Improvement to the quality of software products delivered to the client: Code and documentation

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Abstract *— Elimination of product defects is critical in order to provide quality products to the client. A peer review process and preventive actions were implemented in a software development department; with the objective to reduce the defects by at least 20% in the products delivered (code and documentation). Historical data about defects was collected. The defects were analyzed, classified; their root causes were identified and preventive actions were implemented. It was found that the implementation of the peer review process alone, reduced the quantity of defects in about 23%, and the implementation of preventive actions combined with the peer review, reduced the defects occurrence in about 40%. It can be concluded that the implementation of a peer review process and the effective identification and implementation of preventive actions can reduce the quantity of defects significantly.*

Key Terms *— Defects, preventive actions, root cause, six sigma.*

INTRODUCTION

One of the main objectives of a software engineering (aerospace) company is to provide quality products that fully comply with the requirements of the client. To accomplish this, the company needs to deliver software code and documentation free of defects to the different clients (internal or external). The department, in which the project will be implemented, lacks of an internal peer review process and some important defects preventive procedures, mostly because is a recently created department (less than one year).

The objective of the project is to reduce the quantity of defects (from previous months) in products delivered to the client, for at least 20%, in a specific department of the company. This is expected to be achieved by implementing a peer review process and using tools from the six sigma methodology to identify preventive actions that can be applied to the process.

LITERATURE REVIEW

Studies has been conducted about the importance of quality in the industries, defects classification, the use of six sigma tools for root cause determination and preventive actions.

Quality in the Industry

"Quality means delivering products and services that meet costumer standards, meet and fulfill costumer needs, meet customer expectations, and will meet unanticipated future needs and aspirations" [1]. From the different literature reviewed, it can be stated that quality involves service or product performance, customer perception of quality, customer expectations and customer satisfaction. More specifically, researchers [2] have developed a service quality scale which includes five dimensions: reliability (consistency of performance), responsiveness (readiness to provide the service), assurance (knowledge, competence, courtesy), empathy (attention to costumer) and tangible (physical evidences).

Defects Classification

In the software development industry a defect is a fault that can be present in all the software development artifacts like code and documentation (requirements) [3]. "Having a specific defects classification for requirements is important to analyze the root cause of the problems, build checklists that support requirements reviews and to

reduce risks associated with requirements problems" [3].

There are some methods of classification of defects in the industry, like the Orthogonal Defect Classification (ODC) which is frequently used, however this is more adequate when classifying defects in the code [3]-[4]. In the case of defects classification in the requirements or documentation, some studies were performed and a proposal of qualification was stablish by some authors [3] which includes the following defects classification: "missing or incomplete, incorrect information, inconsistent, ambiguous or unclear, misplaced, infeasible, redundant (duplicated), typo, not relevant (extraneous)" [3].

Six Sigma and Root Cause Determination

"Six sigma is a disciplined, project-oriented, statistically based approach for reducing variability, removing defects and eliminate waste from processes, products and transactions" [5]. Six sigma is driven by the DMAIC process; which consist of Define (what needs to be improve), Measure (collect data), Analyze (identify the root of the problem), Improve (take actions to reduce defects) and Control (reduce via changes in the process) [5]. "Six sigma is a means of saving both the company and the costumer not only money but also all the problems that come along with poor quality" [4].

In order to analyze defects and determine the root cause of them, the following techniques, from the six sigma methodology, can be used: Pareto Charts "(which are specialized bar graphs that can be used to show the relative frequency of events such as defects)" [1], Control Charts (which provides control limits), Cause and effects diagrams "(that help to identify many possible causes for an effect or problem)" [1], and the 5 Whys method (ask why the issue occurs 5 times).

Preventive Actions

Some literature [4] provides guidelines about what changes can be implemented depending on the type of defect. For example, if the root cause of the defects in requirements was the ambiguity of requirement specification, a workshop focused on requirements can be done to all the team.

It can be concluded that "defect prevention reduce the development time and cost, increase customer satisfaction, reduce rework effort, hence decreasing cost and improve the quality of the product or service" [4].

ACTIVITIES

The following activities were performed in order to fulfill the objectives of the project.

Peer Review Process Implementation

During the second week of March 2015, the department implemented an internal peer review process. This was done because the department is relatively new (less than one year) and it lacks of some processes that can contribute positively to the quality of the products delivered to the client. The main objective of this implementation is to reduce the quantity of defects that are present in the products delivered to the client.

Historical Data Collection

Defects data from the months of November 2014 to February 2015 was collected. A P-Chart, created from that data, is shown in Figure 1. As noticed in the P-Chart, the average proportion of defects, for those four months, was calculated to be about 0.2879, which means that about 28.79% of the artifacts (lines of code and pages of documentation) delivered to the client contain defects.

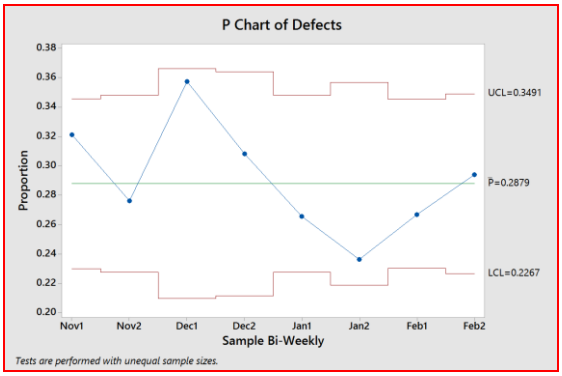

Figure 1
P-Chart of defects (Pre project implementation)

Defects Classification and Analysis

The collected defects from the previous four months were analyzed and classified. Based on the literature review and with the feedback of the leads and managers from the department, the defects classification from Table 1 was used.

Table 1
Defects Classification

Functional	*Cosmetic*	*Escape*
Incomplete	Misplaced	Defects from other phase
Incorrect	Duplicated	
Inconsistent	Typo	
Ambiguous	Not Relevant	

Based on this classification, the defects were grouped, and a Pareto chart was developed in order to determine the major offender (defects that occurs more), see Figure 2. As can be noticed in the Pareto chart, the quantity of the functional defects is 585 (56%), the quantity of the cosmetic defects is 408 (39.1%) and the quantity of the escapes defects is 51 (4.9%), meaning that the functional defects are the major offender.

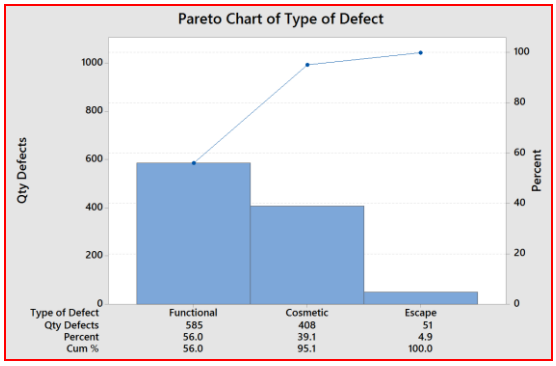

Figure 2
Pareto Chart of Types of Defects

Root Causes Determination

The major offender, found the previous activity, was analyzed using the six sigma tool of cause and effect, and the "5 why's" technique, in order to find the root cause(s) of it. This was conducted with the help of the leads and managers of the department. A summary of that analysis can be found in the first and second column of the Table 2.

A great part of the functional defects are identified by the client as incorrect, ambiguous, incomplete or inconsistent. As seen in the second column of the Table 2, a variety of root causes were identified, like for example the lack of experience of the team, and also the lack of a standardized way to write the requirements and perform the work. However because of time constraints, only activities related to the prevention of two roots causes (lack of experience or system knowledge, and lack of standardization) were executed. Note that the underlined root causes in Table 2 were that ones that were selected to be improved.

Preventive Actions

In order to address the identified root causes of lack of experience or system knowledge of the team and the lack of a standardization, the following activities were performed: a list of qualified peer reviewers was established, standardized templates for requirements generation were developed, a training of how to use the standardized templates and a training to provide more knowledge of the systems, was given to the whole team. This activities were performed with the help of the leads and managers of the department. A summary of that analysis can be found in the third column of the Table 2. Note that the underlined preventive actions in Table 2 were that ones that were implemented in the process.

RESULTS AND ANALYSIS

After the implementation of the peer review process and the implementation of the identified preventive actions, new data about the defects was collected. The following subsections shows the data collected in the different phases of the project and the comparison between the new collected data and the data collected before the implementation of the project activities.

Collected Data

Data was collected for the last two weeks of March 2015 and for the first two weeks of April 2015.

Table 2
Root Causes and Preventive Actions for Functional Defects

Sub Type	Root Cause	Preventive Actions
Incomplete	• Requirements not available • Requirement from client ambiguous • Incorrect use of development tools • Lack of time • Lack of experience • Document outdated	• Periodic meetings with the client • Training to the developers • Use of version tracking system • Identify experienced reviewers
Inconsistent	• Wrong source of data • Requirement ambiguous • Lack of experience • Different developers	• Training to the developers • Resource utilization planning • Create templates
Incorrect	• No standardization of requirements • Not enough information from client • Developer without experience • Requirement ambiguous • Lack of system knowledge	• Create templates for requirements. • Training to the developers • Periodic meetings with the client • Identify experienced reviewers
Ambiguous or Unclear	• No standardization • Different developers • Lack of experience	• Create templates • Training to the developers • Resource utilization planning

During those dates the implementation of the peer review process was in place, but not the implementation of the identified preventive actions. Also data for the first two weeks of March 2015 was collected (that data doesn't include the peer review process). All this data is contained in the Table 3.

Table 3
Data collected (March and 1st two weeks of April)

Date	Artifacts Qty.	Defects Qty.	Proportion	Functional Defects	Cosmetic Defects	Escape Defects
March 1st – 2nd Wk.	575	155	0.27	80 (52%)	65 (42%)	10 (6%)
March 3rd – 4th Wk.	512	101	0.20	60 (59%)	23 (23%)	18 (18%)
April 1st – 2nd Wk.	468	107	0.23	76 (71%)	26 (24%)	5 (5%)

The collected data, for the last two weeks of March and the first two weeks of April, shows that the proportion of defects was reduced, from 0.28 (see Figure 1), to an average of 0.22. Also it can be noticed that there is a significant reduction in the quantity of cosmetic defects compared with the previous data collected in Table 1 (from 39.1% to about 24%).

Also data was collected for the last two weeks of April 2015 and for the first week of May 2015. During those dates the implementation of the peer review process and the implementation of the identified preventive actions were in place. This collected data is shown in the Table 4.

Table 4
Data collected (3rd and 4th wk. of April and 1st wk. of May)

Date	Artifacts Qty.	Defects Qty.	Proportion	Functional Defects	Cosmetic Defects	Escape Defects
April 3rd – 4th Wk.	497	85	0.17	59 (69%)	22 (26%)	4 (5%)
May 1st Wk.	230	40	0.17	28 (70%)	10 (25%)	2 (5%)

The collected data, for the last two weeks of April and the first week of May, shows that the proportion of defects was reduced even more (to a proportion of about 0.17). It can be noticed that the quantity of cosmetic defects remain nearly the same as in the Table 3, meaning that the reduction of defects was due mostly because of the reduction of functional defects.

With the collected data of Table 3 and 4, a new P-Chart (see Figure 3) was generated which also takes in account the previous data (without the implemented project actions). The phases in the P-Chart are denoted as Pre, which contains the data before the implementation of the project, the Post (PR Only), which includes the data with the implementation of the peer review process only, and Post (PR and PA), which includes the data with the peer review process and the preventive actions implemented.

It can be seen that in each of the different phases of the project, a reduction in the proportion of defects was obtained. In the pre-project phase the proportion of defects was about 0.2879, then in the

next phase, Post (PR Only), it was reduced to about 0.22 in and the final phase, Post (PR and PA), the proportion was reduced to about 0.1719.

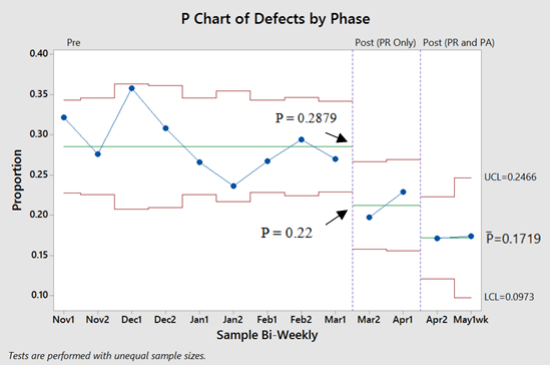

Figure 3
P-Chart of defects (All phases)

CONCLUSION

A reduction of about 23% (0.2879 vs. 0.22) in the quantity of defects, in the products delivered to the client after the implementation of the peer review process in the department, was achieved. This result is due mostly because the significant reduction of cosmetic defects. Also, an overall reduction of about 40% (0.2879 vs. 0.1719) in the quantity of defects in the products delivered to the client, after the implementation of a peer review and the implementation of the identified preventive actions, was achieved. This result is mostly because of a significant reduction of functional defects with the implementation of the preventive actions. It can be concluded that the objectives of the project, of implementing an internal peer review and to reduce the quantity of defects in at least 20%, were achieved.

The project also contributed positively to the quality of the products (code and documentation) that the department delivers to the client. An internal peer review process was established in the department (there was a lack of this process) also a variety of root causes were discovered during the project, which can be cataloged as an essential information that can be used for the continuous improvement of the quality of the products in the department.

The other root causes, for which no preventive actions were established, needs to be analyzed in the near future by the department in order to continue with the reduction of defects that are delivered to the clients.

REFERENCES

[1] Ozeki, K., et al, *Handbook of Quality Tools.* Productivity Press, Inc., 1990. Print.

[2] Nakhai, B., et al, "The challenge of six sigma in improving service quality*", International Journal of Quality & Reliability Management*, Vol No. 26, 2009, 663-684.

[3] Lopes, I., et al, "Classification of Defect Types in Requirements Specifications: Literature Review, Proposal and Assessment", *Information Systems and Technologies (CISTI),* Vol No. 6, 2011, 555–560.

[4] Kumaresh, S., et al "Defect Analysis and Prevention for Software Process Quality Improvement", *International Journal of Computer Applications,* Vol No. 8, 2010, 42-47.

[5] Henderson, G. R., *Six Sigma Quality Improvement with Minitab*. John Wiley & Sons, Ltd., 2011. Print.