Implementation of Six Sigma Concept to Improve Software Product Quality at XYZ Company

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Abstract*: Information technology is growing so rapidly that many companies need software products to improve the efficiency and effectiveness of company operations. XYZ Company, which manufactures various software products to meet market needs, is aware that there are deficiencies in the quality of its products. These deficiencies can reduce customer satisfaction and have a negative impact on the company. Therefore, we need a good method to improve product quality. One method of quality improvement that is widely studied and applied by companies is Six Sigma. Six Sigma is a method that focuses on improving product quality that will increase the effectiveness and efficiency of all operational processes to meet satisfaction and customer needs using five stages of DMAIC namely Define, Measure, Analyze, Improve, and Control. The results of using the Six Sigma method is a continuous improvement program that is expected to assist companies in improving the quality of software products produced by utilizing information systems. In this research, we first formulate problems based on references from previous studies, then design research sampling using the Six Sigma concept. Based on five stages of DMAIC, this research results seven recommendations to be implemented to improve the quality of software products at XYZ company. After all the recommendations in this research are implemented, the estimated sigma level of the quality software products increases by 0.46σ (3.71σ to 4.17σ).

Keywords*: Software Products, Six Sigma, Improving Product Quality, DMAIC.

I. INTRODUCTION

Information technology in the globalization era is growing rapidly so that there is a lot of market demand for software products to improve the efficiency and effectiveness of the company's operations. Furthermore, many companies use information technology as a solution to develop their companies. This has led to the emergence of many new information technology companies to meet these market needs and create increasingly competitive business competition for existing companies that have been involved in the information technology industry.

XYZ company which has long been engaged in the information technology industry began to think about ways to retain old customers and reach new customers, especially in the sale of software products. In the process of purchasing products by potential customers, potential customers of course expect good products quality. Therefore, companies must focus more on preparing systematic operational production processes that are effective and efficient in order to produce good software products quality that will increase customer satisfaction and corporate value.

The company's XYZ software team that manufactures various software products is aware that there are deficiencies in the quality of software products that will have a negative impact on the company. Software products that still have defects (bugs) must be repaired again and take additional time. In 2018, the XYZ company received many consumer complaints over the quality of the software products produced. This indicates that the software product does not meet consumer criteria and reduces the level of customer satisfaction. This problem can be caused by various factors, namely the process of analysis, design, develop, testing, and documentation.

Product quality is an important parameter to increase customer satisfaction. Therefore, we need a good method to improve product quality. One method of quality improvement that is widely studied and applied by companies is Six Sigma. Six Sigma is a method that focuses on improving product quality and increasing the effectiveness and efficiency of all operational processes to meet customer needs and satisfaction [1].

II. RESEARCH METHODOLOGY

In this study, researchers first formulate problems based on references from previous studies as a reference in providing solutions to the problems discussed in this study, then design research sampling using the Six Sigma concept.

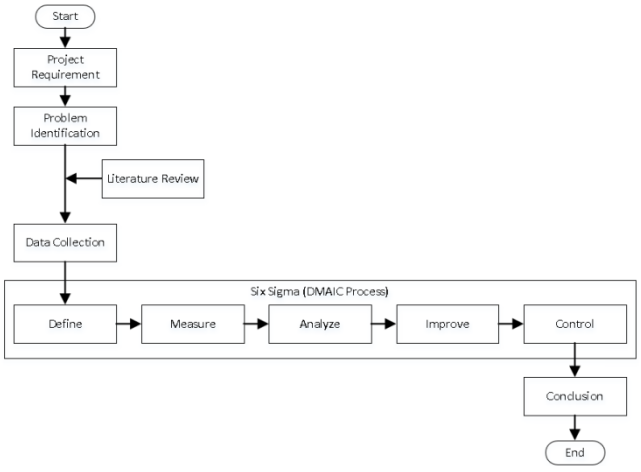

Fig. 1.Research Model

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A. Collection Data Method

Data Collection is done to obtain information in this research. The following are the methods of data collection carried out:

- Primary data is data obtained from direct observations and measurements. These data include sampling data is used to calculate the sigma level of production of software products, data from interviews with the software production team related to software product quality issues, and data on customer complaints for software products from March 2018 - February 2019.
- Secondary data is data obtained from indirect observations and measurements. These data include Company profile data regarding history and policies issued by the company, data on work instructions and process flow of software products production.

B. Quality

Quality is one of the factors considered by consumers in choosing a product or service [2]. The definition of quality basically has a broad scope of understanding depending on the perspective of the party that defines it. The traditional definition of quality is based on the point of view that products and services must meet user requirements. Some definitions of quality according to quality experts [3]:

- Deming (1986) states that the difficulty in defining quality is to translate the users' upcoming needs into a measurable characteristic, so that a product can be designed and provide satisfaction with the price paid by the user
- Crosby (1979) states that quality is conformity with demand or specification.
- Juran (1974) states that quality is the worthy of use.

Companies that focus on improving quality and productivity will become superior companies. To become a superior company, management must find the right way to improve quality and productivity simultaneously. Increased productivity through quality will provide benefits because it can reduce rework and increase customer satisfaction [4]

C. Six Sigma

Six Sigma is defined as a systematic approach to strategic process improvement that relies heavily on statistical tools and scientific methods to reduce the level of product defects determined by the customer [5]. Six Sigma can be considered as a business strategy that aims to reduce the cost of producing products and services and create a significant increase in customer satisfaction through the integration of statistical and business processes into an integrated model of processes and improving the quality of products and services. In general, Six Sigma is a quality strategy that can be implemented as a quality improvement procedure [6].

The company applies the Six Sigma concept by utilizing the process of repairing problems in five Six Sigma phases called DMAIC, namely define, measure, analyze, improve, and control [4]. Projects that use Six Sigma to control quality usually follow the process of correcting DMAIC problems. The DMAIC process is a systematic and closed process for continuous improvement that is scientific and factual [8]. The DMAIC process can be explained briefly as follows in table I [9].

Table- I: DMAIC Process [9]

Process	Description
D	Define – Define the problem
M	Measure – Measuring the existing system
A	Analyze – Analyze the system to identify the current system performance or desired process and objectives
I	Improve – Improve the system
C	Control – Control new system

Based on the phases contained in the Six Sigma concept, this research was conducted to obtain results that can be used to improve the process of product processing to improve the quality of software products at XYZ Company.

D. Define Phase

The first phase of the Six Sigma methodology is define. This phase defines the problems that occur, determine the desired improvement and identify what is important for customers [10]. Some steps taken by the Six Sigma project implementation team are identifying problems that occur and collecting data.

An important measurement tool that can be used for this phase is the Project Charter and SIPOC Diagram. Project charter is used to describe customer requirements, process maps, and Voice of Customer (VOC) data. Examples of VOC data are complaints, surveys, comments, and market research that represent the views and needs of the company's customers [9]. The format of project charter varies greatly, but at least it must contain basic information about business cases, problem statements, project scope, project goals, project benefits, roles and timelines [11]. The SIPOC diagram (Suppliers, Inputs, Processes, Outputs, and Customers) is used to provide a clear top-level picture of any process that needs to be improved. SIPOC diagrams visually document the sequence of events needed to produce specific results and gather important details about the beginning and end of a process [12]. SIPOC analysis includes the following [11]:

- Suppliers – includes the suppliers who provide input to the process.
- Inputs – identify the input that will be used by a process to produce output.
- Process – determine the sequence of existing processes or activities.
- Outputs – identify the output or results of the process that can be in the form of products/services that are of value to the customer.
- Customers – includes all customers who use outputs from process results.

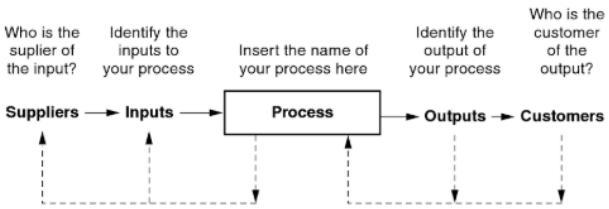

Fig. 2.SIPOC Diagram [11]

At this phase the first thing to do is to define the process of software production involved, the sequence of processes and interactions between processes. To determine the problems that occur on the software team of XYZ company, researchers will do:

- Direct interviews with related parties, especially the leaders and members of the software team to formulate the problem to be solved.
- Collect software product complaint data for a certain period.
- Using Project Charter measurement tools and SIPOC diagram to identify problems that occur.

E. Measure Phase

The second phase of the Six Sigma methodology is measure. The main activity undertaken is to identify problem areas and provide baseline data on current process performance [10]. The measurement process at this phase is carried out by determining what is measured, the type of production defects that occur the most, and measuring the level of production defects.

The statistical measurement tool that can be used in this phase is the Pareto Diagram. The Pareto diagram developed by Vilfredo Frederigo Samoso at the end of the 19th century is a graphical method for comparing and sorting a series of levels which are described in the form of a histogram.

In this second phase, the researchers will carry out a measurement process to find out the factors that cause the quality of the product not in accordance with the standards. The following are some steps to be taken in the measurement process:

- Define the flow of the software production process at XYZ company to identify what variables are causing the problem.
- Determine the type of defect that occurs most frequently in the software production process by using the help of pareto diagram.
- Perform sigma process calculations aimed at knowing what percentage of the average waste time (bugs) generated for the production of software products.

F. Analyze Phase

The next phase of the Six Sigma process is analyze. At this phase, an analysis of the causes of the identified problems is carried out, then validate them with data and provide solutions that have been tested [10]. This analysis phase will analyze the production process and determine whether the production process will be improved or redesigned. A project team that works on a Six Sigma project, commonly referred to as a Six Sigma team, investigates and verifies data to prove the suspected root cause of the quality problem and reinforce the problem statement.

The statistical tool that can be used in this phase is the fishbone diagram. Fishbone Diagrams are graphical ways to show the real causes behind problems or effects systematically. This visual form helps present results to others in order to determine the problem, identify possible causes, and reduce the possible causes that might occur.

G. Improve Phase

In the improve phase, the process of implementation of suggested solutions and ideas is carried out to eliminate, correct or reduce the identified problems [10]. This is useful for improving the performance of the production process and making things better, cheaper, and faster. The Six Sigma team will review the results of the trial to refine the solution, if needed, and then implement the solution if needed [12].

At this phase, researchers will design a proposal that the unfavorable process can be improved and then applied to the process of producing a software product. The main activity in this phase is to create improvement solutions and ideas of the problem factors found in the Analyze phase. The measuring instrument used for this phase is the Failure Mode and Effect Analysis (FMEA).

H. Control Phase

The last phase of the Six Sigma methodology is control. At this phase the process of evaluating the implemented solution, controlling the production process that has been improved, and ensuring the stability of the solution improvement is carried out [10]. The main activity of this phase is to preserve and maintain the conditions of improvement solutions and ideas.

One of the tools used in this phase is Control Chart. Control chart is a chart that gives an overview of the behavior of a process to find out whether a business process is running under controlled conditions or not.

III. RESULT AND DISCUSSION

A. Define Phase

At this phase we define, map, and determine the process of software production involved, the sequence of processes and interactions between processes.

1. Identification of Problem
   Based on the results of interviews with the leaders and members of the software production team it was found that the problem to be solved was as follows:
   - The quality of software products in the application package produced by software team.
   - Factors that cause problems in the quality of software products have not been clearly defined and still require fast and appropriate handling, such as the production process of software that is not in accordance with the Standard Operational Activities of making application packages.

2. Data Collection
   The data collected is a monthly application complaint report data for one year (March 2018 - February 2019) at XYZ company. Complaints data collection in Table II is done so that the author can take measurements in next phases.

Table- II: DMAIC Process

No	Problem Type			
	Requirements	Design Errors	Coding Errors	Documentation
1	1	1	1	6
2	0	1	10	0
3	0	0	14	0

No	Problem Type			
	Requirements	Design Errors	Coding Errors	Documentation
4	0	1	4	0
5	0	0	1	2
6	5	2	13	0
7	0	3	15	1
8	1	0	15	3
9	0	1	11	0
10	0	1	8	0
11	0	1	8	0
12	0	0	2	0
Total	**7**	**11**	**102**	**12**
%	**5.33**	**8.33**	**77.27**	**9.09**

Based on company policy, the two highest types of complaints will be made as the main priority for improvement. With these improvements, we hope that more consumers could be satisfied because their expectations can be meet. From Table II above, there are two type of highest complaint, namely:

- Coding Errors: 77.27%
- Documentation: 9.09%

3. Project Charter

Project Charter describes several elements, such as problems that occur in the company, the scope of the project, the role of each team member, what will be provided (milestones/deliverables), and the support.

Table- III: Project Charter

Project Name: Implementation of Six Sigma Concept to Improve Software Product Quality at XYZ Company
Business Case: Information technology is currently growing rapidly so that many companies need software products to improve the efficiency and effectiveness of the company's operations. This makes more and more new information technology (IT) companies exist, giving rise to increasingly competitive business competition. XYZ company as a long-standing Information Technology company since 1990 must have a reliable strategy to be able to retain old customers and reach new customers by improving the quality of software products. Good quality products will increase customer satisfaction and company value.
Problem statement: XYZ company especially software team that manufactures various software products is aware that there are deficiencies in the quality of its products. This can reduce customer satisfaction and have a negative impact on the company. This quality problem can be influenced by various factors that start from the process of analysis, design, develop, testing, and documentation that cause many bugs (production defects) that affect the quality of software products.
Goal Statement: Improve the quality of software products so that customer complaints are reduced and have a positive impact on the company
Project Scope: - Software product quality made by software team - Research is conducted on the Product Complaints Report for the period of March 2018 - February 2019.
Milestones Start Date: 01 November 2018 End Date: 31 July 2019

Phase	Target Date
Define	November 2018
Measure	November 2018
Analyze	November 2018
Improve	December 2018 – February 2019
Control	March 2019 - completion

4. SIPOC Diagram

The SIPOC diagram provides a clear picture and visually documented of workflows from suppliers to customers.

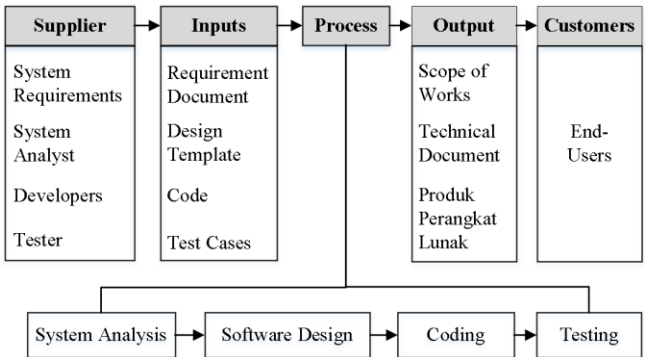

Fig. 3.SIPOC Diagram of Software Product

- Supplier is a person or group of people or system that provides resources needed by the company to produce goods or services. In this research, supplier includes system requirements, system analysts, developers, and tester which provide input for the production process of software products.
- Input is material, information, or other resources provided by supplier to be consumed or transformed in the production process, which includes requirement documents, design templates, codes, and test cases.
- Process is a group of actions and activities that change Input into Output, which includes system analysis, system design, coding, and testing.
- Output is the product, service, information, report or document produced by the process for use by the customer. In this research, it includes scope of works, technical document, and software products.
- Customer is the party that receives the output generated by the process, which includes end-users.

B. Measure Phase

At this phase, researchers carry out several measurement processes to find out how the conditions of the processes that are running before improvements are made using the Six Sigma methodology.

1. XYZ Company Production Process

The flow of this production process is as a reference for measuring the causes of declining product quality by looking at which parts are involved in the software production process that correlates with product quality and will be used as an analysis phase in the next sub-chapter.

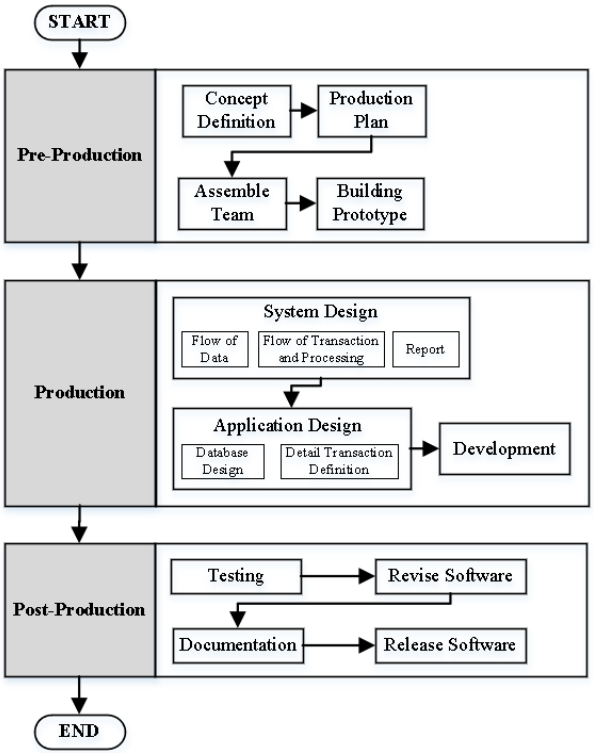

Fig. 4.Software Product Process Flow Chart

This production process flowchart is used as an analysis material in the next phase by looking at the correlation between software bugs and which parts are involved in the software production process.

2. Making Pareto Diagram

To determine the type of defect that most occurs in the software production process, the Pareto diagram is used. The data used in making pareto diagrams is data on the number of complaints for defects obtained by customers when using software products in the period March 2018 - February 2019.

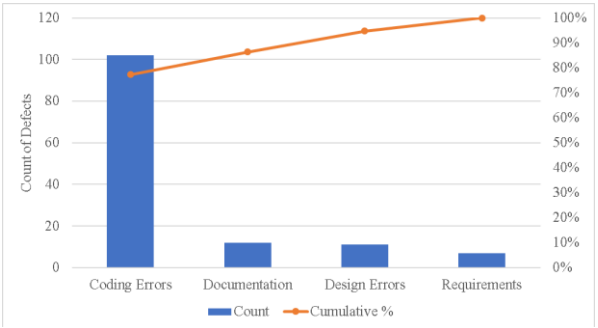

Fig. 5.Pareto Diagram of Software Product

Based on the pareto diagram above, the highest type of defect contributing to the total software production defects in the period March 2018 - February 2019 is the type of defect "Coding Errors" with a percentage of defects of 77.27% of the total product defects. From the pareto diagram, the priority order of handling the problem of existing complaints are (1) Coding Error, (2) Documentation, (3) Design Errors, and (4) Requirements.

3. Sigma Calculation

This sigma calculation is to show the level of software production sigma. The calculation steps are as follows:

- Unit (U) = 201
- Opportunities (OP) = 4 characteristics examined
- Defect (D) = 132 / 12 = 11
- Defect per Unit (DPU) = D / U = 0.0547264
- Total opportunities (TOP) = U x OP = 804
- Defect per Opportunities (DPO) = D / TOP = 0.013681
- Defect per Million Opportunities (DPMO) = 13681

Sigma level calculation can be done using a Six Sigma calculator. One of them is on the website https://www.isixsigma.com/process-sigma-calculator/.

The calculation of the Six Sigma level above shows that from the total DPMO of 13681, the Sigma level is at the level of 3.71σ. The achievement of this sigma value can be said to be "quite good". To be able to improve the quality of software products so that they can be competitive with other companies, the sigma values above must continue to be improved until they reach the limit of perfection, which is 6σ.

C. Analyze Phase

The Analyze phase is the next step after the Measure phase of the DMAIC method. At this phase an analysis and identification of the causes of the problem is carried out so that actions can be taken to overcome the causes. The Six Sigma tool used at this phase is fishbone diagram that illustrate some common causes that result in a decrease in the quality of software products.

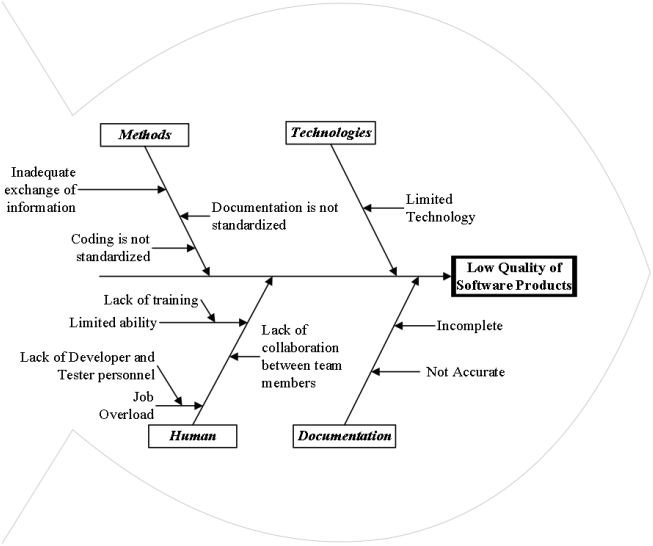

Fig. 6.Fishbone Diagram

In Figure 6 there are several causes that cause the quality of software products to decline, namely:

1. Methods

The methods that cause the quality of software products to be low are as follows:

- There is no standard coding of applications that cause common bugs such as mismatch screen displays, naming, and error messages.
- Inadequate exchange of information between system analysts, developers, and testers so that the production of applications is not as expected.

2. Technologies

The technology or tools used by system analysts, developers, and testers in

the production process are still limited.

- The limited technology used by system analysts causes the design of the system and applications are not clearly conveyed to the developer.
- The limited technology used by developers causes the results of software products to be inferior.
- The limitations of the technology used by the tester cause the test results are not good.

3. Human

In this case the low quality of the software product is due to the following things:

- Limited developer ability in coding applications due to lack of technical training in programming for the latest technological developments. This limited ability causes the lack of ability and knowledge of developers in coding applications so that the resulting application is less satisfying.
- Lack of collaboration between system analysts, developers, and testers so that misinformation of the software process happened frequently.

4. Documentation

- The documentation provided to customers is incomplete so application users have difficulty getting information on how to use the software.
- The documentation given to the customer is inaccurate so that the customer often operates the software in wrong way.

D. Improve Phase

At this phase, repairs or actions are made to the causes of existing problems with the aim that the causes of these problems can be overcome or even eliminated. The tools used in this phase is the Failure Mode and Effect Analysis (FMEA) to identify the causes of errors in the production process, prevent problems or failures that can cause product defects and recommendations proposed for improvement.

Table- IV: FMEA – Coding Errors "Methods"

Description		Methods	
Failure Mode Analysis	**Potential Failure Mode**	Inadequate exchange of information	Coding is not standardized
	Potential Effect of Failure	Low quality of software products	
	Potential Causes of Failure	Inadequate means of contact between team members	There is no coding standard
Action Plan	**Recommended Action**	- Internal technical and application process sharing monthly - Intensive communication between team members so that all bug problems can be resolved properly - Implementation of the "Trello" tool as a means of coordination between team members	Standardize coding applications

Table- V: FMEA – Coding Errors "Technologies"

Description		Technologies
Failure Mode Analysis	**Potential Failure Mode**	Limited technology
	Potential Effect of Failure	Low quality of software products
	Potential Causes of Failure	Tools used
Action Plan	**Recommended Action**	- Implement "Rapid Development" tools such as Windev to develop applications - Implement the "Test Studio" and "Active Presenter" tools for testers to test applications

Table- VI: FMEA – Coding Errors "Humans"

Description		Humans	
Failure Mode Analysis	**Potential Failure Mode**	Lack of collaboration between team members	Job overload
	Potential Effect of Failure	Low quality of software products	
	Potential Causes of Failure	Inadequate means of contact between team members	Lack of Developer and Tester personnel
Action Plan	**Recommended Action**	Implement tools like Trello as a link between team members	Add developer and tester personnel

Table- VII: FMEA – Documentation

Description		Documentation	
Failure Mode Analysis	**Potential Failure Mode**	Incomplete	Not accurate
	Potential Effect of Failure	Lack of information on using the software	
	Potential Causes of Failure	The author lacks knowledge of software	
Action Plan	**Recommended Action**	Add documents other than the "Manual Guide" document	

E. Control Phase

Control phase is the last phase in solving problems using the six sigma DMAIC method. This phase is useful for monitoring the results of improvements made in order to achieve the expected targets. In this phase an evaluation of each proposed improvement is carried out in accordance with the FMEA table in the Improve Phase. Some things that need to be done at this phase are as follows:

- Evaluation of the number of production defects/bugs is carried out at the end of each month to see whether there are significant positive effects on both the production process and the reduction in bug levels. This is done by documenting the number of production defect complaints every month.
- Making documentation for all efforts made in repairing production defects and included it in the application "Trello".

- Making Control Chart to control the production process of software products every three months so that it can be evaluated whether the number of customer complaints over software product bugs is reduced or not.

IV. CONCLUSION

Based on the results of research using the Six Sigma method which aims to improve the quality of software products by reducing the number of production defects, conclusions can be reached as listed below:

1. Production of software products by XYZ company is classified into 4 characteristics, namely Requirement, Design, Coding, and Documentation.
2. The quality of software products at XYZ company was improved with the following recommendations:
   - Standardize coding applications.
   - Implement the "Rapid Development - Windev" tool to make it easier for developers to develop applications.
   - Implement the "Telerik Test Studio" and "Active Presenter" tools for the tester to conduct and record the application testing process.
   - Conduct technical training regarding the latest technological developments, namely training to develop Android and MVC applications.
   - Conduct internal sharing regularly every month to share technical knowledge and application processes between team members (System Analyst, Developer, and Tester).
   - Conduct intensive communication between system analysts, developers, and testers, so that all bug problems can be resolved properly.
   - Establish standardized documentation and add documentation of "Operational Guide", "Troubleshoot", and "Installation" to facilitate users to operate the software used.
3. After all the recommendations are implemented, the estimated sigma level of the quality software products increases by 0.46σ (3.71σ to 4.17σ).

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