Addressing Quality Issues: Theory and Practice A Case Study on a Typical Software Project

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ABSTRACT

This paper demonstrates the difference between theoretical quality design and practical quality issues and problems, as these were documented for a typical software project. The aim of this paper is to share with readers conclusions based on over ten years of experience in software projects management and research in the field of software quality assurance by presenting simple issues related to the design, implementation and delivery of a typical software project. The project presented in this paper serves as a model of a typical software project (case study), in an effort to offer specific practical examples for demonstrating the practical quality issues and problems arising in the majority of software projects. Both the initial design of the quality and the practical issues that arose during implementation affecting final product quality are discussed in this paper. Moreover, the gap existing, in some cases, between theory and practice is presented.

Keywords: Software Engineering, Software Quality Assurance, Project Management, ISO9126, Quality Criteria, Data Quality.

1. INTRODUCTION

In most software projects the quality of the final product is designed during the first phases of the project. There are many methods to design software quality, some of them [1,2,3,4] being more popular than others. The use of such methods, most times, results in a well defined, documented (within the developing unit[1]) and repeatable way to produce software. During the early phases of the project, the factors that affect product quality are detected and the criteria related to these factors are tracked down. The selection of the factors and the criteria is normally based on a standard. Even if we accept the argument that there are many software engineering standards [5], some of them ad hoc causing more problems than those they solve [6], in most occasions, the selection of the proper standard is of great assistance during the early design of product quality. Nowadays, most software developing units have shifted from FCM [7] and CSQ [8] to ISO9126 [9] or more recent (but yet not thoroughly tested in practice) models [10,11], for the selection of factors that affect product quality.

Regardless of the method and model selected, the developing unit proceeds to a number of actions during the initial design of quality. It determines the project quality plan (based on the unit's quality manual). Then, it traces down specific development actions that will critically affect the final product quality. Finally, it sets specific quality goals and defines the techniques that will be used for testing the achievement of these goals. However, it is not unusual that a big divergence exists between *theory* (following a quality method to design quality) and *practice* (what actually happens during software development, when unforeseen problems arise). It is the duty of proper management, during the development phase, to monitor these problems and take corrective actions as soon as they arise by modifying the initial design without, nevertheless, affecting the major goal: *ensuring final product quality*. This is why most proposed software management methodologies [12,13,14,15] emphasize on management's commitment to quality and on managers' ability to handle practical problems that arise, without compromising quality.

Of course, problems are not always unforeseen. The ability to foresee and prevent problems is highly related to the development unit's level of maturity. For example, a software development unit being on CMM [16] level 3, will foresee and prevent more problems than one being on level 1 that operates based on ad hoc techniques invented by the engineers. The same applies in the case of a development unit certified with ISO9001 [17], or one that has succeeded in the Baldrige Awards [18]. But even in such units, management's ability to handle practical problems is critical for the achievement of the pursued product quality.

This paper presents a typical software project as a case study in an effort to offer specific practical examples for

[1] The term 'developing unit' is used in this paper to represent what may be a software company, a development division of an enterprise, a small software house, a research team, etc.

demonstrating the practical quality issues and problems arising in the majority of software projects. The development unit in this case study (Computer Technology Institute, Research Unit II [19]) has not been certified by ISO9001, nor has it been assessed based on CMM, therefore may be considered as a unit of low maturity level (although it is certainly aware and uses software quality techniques and standards). This paper presents both the initial quality plan and the practical issues that arose during implementation, affecting final product quality and discusses the gap between theory and practice. Section 2 briefly presents the software project. Section 3 discusses parts of the initial quality plan, while section 4 presents the practical problems that arose. Finally, section 5 reports on the conclusions of this paper.

2. THE SOFTWARE PROJECT

The software project presented was a 15-month duration, relatively small, but content intensive software project, involving no high technical risk or innovation. The project's goal was the design, implementation and delivery of a web-based tourist guide for the West Region of Greece. The customer was the WestGate Teleport company [20]. The project was completed on time and according to schedule and is currently available to the public [21]. The primary subtasks of the project were the following:

i) Specification of the material to be included in the guide.
ii) Collection of original data (content) for the guide (such as digital images and informative documents).
iii) Design and development of the database for the storage and handling of the data.
iv) Design and implementation of the authoring tool and the automatic publisher that imports the data.
v) Testing and delivery of the final web site.

According to the system requirements, the database had to be located in a different server than the web site's server and the authoring clients had to be distributed so as to allow different authors (content creators) from different locations to upload content simultaneously.

The development team had years of experience in software projects, however, it had never developed a similar project. It should be noted that heterogeneous personnel were involved in this project. The personnel involved (approximately 25 persons) varied from software engineers and web page designers to historians, photographers and content authors, as well as specialized personnel (content reviewers) in charge of specifying the type of material to be included in such a tourist guide and testing the validity of the content. Furthermore, it should be noted that this heterogeneous team comprised of people with different cultures and working methods that had never collaborated before, making teamwork even more difficult.

3. DESIGN OF PRODUCT QUALITY

Although the initial design for the quality was based on ISO9126 quality characteristics decomposition (*Functionality*, *Reliability*, *Usability*, *Efficiency*, *Maintainability* and *Portability*), this section focuses only on those characteristics that are related to the problems which occurred during the project life cycle. In the case study presented, these characteristics were *functionality* and *usability*. Reliability problems were related to the use of two different servers (database and web site), but were trivial and easy to predict. Efficiency and portability were also highly related to the particularities of web applications development and are easy to handle for most experienced development units. Finally, maintainability was assured by the development method and the measurement methodology [22], as well as the available automated tool [23] and caused no practical problems during the limited duration that followed project delivery. Therefore, the discussion that follows focuses on functionality and usability characteristics and related issues.

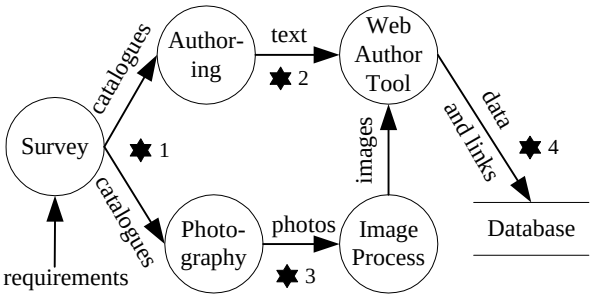

Figure 1. DFD Level 1, Part A.

Figure 1 shows the first part (Part A) of the second level (level 1) of the project's Data Flow Diagram (DFD) [24,25]. The diagram is separated in two parts in order to facilitate presentation. The stars in the figure are not part of the DFD notation and are used to represent points of the project demanding actions related to quality issues that affect final product quality. These points will be discussed hereinafter. The second part (Part B) is presented in figure 2 later on.

As shown in figure 1, the first point presented (indicated with ✸1) includes the results of the survey, i.e. catalogues resulting from the initial specification of the material to be included in the tourist guide. These catalogues were subsequently sent to photographers and content authors to prepare the material and documents to be incorporated in the guide. The proper selection of the items to be included in the catalogues was highly related to the final product *functionality*, since lack of information would result in a non-functional guide. Therefore, the quality plan included an audit phase before the finalization of the catalogues, during which a specialist in the field made a detailed review of the catalogues.

The second point presented (indicated with ✸2) is related to the task of preparing the documents to be incorporated in the guide. During this phase, several authors produced information of various types (historic, cultural, touristic, social, etc.), according to the catalogues. Consistency of these documents was correlated to the final guide's *usability*. To ensure consistency, detailed instructions were given to all authors (about style, text size, emphasis on certain points, description of images, etc.). In a similar way, the third point (indicated with ✸3), including the generation of the digital material (creation of digital images and thumbnails) and its pre-processing, was also related to usability and the approach described above was followed in the initial quality design.

Finally, the fourth point (indicated with ✸4) shown in figure 1, is related to the criteria implemented during the distributed authoring process (involving the quality of the authoring tool and the coordination of the authors). Since several authors had to upload material, thus increasing the possibility of mistakes that would affect *functionality*, the initial design provided for full compliance with the catalogues. Moreover, authors were instructed to upload all items individually based on specific coding mentioned in the catalogues.

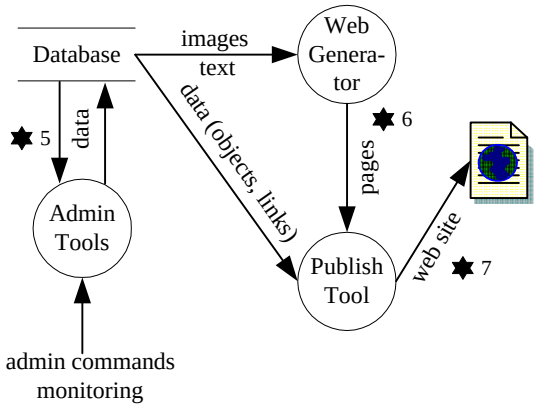

Figure 2. DFD Level 1, Part B.

With regard to the points shown in figure 2, the fifth point (indicated with ✸5 in figure 2) is related to the database and supporting (administrative) applications. Since data integrity is a sub-characteristic of *functionality*, the administrator had to be enabled to monitor the data and make any required modifications. The sixth point (indicated with ✸6) is related to the automatic publisher and interoperability issues. This tool collected all data from the database and, based on the initial catalogues, created the relevant pages (leaf pages) for the web site. Since lack of data is related to *functionality*, the system incorporated procedures to check and report incomplete pages, according to the initial quality design. Finally, the seventh point (indicated with ✸7) includes the criteria used for assuring the quality of the final product, i.e. the web page design (introductory pages, structure and all non-automatically generated pages) and was highly correlated with product *usability*. With regard to final product testing, the initial quality design provided for a survey of user-perceived quality [26] and modifications in the final product.

Summarizing, the quality plan emphasized mostly on data collection and data quality, rather than on the supporting tools. The reason was the great impact that content quality would have on final product quality, enforced by the fact that many individuals (with heterogeneous profiles and cultures) were involved in the production of the content. The creation of the supporting tools was relatively easy (thanks to the experience of the developing unit and the aforementioned quality assurance methods used).

4. PRACTICAL PROBLEMS

As previously mentioned, unforeseen problems may occasionally occur and the management needs to take immediate corrective actions. Modifications to the initial quality plan were necessary at all points presented in section 3. With regard to all other points of the project (such as specification of requirements, development of authoring tools, photography, image processing, database design, development of administration tools, publishing the data from the database, etc.) no deviation from the initial quality plan was reported.

Regarding the *first point*, it was proven that despite the introduction of the audit phase, the catalogues turned out to be incomplete, since most of the authors (preparing the documents for the items included in the catalogues) came up with sound suggestions of items to be included in the catalogues. Corrective action was not to follow the initial catalogues for the web authoring, but to expand the catalogues (using the audit phase as a continuous approval or rejection of authors' suggestions). Consequently, the photography phase had to be expanded to include new items.

The corrective actions taken with regard to the first point facilitated the work of the authors, but still minor problems were encountered with regard to the *second point*. Despite the instructions planed to ensure consistency, there were cases where few authors deviated from these instructions, especially towards the latest stages of document delivery. The corrective action taken was the performance of a thorough sampling test (examining conformance to instructions) in the latest stages of document delivery.

With regard to the *third point*, problems were related to the expansion of the initial catalogues that could result in documents lacking visual material. The corrective action taken was to break up the task of photography in two phases. The first phase was completed as designed, while the second commenced after the completion of the final catalogues. This caused a shift in the Gantt chart, but not in the overall project delivery (since taking and

processing photographs could run in parallel with most project tasks).

Regarding the *fourth point* and the use of the authoring tool to distribute uploads of data into the database, the problem was that this task should either follow the initial catalogue or –following the changes in the previous points– be modified to include the authors' suggestions. An entirely different plan had to be followed based on the new form of the data. This led to minor modifications to the uploading tool, but also caused another problem related to the redistribution of data into categories. In other words, the structure of the data (determination of new categories and sub-categories) had to change as well, in order to assure final project's functionality, following the modification of the catalogues; therefore, corrective action had to be taken. The introduction of new data only in one case resulted in the introduction of a new category. However, the amount of data in many categories exceeded the initial estimation, therefore, new sub-categories were introduced.

As a result of changes related to the previous point, modifications related to the *fifth point* were also required. The initial administrative tool (a typical monitoring tool) had to be modified to a more functional tool, since it now had to be used for the location of proper data uploads, the separation and denomination of proposals for new entries into catalogues, the incorporation of approved entries and rejection of the non-approved and to report data that did not fit into a catalogue category. The consequent corrective action taken was the modification of the administration tool so that it could be used for these functions. This part of the corrective actions was critical, since due to the modifications to the initial plan, data integrity was not ensured any more by the use of the catalogue (forced by the authoring tool), but had to be ensured by procedures incorporated in the administration tool.

The automatic publisher, *sixth point*, was initially designed to base page generation on catalogues, presuming that no additional data were inserted into the database. However, after the modifications to the authoring tool and the human intervention (using the administrative tool) that was not the case. The corrective action taken was to include extra checking procedures into the publisher for missing data (pages lacking text, images, or thumbnails) or unused data. Furthermore, the publisher tool was enhanced with capabilities to detect repeated data in pages (and report these pages for further testing) and generate pages even if certain data (images or thumbnails) was missing, provided that at least a text was available.

Regarding the *seventh point*, as expected, the web site's usability was not only dependent on the content, but also highly dependent on the structure of the site [27], the links and the overall design philosophy [28]. To cope with this matter, the web site design followed recent proposals [29,30] on how to organize web sites and increase usability. Furthermore, the structure of the web site had to be modular enough to enable automatic page generation based on the data stored in the database. In an effort to maximize usability and ensure maximum user satisfaction, measurement of users' opinion [31] was introduced[2].

Summarizing, practical problems –mostly dependent on data quality– caused deviations from the initial quality plan. Corrective actions taken emphasized on the introduction of additional audit procedures focusing on data quality. In order to support such procedures, slight but unforeseen modifications to the supporting tools were necessary. These modifications had to be introduced as soon as possible in order to ensure the quality of data, which was a critical factor for the overall system quality.

To present the size of the project and justify the need for immediate corrective actions, it should be noted that the project had to cover 11 prefectures of Western Greece, a relatively large geographic area full of historical monuments, natural beauties and other tourist attractions. The initial project requirements demanded the collection of original and unpublished material (text and photos) in a relatively limited time period, thus introducing a time factor that was critical for the success of the project. Consequently, the corrective actions were essential not only for quality assurance of the final product, but also for ensuring that the project would end in due time. Indeed, it was completed on time (according to the initial schedule).

5. CONCLUSIONS

In most developing units, effort is made to assure final product quality by means of a quality plan defined in the early stages of the project. During the phase of quality design, quality goals are defined and final product quality characteristics, on which development will focus, are documented. This leads to the determination of the method to be used in order to reach the goals, as well as the placement of emphasis on specific quality characteristics that require special attention. In the presented case study, these characteristics were usability and functionality. The achievement of these goals depends, to a great extent, on the quality plan (selection of suitable goals and determination of the appropriate methods).

Developing units experienced in quality assurance, using a sound quality process and being on a high maturity level, are usually successful in this task. Even in such units, deviations are not rare. In the case of less mature developing units –like the one in the presented case study– due to lack of experience, quite often, the initial quality plan is not followed in every aspect and unforeseen factors that could compromise product quality are occasionally introduced in the development process.

[2] This survey was part of a broader act that included more elements than web site usability.

In such cases, the management[3] is asked to play an important role. If the developing team sticks to a non-applicable quality plan and does not take immediate corrective actions, the product quality might be significantly compromised. It is the management's duty to introduce corrective actions into the entire development plan, such that will not act as temporary 'fire extinguishers', but will form part of the overall commitment to quality. The ability and success in dealing with such problems of quality plans is a valuable experience that helps the developing unit to obtain a higher level of maturity and achieve better planning in the years to follow.

A conclusion based on this case study is that the existence of a proper quality plan is a determining factor for achieving quality goals. However, in many cases, the initial quality plan needs modifications in order to assure final product quality. In such cases, flexibility is demanded and immediate, sometimes drastic, corrective actions should be taken, always bearing in mind that the one should be committed to quality and not to the initial plan. This is a critical decision for achieving final product quality. With the presentation of this case study we demonstrate (using as an example the development phases of a real world product) that product quality is not only assured by the initial quality plan. Quality assurance is a continuous activity that requires alertness and commitment to quality, regardless the cost.

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[3] The term 'management' is used to include the project manager and quality manager or, if the latter does not exist (as in the case presented) the quality consultant.