring; successful improvements should be standardized as a base for further actions.

There is a number of myths about the applying of the six sigma to the business practice. The most important of them is that this quality improvement methodology cannot be used in services. Nothing further from the truth. Growing specialist literature containing most studies made by practitioners proves the six sigma potential in this area (CHAKRABARTY, T., TAN, K.C. 2007).

On the other hand it is worth mentioning that implementing the six sigma in services may cause some difficulties related to gathering reliable data, interaction between the customer and service staff and occurrence of various subprocesses.

As a response to these problems, a set of recommendation for the six sigma applying in services was created such as: appreciating the customer's influence on the company success, the need to choose the most valuable processes, the necessity to define the concept of a service defect and its gauge, the perception of the six sigma as a long-term commitment (ANTONY, J., BANUELAS, R. 2002).

The particular attention should be paid to adapting the six sigma methodology to the requirements of the service process. The basic assumption about reducing all process variation in the aspect of services translates into providing flexibility of the service delivery (in terms of customers' needs and expectation) while maintaining a high consistent level of service quality. The six sigma should be the path of education in understanding and adapting to the evolving customers' needs with reducing negative deviations of service delivery identified by the company by continuous research of customers' needs.

2. Experimental

The aim of the case study has been to improve the chosen service process with using the six sigma methodology based on the DMAIC cycle and its tools.

The subject of the research has been, determined as very important, customer service process realising in an enterprise being a branch of an international company from the culture and entertainment industry.

The first part of the study has been to define the area of improvement by identifying and measuring the current situation of the process.

Afterwards, collected data has been analysed which contributed to the indication of the causes of the problems and developing proposals for their solutions. The last part contains the aspect of controlling the applied process modifications and the benefits of their implementation.

3. Results and discussion

The initial sigma value calculated for the customer service process according to the theoretical algorithm (HARRY M, SCHROEDER R. 2001) has been presented in table 1.

Table 1. Initial sigma value

No.	The phase	The result
1.	Determining the process	The customer service process
2.	Number of analysed units being the result of the process	100 transactions carried out one by one
3.	Number of flawless units	91
4.	Performance indicator [3:4]	0,91
5.	Defect indicator [1-4]	0,09
6.	Number of CTQ [N]	waiting time, service time, cost, staff's attitude, staff's knowledge, convenience, faultlessness, information N=8
7.	Defect rate for critical features [5:6]	0,01125
8.	Number of defects per million opportunities [7x1000000]	11250
9.	Initial sigma value [from sigma conversion table]	**3,77**
10.	First conclusion about quality	process does not meet customer requirements

According to the presented data it can be stated that the studied process is close to reaching level 4 of 6 sigma which means that there are many variations during it that cause the process instability which may result in customers dissatisfaction.

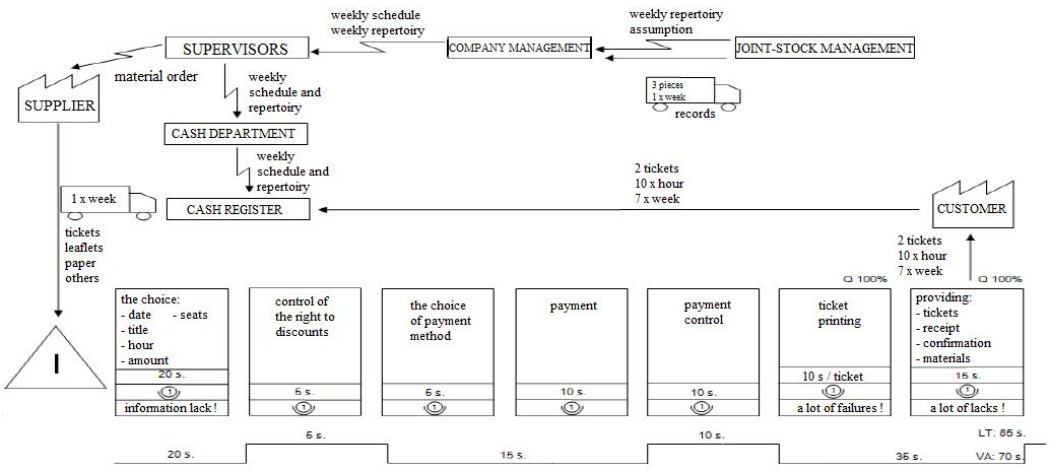

Fig. 1. Value stream mapping-the current state

Measurement and analyzing of the process is worth starting with presentation of this course. For the purposes of this study the value stream mapping (Fig. 1) has been used.

In understanding the course of the process from technical point, the value steam mapping method can be useful. It shows the material, energy and information flow in the implementation of the service process (KLIMECKA-TATAR, D. 2017).

The average customer's service lasts eighty five seconds. Seventy seconds is value added time. In the aspect of analyzed customer service it is worth mentioning about the lack of transport in this kind of process that the most often is the main cause of time and cost waste. Therefore, improving in relation to the value steam should be focused on removing identified errors in value adding stages of the process.

According to the diagnosed process flow, the first and the last two stages contain warning notes about information (first stage) and material (last stage) deficiencies and a lot of failures observed in the one before last stage.

Afterwards, process FMEA was carried out to analyse the types and effects of the each step's failures (table 2).

Table 2. Process FMEA

Process step	Potential failure mode	Potential failure causes	Potential failure effects	Occurrence	Detection	Severity	RPN
order placing	wrong order	misunderstanding of customer expectations	time waste, queue, material waste, customer dissatisfaction	2	2	10	40
payment	wrong command	customer misunderstanding, lack of knowledge	money waste, customer dissatisfaction	3	2	10	60
	wrong amount	hurry	money waste, time waste	1	1	10	10
order printing	machine failure	technical cause	time waste, material waste	6	8	7	336
		employee inadvertence	time waste, material waste	4	5	7	140
order delivery	deficiencies in the order	material lack	customer dissatisfaction	5	3	8	120
		employee inadvertence - hurry	customer dissatisfaction	3	3	8	72

For the purpose of the analysis the process was divided into four main stages: order placing, payment, order printing and delivery for which were indicated potential failures and their causes and effects. Then, occurrence, detection and severity indicators were pointed out for calculation of Risk Priority Number.

According to the presented data three main failures which RPN is the highest are: machine failure caused by technical problems (RPN=336), machine failure caused by employee inadvertence (RPN=140) and deficiencies in the order caused by material lacks (RPN=120). Technical problems of machine failures are related to the unmodernized equipment used for customer service and the small steps method of improvement based on the DMAIC cycle cannot find there practical use. Worth noticing are machine failures caused by employees inadvertence due to their oversight of settings that can be avoided. The last of the most important failure are deficiencies in the order that are mainly effect of material lack at the service stand. All of the failures perceived as the most relevant result in lack of customer satisfaction that explains lower level of service quality.

Conclusions from the presented value steam and process FMEA in the form of identified problems were included in the anonymous survey. A sheet of survey, contained three statements for which the respondents assigned ratings that indicated their agreement or disagreement, was used in electronic version. The questionnaire was based on the typical Likert scale- five point scale with 1 meaning ''*strongly disagree*'' and 5 meaning ''*strongly agree*''. In the study participated one hundred respondents, all of them at age 18-30, including 60% females and 40% males.

The first statement was: The customer service staff's information deficiencies bring down customer's opinion about the service quality. Figure 2 shows the respondents' view.

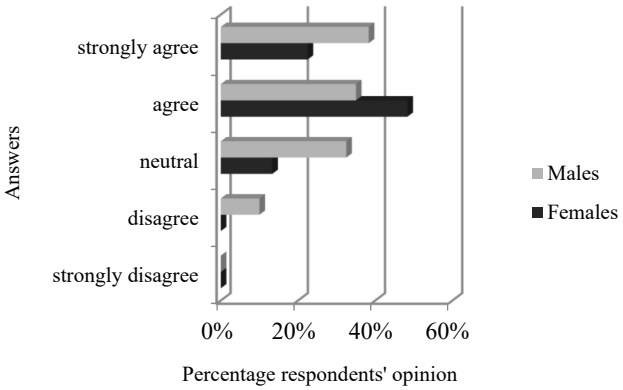

Fig. 2. Information deficiencies as a factor determining service quality

The data shows that more that a large majority of the respondents strongly agree (32%) or agree (43%) with that statement which means that three out of four of them perceive staff knowledge as an important factor of service quality and its lack results in their worse opinion. Every fifth respondents are neutral about it, including 32,5% of all asked males and only 13,3% of females. It is worth noticing that only 4% respondents (10% of males and any female) disagree with the statement and no one strongly disagrees.

The next statement referred to efficiency and faultlessness and their influence on the service quality (Fig. 3).

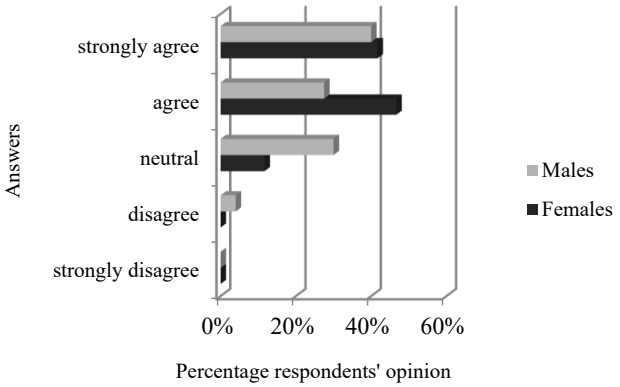

Fig. 3. Efficiency and faultlessness and their influence on service quality

The respondents' view presents that the lack of efficiency and faults occurring during customer service affects the customers' opinion about the quality. 80% of them strongly agree (more than 40% of asked women and men) or agree (47% females and 27,5% males). It means that high quality of the customer service depends mainly on undisturbed course. 20% of the respondents are neutral again and only one of them disagree with this assumption.

Last but not least questionnaire statement was about the stage finishing the customer service (receipt and other material delivery and farewell) - whether it is important phase and how much it define the perceived service quality (Fig. 4).

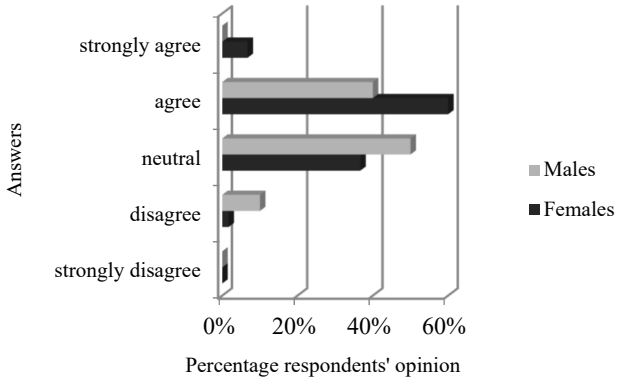

Fig. 4. The importance of the last stage of customer service

According to the presented data it must be noticed that more than half of the respondents strongly agree (4%, all females) or agree (55% including 65% of asked women and 40% of men) with that statements. Also a large proportion of neutral responses is worth noticing. It means that the last phase of the customer service should be perceived as an important one but in comparison with showed previous two aspects its value in the service quality and its improvement is lower.

The conclusion of the survey results is that the most important problems of service quality are in customers opinion lack of staff's information and knowledge and too low efficiency and faultlessness of the service process. To reduce these misstatements and simultaneously increase the service quality and sigma level searching for causes has been carried out by Pareto chart (information deficiencies) and process FMEA (service process failures).

Using Pareto chart as a method of analyzing helped to point out information deficiencies' most frequent causes which removal should be conducted (Fig. 5).

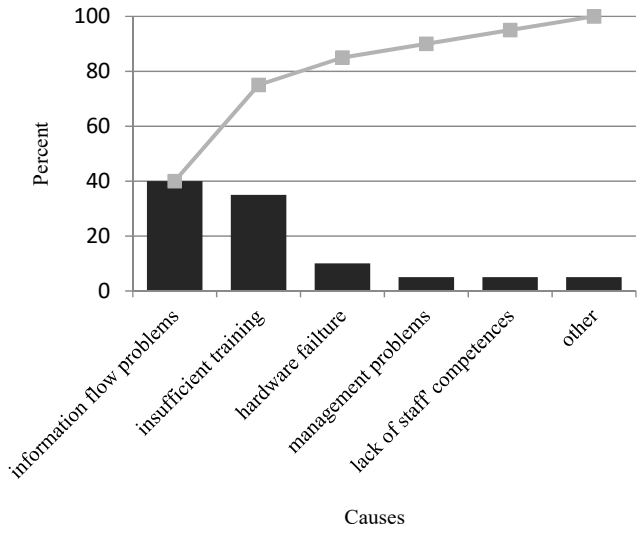

Fig. 5. Pareto chart of information deficiencies

For the needs of this study one hundred reasons identified one by one for information deficiencies have been analysed. According to the presented chart it can be noticed that two main causes entail nearly 80% of the occurrence of the problem. These are:

- information flow problems,
- insufficient training.

The other causes such as: hardware failure (which do not allow the employee to obtain information contained in the system), management problems (lack of knowledge gained by the management board resulting in its lack in the entire service company) or lack of staff's competences (personal problems of employees with obtaining and providing information) are responsible for only 20% of the appearance of the problem.

It means that information failures will be significantly reduced if only two first causes are improved. The first of them refers to the information flow through the company- the employee does not have the required information in a timely manner because they not have been delivered by the management. Insufficient training cause is about too short and imprecise training which do not allow to gain all knowledge necessary for proper customer service.

The next equally relevant of identified problems- too low efficiency and faultlessness of the customer service was more closely analysed by caused-and-effect diagram (Fig. 6).

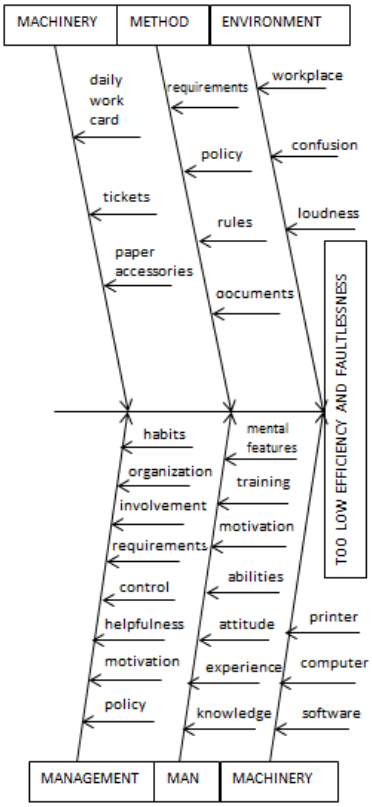

Fig. 6. Caused-and-effect diagram

According to the presented data it should be noticed that there are a lot of potential causes of the analysed problem's occurrence from each group of the fishbone diagram. Two of these groups are worth particular attention: man and management. It means that the efficiency and faultlessness of customer service is depended mainly on human factor and approach to management which confirms the value of people as the most important determinant of service quality. Among the most relevant reasons of analyzed problem from man group there are: lack of training, experience and knowledge and staff's attitude, abilities, motivation and personal mental features. Causes related to the management include: involvement and helpfulness of the management board, formal policy of company, previous habits and basic management functions such as organization, monitoring and motivation.
Improve phase is mainly based on the results of presented analysis. For the purpose of this study the Impact and Effort Matrix as a tool of improvement was chosen.

To begin with, Impact and Effort analysis has been presented in table 3. Cost and difficulty of implementation and CTQs' weights have been estimated. Afterwards, the impact of potential solutions of the identified problems on the CTQ's was rated on a scale 1-10. Total score presents the impact of potential solutions on quality of service process.

The potential solutions are: information flow change, staff training, management board training, reorganization of workplace and reorganization of process flow. There were calculated cost implementation, processing difficulty and each idea's impact on every critical-to-quality including waiting time, service time, cost, staff's attitude, staff's knowledge, convenience, faultlessness and information.

Total score is the product of particular factors and their weight.

Table 3. Impact and Effort Matrix results

Weight (importance factor)	Cost of implementation	Difficulty of implementation	Impact on CTQ1	CTQ2	CTQ3	CTQ4	CTQ5	CTQ6	CTQ7	CTQ8	Total Score
	6	*6*	*5*	*9*	*5*	*7*	*9*	*5*	*9*	*9*	
Potential Solutions (No.)											
information flow change (1)	4	5	1	3	1	1	8	3	8	9	**338**
staff trainings (2)	6	3	5	7	1	4	9	1	8	8	**275**
management board trainings (3)	6	5	2	3	1	4	3	1	4	4	**240**
reorganization of workplace (4)	8	8	5	6	1	6	3	4	5	5	**359**
reorganization of process flow (5)	9	9	6	6	1	3	3	5	5	5	**360**

The achieved outcomes can be visualised on an Impact&Effort chart (Fig. 7).

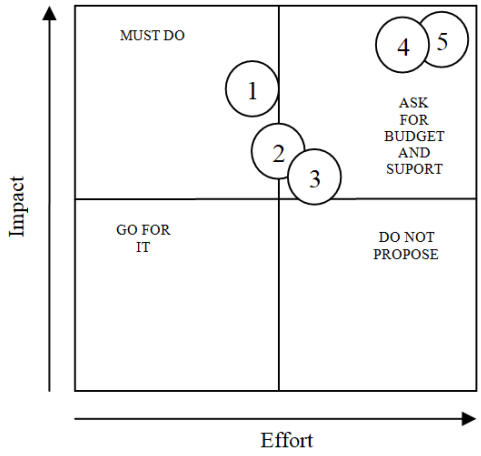

Fig. 7. Impact and Effort chart

The data show that all of the potential solutions of identified problems have valuable impact on customer service quality. It is worth noticing that two of them (solution 4: reorganization of workplace and solution 5: reorganization of process flow) are most influential and the most difficult to implement due to the need to incur the highest effort and cost. Therefore, there are in group requiring analysis of profitability. Particular attention should be paid for the first potential solution: information flow change. It is not as costly as the others but very influential. This solution consists in providing all necessary information to the customer service staff immediately after its delivery to management board. It means that the information does not wait and if management board has it, so does service staff. This may reduce information lack caused by uniformed staff. Material costs of the presented idea are not high but difficulties may

arise in the managements' conviction to existing habits' change. However, benefits of change's realization are potentially large. Better availability of information among staff will increase the number of transactions made without any irregularities, resulting in customer satisfaction and higher service quality.

Solutions that should also be analysed are related to trainings. Staff training is considered as half *''must do''* and half *''ask for budget and support''* because trainings are usually connected with incurring costs, mainly financial ones. Anticipated benefits and advantages of this idea realization balanced out because the company gains more satisfied customers and has trained staff.

Implementation of the first two solutions of customer service improvement will change the sigma level. Initial sigma value, based on 91 flawless units was calculated to 3,77. After improvement, number of flawless units should be 95 that means sigma target fourth level (4,00).

Improvement solutions implementation should be constantly monitored. It is worth using supervision over the practical application of changes. The results of customer service changes also require customer voice control. Suggested tools are customer surveys that allow to obtain a current opinion about perceived quality of services. Applied ideas, as new standards, are the basis for further improvement that should be continually realized.

4. Summary and conclusion

The results presented in the paper shows that six sigma based on the DMAIC methodology finds practical application in services improvement. Although the necessity of perception six sigma as a level of failures in the service process instead of process variations, six sigma tools are useful for raising level of service quality.

Initial sigma value was a confirmation that process does not meet customer expectations. Current value steam of the process presented features that should have been measured and analysed.

Voice of customer included in survey indicated the significance of particular stages of the process. Analysis of the problems with using Pareto chart and caused and effect diagram allowed to determine the causes of problems occurring in these stages: insufficient staff training and communication deficiencies caused by previous habits.

Impact and Effort Matrix results helped to identify the most influential solutions of the problems.

The results of research may be practically implemented in in the business practice of the researched enterprise. The change of information flow and more staff training depends on the approach and decision of management board. Rightness of proposed by the author solutions' implementation has been presented in this paper.

The results of this paper may also be used by other service enterprises which strive to improve the customer service quality that low level is mainly caused by human factor.

The paper may be the basis for further research into the implementation of the six sigma methodology into service processes.

Reference

ALHURAISH, I., ROBLEDO, C., KOBI, A. 2017. *A comparative exploration of lean manufacturing and six sigma terms of their critical success factors,* Journal of Cleaner Production, Vol. 164, 325-337.

ANTONY, R., BANUELAS, R. 2001. *A strategy of survival*, Manufacturing Engineer, Vol. 80, No. 3, 119-121.

ANTONY, R., BANUELAS, R. 2002. *Key ingredients for the effective implementation of six sigma program*, Measuring Business Excellence, Vol. 6, No. 4, 20-27.

CHAKRABARTY, T., TAN, K.C. 2007. *The current state of six sigma application in services*, Managing service quality, Vol. 17, No. 2, 194-208.

HARRY, M, SCHROEDER, R. 2001. Six Sigma. Wykorzystanie programu jakości do poprawy wyników finansowych, Dom Wydawniczy ABC, Kraków.

INGALDI, M. 2018. *Overview of the main methods of service quality analysis*. Production Engineering Archives, Vol. 18, 54-59, DOI:10.30657/pea.2018.18.10

HENSLEY, R.L., DOBIE, K. 2005. *Assessing readiness for six sigma in a service setting*, Managing Service Quality, Vol. 15, No. 1, 82-101.

KLIMECKA-TATAR, D. 2017. *Value stream mapping as lean production tool to improve the production proces organization-case study in packaging manufacturing*, Production Engineering Archives, Vol. 17, 40-44, DOI: 10.30657/pea.2017.17.09

KOWALIK, K., KLIMECKA-TATAR, D. 2018.*Service quality model based on the 4Q's model and the system approach to service quality management,* Proceedings of the 2nd International Conference Contemporary Issues in Theory and Practice of Management, Częstochowa, 236-243.

KWAK, Y.H., ANBARI, F.T. 2006. *Benefits, obstacles and future of six sigma approach*, Technovation, Vol. 26, 708-715.

LINDERMAN, K., SCHROEDER, R.G., ZAHEER, S., CHOO, A.S. 2003. *Six Sigma: a goal theoretic perspective*, Journal of Operation Management, Vol. 21, No. 2, 193-203.

NAKHAI, B., NEVES, J. 2009. *The challenges of six sigma in improving service quality*, International Journal of Quality & Reliability Management, Vol. 26, No. 7, 663-683, DOI: 10.1108/02656710910975741

SMĘTOWSKA, M., MRUGALSKA, B. 2018. *Using Six Sigma DMAIC to improve the quality of the production process: a case study,* Procedia-Social and Behavioral Sciences, Vol. 238.

ULUSKAN, M. 2016. *A comprehensive insight into the Six Sigma DMAIC Toolbox,* International Journal of Lean Six Sigma, Vol. 7, No. 4, 406-429., DOI: 10.1108/IJLSS-10-2015-0040

六西格玛作为提高服务质量的一种方法

關鍵詞

DMAIC循环
起色
质量
服务流程
六个西格玛

摘要

本文进行和描述的分析目的是介绍基于DMAIC循环的六西格玛方法在提高服务质量方面的实际应用。本文的第一部分包含六西格玛的理论框架以及在服务方面使用其工具的问题。
之后，计算出初始西格玛值，表明需要改进。
测量阶段由价值流映射，过程FMEA和客户调查开发，其结果已在帕累托图和鱼骨图中进行了分析。改进阶段包括影响和努力矩阵以及由于故障减少和服务质量改进而可以实现的目标西格玛水平