The Improvement of The Efficiency for The Quality Assurance Information System Based on The Six-Sigma Principle

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ABSTRACT

This paper presents the development of the efficiency of a quality assurance information system based on the six-sigma principle for schools in northern Thailand. The aim of this research is to solve all problems occurred in the previous system such as the awkward user interface, no quality standard support, users' confusions in workflow process, the inaccurate and unreliable information system process etc. The six-sigma foundation is operated by five processes, which are the define phase, the measure phase, the analyze phase, the improve phase, and the control phase (DMAIC). According to the studies, the measurement of the users' satisfaction and expectation is divided into three parts: standard-based service, system reliability, and processing speed. As the results, the quality measurements from both technical and non-technical are ranged on 2-sigma level. These measurements confirm that the proposed system provides the improved services better than the previous system and it can solve all problems as mentioned above effectively. Moreover, it can raise the efficiency of the service system based on the quality assurance standard for the mission of the schools in the northern region.

Keywords: Six-Sigma Principle, DMAIC, Quality Assurance Information System, Sigma Level

1. INTRODUCTION

National Education Act B.E.2542 provides and considers quality assurance in schools, and it is one of the processes of educational administration, which was managed and developed continuously to a standard quality in education for supporting the external quality assurance [1]. However, many schools in the northern region still have the problems with the information criteria management and the quality assurance indicators, which cannot completely integrate the routine works with the quality assurance in education works. Due to the large amounts of data and many of the people in several segments, it is so difficult to manage all information because most of them have not been arranged in electronic documents. Consequently, it increases the teacher workloads to gather each information in the schools during the period of quality assurance in education causing the deviation of the information and it cannot reflect the real quality of the schools. Therefore, those problems will be solved by using the quality assurance information system, which is one of the databank development projects and business intelligence for quality assurance system. It uses for reducing the complicated tasks in information management for the people who are responsible for quality assurance in the schools of the northern part of Thailand [2]. The databank system can collect user's information from both the daily tasks and other sources. All information will be used for supporting the manager's decision in terms of decision support system [2]. The proposed software in this research, which is used for solving the quality assurance in educational issues, starts from the business process model development. It identifies a level of working functions connecting with the analysis system and leads to develop in the information system by explaining as a symbolic model, which is called business process modelling notation (BPMN) [3]. The system model is created by a sequence of unified modelling language (UML) [4]. Then, the information system is employed for testing the system efficiency by following the law of the Six Sigma standard in a way of quality in dimensions. It consists of a standard pattern, an appropriate management, and a responsibility of the organized missions. These allow both the customer and the manufacturer to get the benefits of the investment both resources and productive values [5]. The Six Sigma has five steps, which are the define phase, the measure phase, the analyze phase, the improve phase, and the control phase (DMAIC). Its quality development is the way either to reduce the flow or to rebuild the level of quality to achieve the level of Six Sigma by using the quality process and statistics method development. This research purposes all information based on the efficiency of the quality assurance information system used the Six Sigma to survey the satisfaction of the sample in schools. In addition, it is used for studying the reasons for user dissatisfaction on the services to solve its quality problems and seeking the way to

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control on working process more efficiently.

2. RESEARCH METHODOLOGY

The Six Sigma is the idea to improve the quality of the organization. It can reduce errors that occur in the process by using the principles of statistics. Many businesses have adopted the Six Sigma technique to improve the quality of their organization, for instance, the case study narrowly focuses on reduction/elimination of two imperative responses in spray painting process producing shock absorbers, namely peel off and blisters using the Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) approach that highly impacts quality at customer end [6]. The present article presented a Lean Six Sigma (LSS) project management process improvement model and a case study test developed in a real enterprise environment which has a formal and established project management system PMI based. The LSS proposed approach is a DMAIC cycle-based proposal [7].The five stages of six sigma improvement model DMAIC (define, measure, analyse, improve, control) is the core Six sigma management system based on JMP/SAP system. In this system, operators can acquire batch data of production in different stages through the top of the SAP system as required, and then make connection between JMP and SAP system, finally put forward an efficient improvement plan after analysing on production data by using JMP [8].

As mentioned above, the solution process of the Six Sigma standard has 5 phases known as DMAIC. Both the define phase and the measure phase will be improvably focused in this research.

1) The studying of the Define phase consists of the Quality Assurance Information Systems (QAIS), system results, and service problems. Firstly, the information from all studying is formed as a Macro Process Mapping. Secondly, both analysis and mapping of the process (or SIPOC analysis) are used for seeking the user's need and expectation (or SIPOC and Requirement Analysis) to create a Micro Process Mapping, which is shown the minor process of the system [9]. Thirdly, all information from those processes is used to build the need of the system users. Finally, the summarization is employed to make a project indicator for this research (or Metric) leading to solve all problems in the Business Metric, which is in both user level (or Project Metric) and topic level (or Theme). As the results, the proposed technique can synthesise the important factors affecting to both service quality and user's satisfaction. Furthermore, the questionnaire is randomly corrected from all users by using non-probability sampling [10]. Due to users' sample is clear, the purposive sampling is employed in the 26-schools sample divided into 4 categories. Each category requires for 2 samples per school from executives, teachers, quality assurance staffs, and students (totally 208 samples).

2) Measure phase is to measure an important aspect of the project and to analyze the quality process by using the tree diagram to find and to choose the indicators [9]. First, the criteria weighting technique is used for creating an indicator account. Second, a check sheet is employed for collecting information in the QAIS testing for 240 days [11]. Third, from the information in a check sheet, it is manipulated to seek all flaws and mistakes in the services. Fourth, the analysed information from the processes based on baseline sigma is used for finding the system mistakes, which is randomly compared with one million samples (or Defect per Million Opportunity). The founded mistakes are analysed based on
DPMO = Defect Counted ÷ (Unit Counted × Defect Opportunity) × 106 solutions

Fifth, the quality level (or Sigma Level) is calculated from the number of both the receiving problems and the unsolvable problems. In the case of counted information, it can be calculated from the bad proportion, $\bar{P}$[12], as

$$\bar{P} = \frac{\Sigma np}{\Sigma p}, \tag{1}$$

where Σnp is total number of defect products overall, and Σp is total number of determine products overall.

The Z benchmark technique is used for calculating the level of quality (or Sigma level) to estimate the counting performance searching all information at the Sigma level; it is named as the long terms indicator, Pp. Finally, the counting information is compared with the divided scale (or the standard scale), Z, by calculating the bad proportion (lookup the defect per opportunity table). The Pp indicator is used for evaluating the efficiency of the process as

$$Pp = \frac{1}{3} Z_{Bench}. \tag{2}$$

3) Analyze phase is the analysis of the data collected from the research tasks such as frequency, variance, the use of the Pareto diagram, system processes, and the hypotheses of the possible causes shown in the tree diagram. Finally, it also proofs the hypotheses and concludes the root cause statement summary.

4) Improve phase is the process of searching the alternative ways to rectify system. The main purpose of this section is to prevent all defects and to satisfy all users in the system. Also, it is utilized for preparing to the real situation by using the proposed process, analysed for the Sigma level to show the quality level of the modified process.

5) Control phase is the process of bringing the improved and tested scheme to use in the real practice by specifying an indicator and a control point. Furthermore, many aspects are created in this section such as writing user's manual, monitoring all processes, both tracking and fixing all problems, and im-

proving system continually.

3. RESEARCH RESULTS

The results in the Define phase show that the QAIS in schools of the northern region in Thailand is designed to compatible with online systems. So, all users are able to access the proposed system anywhere and anytime through .NET technology, Windows Server, SQL Server, HTML, and JavaScript. The main function of the system is composed of nine sections: (1) The management of the schools. (2) The management of criteria and the indicator of the quality assurance in education. (3) The record of the overall operations and the indicator of the quality assurance. (4) The information management and the quality assurance indicator criteria evidence. (5) The quality assurance in education information analysis. (6) The report evaluation management. (7) The committee evaluation management. (8) To create activities for self-evaluation. (9) The store of Educational Quality Assurance (EQA) information. Moreover, the proposed system can report the indicators, which are based on the Office for National Education Standards and Quality Assessment standard, for all users such as executives, instructors, administrative teachers, students, and administrators. Some reports of the QAIS in schools of the northern part of Thailand can be shown in figure 1.

There is a procedure of searching for measuring the users' needs and expectations in the system such as (D1) To specify the users' problems by answering 5 questions (What? Where? When? Why? How?) (D2) To bring all answers from (D1) to draw a Macro Process Mapping, SIPOC model, and Micro Process Mapping (D3) To study basic information of system by studying sources, developed systems, functions of procedural system, results, connections, and securities (D4) During the system testing, as shown in figure 2, the studying of the secondary information is analyzed for searching users' issues such as problems, complaints, comments, and satisfies.

The solutions of the Six Sigma method can be explained by receiving all users' complaints during the system testing for 244 days. From the collection of information from the sample group of the trial system, we found 60 complaints as following: 18 complaints about system speed, 12 complaints about system reliability, 11 complaints about accessibility and usage, 8 complaints about system accuracy, 6 complaints about system security, and 5 complaints about system administrator service. In the testing works of the system found that 60 complaints can be solved within 3 hours.

In the specification of the Metric is used for solving the practical problems: (1) Business Metric is to satisfy all users with the QAIS (2) In Project Metric, we found 2 users' problems: First, the technical defection is appeared by the users' confusions such as the workflow system, data processing, and creating reports. Second, the non-technical defection is raised from administrators' error. (3) Theme (or research title) is the EQA system's quality improvement indicated by Key Process Output Variable (KPOV). It is used to rate the EQA system's satisfaction and to specify the way for evaluating the new system by searching for all problems from sample group for 244 days (March 1 - October 30, 2015). The employee satisfaction index of the purposed system is corrected from the survey with 10 questions: (1) Does the information system cover all functions of the users' work based on quality assurance standard completely? (2) Is the information system the friendly user interface design? (3) Does the imported data section update all information automatically? And is it useful for reducing the waste time from users' work? (4) Do the information system process and display all information speedily, accurately, and reliably? (5) Does the information system store, categorise, and search all information smoothly? (6) Does the information system backup and recover all information effectively? (7) Is all information from the information system up-to-date and compatible with other systems? (8) Is the information system useful for the practical work? (9) Does the information filling control in the information system work securely and correctly? (10) Does service maintenance of administrators instantly respond and resolve all problems effectively?

As all answers from those questions, we found that the Pareto chart can display all non-technical defections in service maintenance of administrators perfectly, e.g., instant responsibilities, fast resolutions. Its cumulative sum is 100%. It also assists to decide to fix the defections in service maintenance of administrators firstly. Then, all technical defections are being solved, e.g., information filling control, security process, backup data section, processing errors, data display, and instant responsibilities respectively as shown in figure 2.

The Measure phase has been used for searching and analyzing the capacity of the administrators' maintenance, the instant responsibilities, and urgent resolutions consequently. By the use of the Tree diagram, it can be used to reflect the procedure of resolution system service and the impact factors on both defections and indicators. The influential factors for receiving all problems can be shown as (1) Communication. The indicator is a time (per minute) (2) Helpfulness. The indicator is the decrease of the users' complaints by the random survey. (3) Courtesy, the indicator is also the decrease of the users' complaints by the random survey as used in (2). All influential factors shown in Tree diagram can be represented in figure 3. Moreover, the Criteria Weighting technique is employed for selecting all indicators by scoring the possibility of the data correction, e.g., simple, resistance, preparation, and advantages. The most scores

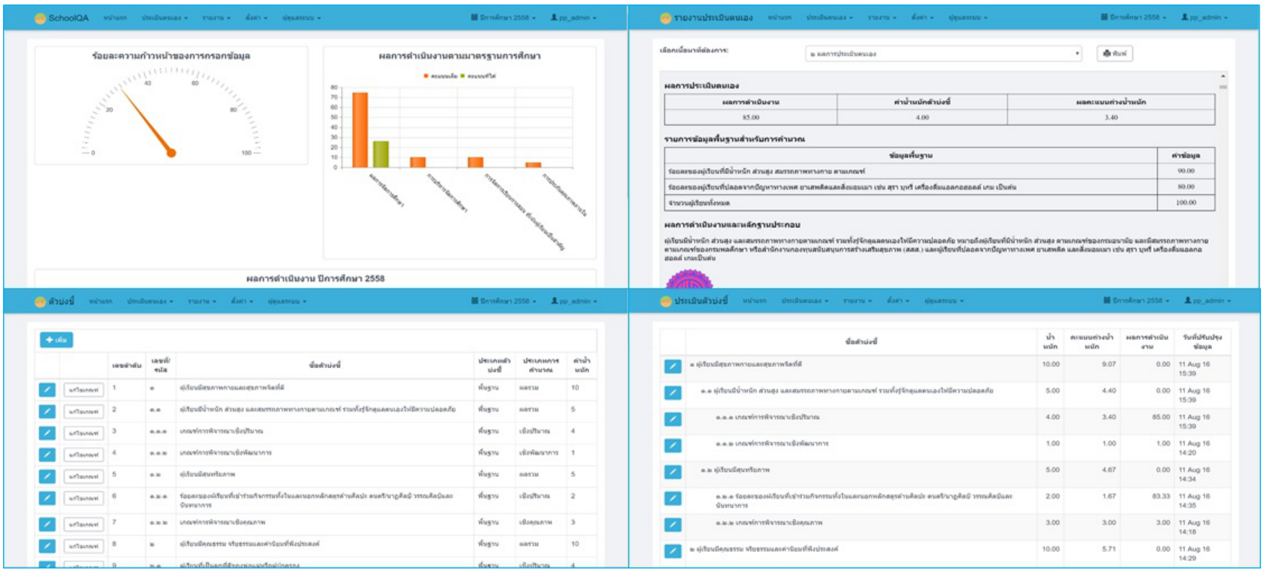

Fig.1: *The QAIS screens.*

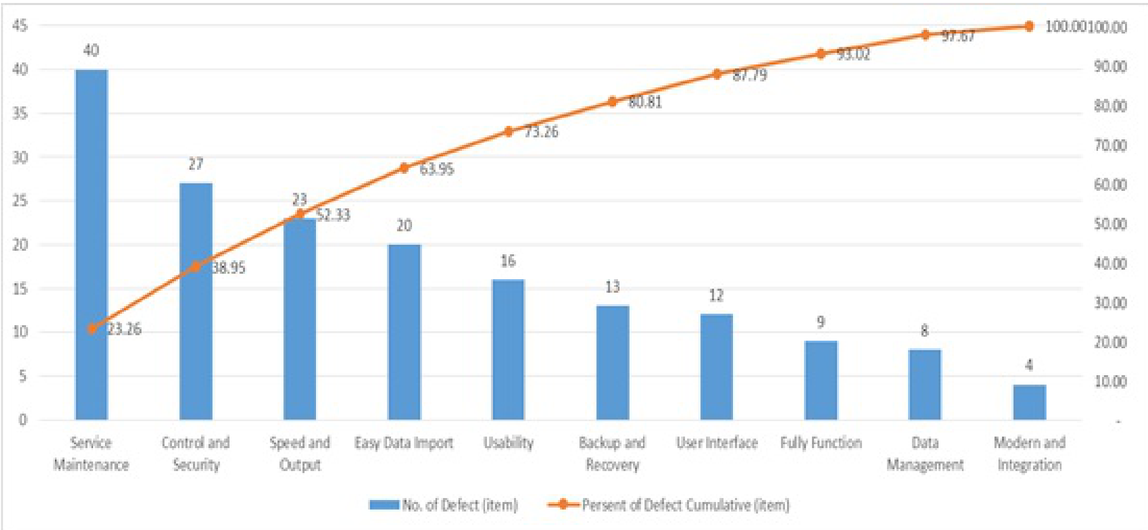

Fig.2: *The defections occurred during the QAIS experiments.*

of the indicators are chosen for data correction by the Check Sheet technique. Then, the service information is corrected by the Tree diagram, e.g., technical and non-technical issues.

From the data correction of the information system's usage for 60 times, we found that 19 deficiencies can be analyzed as the sigma rate standard compared with the number of deficiency and its possibility in 1 million samples (Defect per Million Opportunity). 19 deficiencies are found. According to the formula in [12], Unit counted is the amount of piece of work (Using the number of testing) for 60 pieces of works (or times). Finally, the defect opportunity of the chance of deficiencies is 7 chances per one piece of work (or times).

$$\text{DPMO} = \text{Defect Counted} \div (\text{Unit Counted} \times \text{Defect Opportunity}) \times 106, \tag{3}$$

e.g.,

$$\text{DPMO} = 19 \div (60 \times 7) \times 106,$$

$$\text{DPMO} = 45,238.10.$$

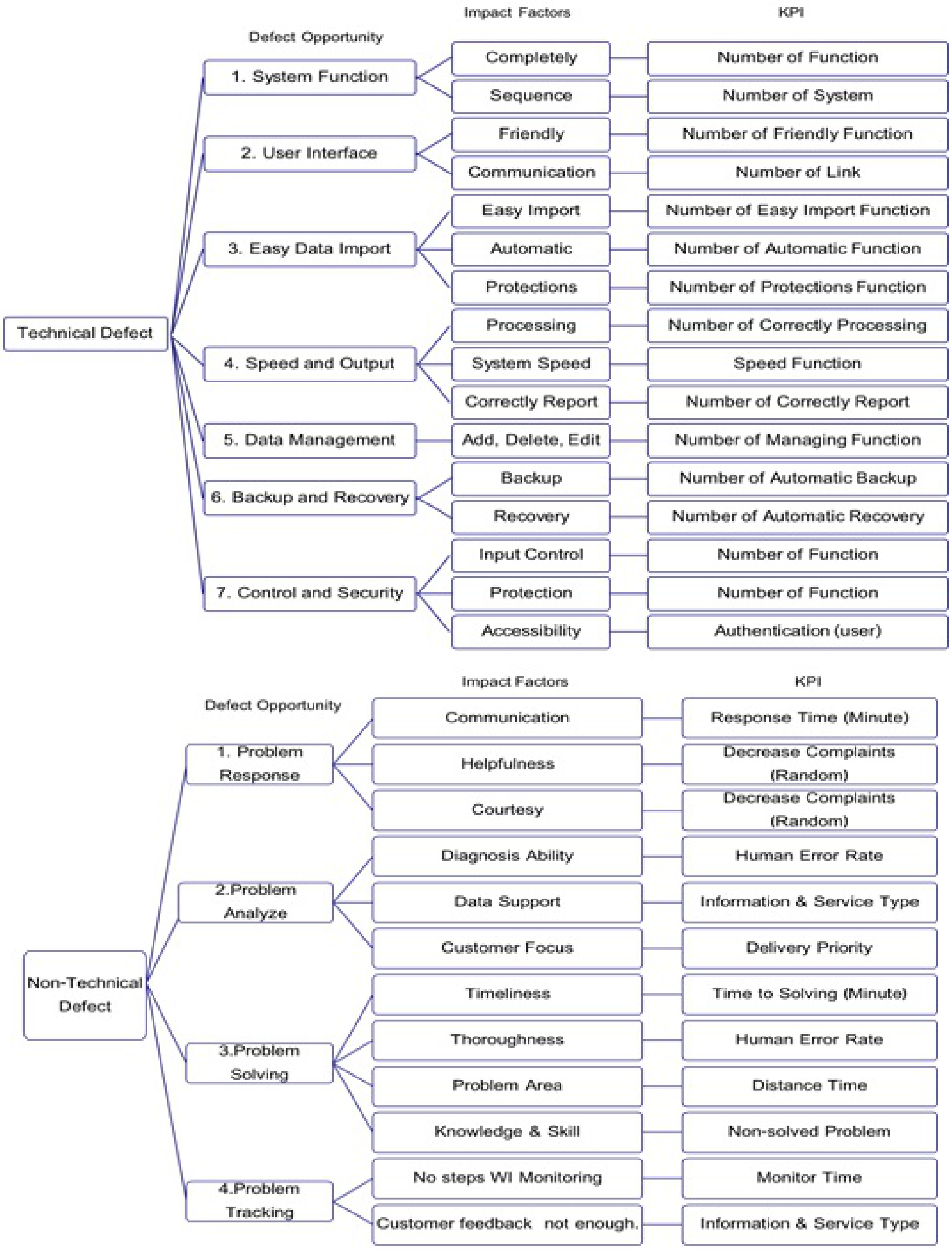

Fig.3: *The tree diagram of the efficiency of both technique and non-technique ways.*

From the lookup sigma conversion table, the short term is 3.20 sigma and the long term is 1.70 sigma. By the use of DPM0 = 45,238.10, the sigma rate is ranged at 2-sigma level by lookup the table. In other words, the deficiency per million is 45,500.124. The Sigma level is used for calculating the quality level by analysing technical information for 60 times. We found 19 deficiencies for this case. In the case of counting data, the $\bar{P}$ is calculated by the ratio of waste as:

$$\bar{P} = \frac{The\ amount\ of\ overall\ deficiency\ products\ (\Sigma np)}{The\ amount\ of\ overall\ examine\ (\Sigma p)} \tag{4}$$

e.g.,

$$\bar{P} = 19 \div 60 = 0.316.$$

The overall deficiency chance in one work is 0.316 The overall deficiency chance is calculated from $\bar{P} \div 2$. So, the deficiency chance is $0.316 \div 2 = 0.158$ chance.

The data correction of the information system for searching all non-technical deficiencies is administrators' information system services for 45 times. We found that 8 deficiencies can be analysed as the sigma rate standard compared with the number of deficiency and its possibility in 1 million samples (Defect per Million Opportunity). 8 deficiencies are found. Unit counted is the amount of piece of work (Using the number of testing) for 45 pieces of works (or times). Finally, the defect opportunity of the chance of deficiencies is 4 chances per one piece of work (or times).

$$\text{DPMO} = \text{Defect Counted} \ \div \ (\text{Unit Counted} \ \times \ \text{Defect Opportunity}) \ \times \ 106, \tag{5}$$

e.g.,

$$\text{DPMO} = 8 \div (45 \times 4) \times 106,$$

$$\text{DPMO} = 44,444.444.$$

From the lookup sigma conversion table [13], short term is 3.10 sigma and long term is 2- sigma. In other words, the deficiency per million is 45,500.124. The Sigma level is used to calculate the quality level by analysing technical information for 45 times. We found 19 deficiencies for this case. In the case of counting data, the $\bar{P}$ is calculated by the ratio of waste as:

$$\bar{P} = \frac{The\ amount\ of\ overall\ deficiency\ products\ (\Sigma np)}{The\ amount\ of\ overall\ examine\ (\Sigma p)}, \tag{6}$$

e.g.,

$$\bar{P} = 19 \div 60 = 0.316,$$

the overall deficiency chance in one work is 0.177, and the overall deficiency chance is calculated from $\bar{P} \div 2$. Therefore, the deficiency chance is $0.177 \div 2$ $= 0.088$.

Figure 4 shows that both the lower specification limit (LSL) and upper specifications limit (USL) are in range at the normal period. According to the sigma conversion table, its quality is in range at sigma level 2.

Figure 5 shows the performance assessment of the counting process from all analysed data. It is used as the index of the long-term process, Pp. The counting data is utilized for comparing in the scale of standard normal distribution, Z, by calculating from waste rate of $\bar{P}$. Also, the index Pp can be used for assessing the ability of capacity process by

$$Pp = \frac{1}{3} Z_{Bench}. \tag{7}$$

e.g.,

$$Pp = \frac{1}{3}(2.00),$$

$$= 0.666.$$

According to the ability process table and waste rate, we found that the ability of process of the long term is arranged in the low rate. (The index of Cp is lower than 0.67).

In the analyze phase, from the Adapted Waterfall system development cycle [14], the technical problems is solved by using system analysis and development for a new system to resolve all problems in the previous system. For the non-technical problems, we analyse the system's gap, processing inefficiency, and the ways to improve the system by using the flow analysis respectively. As the results, the technical problems from administrators are found such as the unclear workflow to solve the problems, the bottleneck of the administrators' works, and their time limitation. Those problems will seriously cause the disruption in the system, and the system has to restart everything again. This leads to waste the response time to all users in the system. A solution to prevent these negative issues is the use of the flow analysis. In addition, it also assists all administrators to respond all problems quickly, to store all information from users effectively, and to plan the solutions of the future problems accurately. The FAQs are corrected from all users to tackle the non-technical problems. By this technique, the users' satisfaction is increased with their convenience. Then, both the Improve phase and Control phase are operated to solve all old problems. They will focus on both the improvement of the problem analysis and the problem's solutions by creating the procedure manual, workflow instructions, and the user's manual.

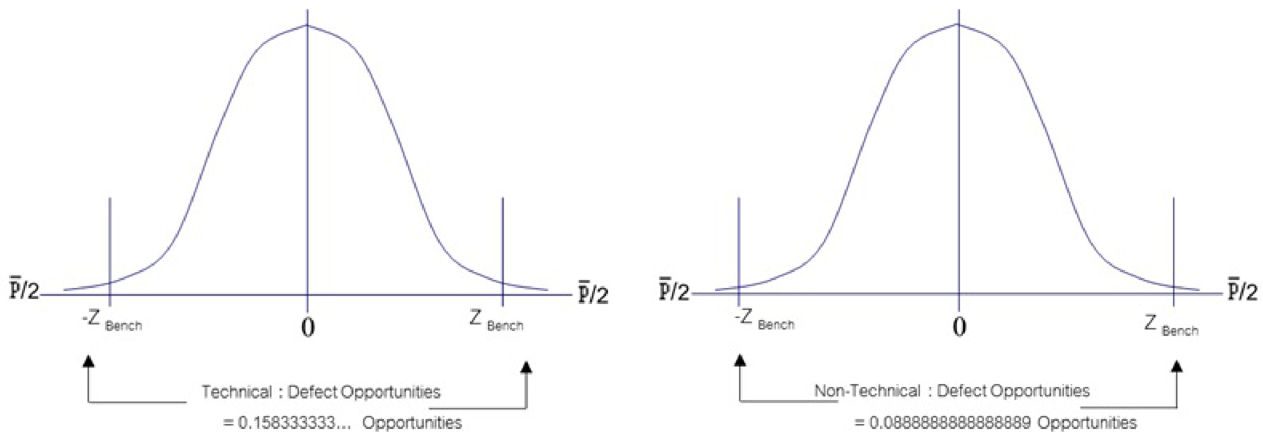

Fig.4: *The deficiency probabilities in both technique and non-technique ways.*

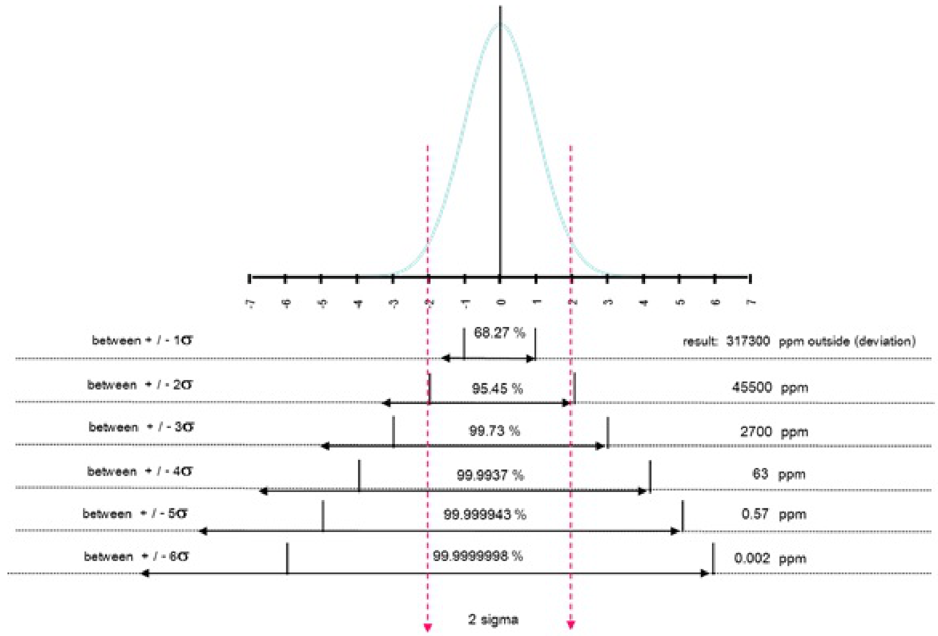

Fig.5: *The levels of processing quality.*

4. CONCLUSION

This paper presents the improvement for the quality assurance information system based on the six-sigma principle. By the use of the data correction from sample groups of the schools in the northern region in Thailand, the proposed technique gains the users' satisfaction by studying the service efficiency of the QAIS based on Sigma standard. Moreover, it also studies the causes of the users' dissatisfaction in the system in order to improve the system process effectively and to enhance the users' satisfaction including finding the alternative ways to control all working flows continually. As the results, both the technical process and the non-technical process are in the same range at the Sigma level, which is rated in the Sigma level 2. In other words, the deficiency per million is 45,500.124. Therefore, the total probabilities of deficiency for technical processes in one task are 0.316. On the other hands, the total probabilities of deficiency for the non-technical process in one task are 0.088.

To improve the technical problems, this research provides both the system analysis and the developed system for solving the old system based on Adapted Waterfall method. In addition, for the non-technical problems, this paper employs the gap analysis, the inefficiency in each process, the novel processes controlled and tracked with the developed processes. Finally, the information system is practically used in the real situations by defining both indicators and quality control points. By the use of the proposed QAIS, the system is continually tracked all problems by the improvement of the system effectively.

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