Managing Factors Which Influence Software Quality Results

Luis Fernandez Sanz, Teresa Diez, Carmen Pages, Jose Javier Martinez
University of Alcala, Alcala de Henares, Spain
Contact(s). luis.fernandezs@uah.es, teresa.diez@uah.es, carmen.pages@uah.es, josej.martinez@uah.es

Abstract— Although the discipline of software quality has been progressing towards to high levels of effectiveness in software projects, project managers suffer from a lack of clear guidelines to help them decide the best options both in terms of effectiveness and efficiency and in expected results in quality. Although there are many metrics for software quality already available, there is today a very weak link between quality metrics and cost and efficiency results. In this paper, we present the approach of the Iceberg Project, an R&D project funded by European Union under the IAPP Marie Curie program where the analysis of factors which influence software quality during projects is linked to a model of Cost of Poor Quality (COPQ).

Keywords/Index Terms—software quality, cost effectiveness, project manager, cost of quality, software metrics.

1. INTRODUCTION*

From early times of software engineering, attention to software quality has been evident. As all sectors, products and services have embraced the concept of quality management and improvement as one of the key axis of global management (together with finances and time to market), the attraction to quality is not a quite distinctive characteristic of software. In Europe, quality is an essential factor for competitiveness so it is strategic for all European stakeholders. The compilation of incidents "Inside risks" by Peter Neumann from the 1980s to today in www.csl.sri.com/users/neumann/insiderisks.html let us realize there is room for improvement in software quality. For European industry, competitiveness in software depends on innovation and quality given that prices cannot be reduced without impacting the workforce. Therefore, Europe should lead all aspects of software quality both in research and practice. It is worth to note that software is an important part of ICT not only in information systems but also as an embedded component of many products or services.

Certainly, software development activity differs clearly from manufacturing of other types of products: besides intrinsic differences between software and other products (Pressman, 2004), processes are different from the most traditional manufacturing of products (Christenson, 1992). In a parallel way to software engineering evolution, the discipline of software quality has been also evolving and generating well-known frameworks and processes models like CMMi (CMMI Product Team, 2006) and ISO15504 (ISO, 2004). Lastly agile methods (e.g. SCRUM [14]) have been emerged with energy as proposed solutions for quality and productivity while more traditional proposals like Unified Process (Jacobson et al., 1999) or classical methodologies and life cycles models are not today choices if not embedded within bigger frameworks, specially, because as opposed to them, they have been well accepted but almost no real rigorous data on benefits have been provided (at least, different studies on CMMi influence have been published during the last years, e.g. (Goldenson and Gibson, 2003) (Hersbleb, 1994).

However, quality is not an isolated feature as it is conceived as a trade-off between results and costs: practical implementation entails issues that a company needs to address and that determine that final success of a SQA process in terms of quality/cost efficiency. There is today a very weak link between quality metrics and economic data: i.e, even though it may be possible to have estimates of quality attributes (more or less accurate, depending on the attribute), the cost entailed by such quality is often unknown. This is a tricky issue for many software organizations that strives to have a clear picture of the quality-cost relationship needed to support their "business" decision processes.

It is true that a good number of studies, e.g. (Van Solingen and Rico, 2006) (Rico, 2004) show productivity improvement and good ROI of quality techniques based on decreasing rework and bad quality costs (Fleckenstein, 1983) especially when the focus is put on prevention and early detection because fixing

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cost rises sharply when defects remain undetected throughout the project phases (Pressman, 2004) (Harrington, 1987). Many more have analyzed the impact of different factors in software quality and productivity. It is important to remark that SQA techniques require non trivial investment in human effort (hence money) so their use should be adapted to each organization both to be effective (e.g. providing an easy-to-use environment) and to be efficient and cost-effective (e.g. reviewing all the code is usually unfeasible so a previous selection of defect-prone parts using metrics and Pareto principle and the help of automatic reviewing tools are a must). In general, adequate quality assurance efforts tend to make more stable delivery schedules and quality levels (Hersbleb, 1994).

However, the feeling in companies (and especially among project managers) is still frequently influenced by the uncertainty as two main challenges appear as unsolved items:

- Given a quality constraint, what is the cost that a company incurs to achieve, measurably, that level of quality? Is there a way to minimize such cost, standing the required quality?
- Given a budget constraint (which prevents from performing all the required quality activities) what is the cost that a company incurs for the missing quality activities? Missing activities implies bad quality: how does this “bad quality” manifests itself during operation, and how much does it cost?

The two points together represent the trade-off that companies typically address in order to decide whether to invest or not in a given quality initiative, and to what extent. At project level, project managers have to cope with the well-known triangle of project dimensions (money, time and quality) and have to estimate how changes in one or two affects the others: as expected due to usual bad management practices, (McConnel, 1996) reports some estimates of up to 40% of cases where project managers are simultaneously pressed along the three dimensions at the same time.

It is true that specific analysis of trade-off of quality techniques has been carried out by remarkable researchers like David F. Rico with his series of studies on ROI for quality techniques and processes (e.g. (Van Solingen and Rico, 2006) and all the studies published in www.davidfrico.com). But it is also clear that deeper and complementary studies should be carried out to address many other factors. As an example see a flavour of variety in (Fernandez and Misra, 2011). It is also essential the consolidation of data from industry and from research.

In order to gain a more solid and deeper knowledge on the relation between quality and economic results in software projects, a consortium of universities and companies specialized in software quality have been granted by European Commission under the IAPP Marie Curie programme to carry out a four years' project named ICEBERG. The consortium is leaded by Assioma.Net (http://www.assioma.net/), a specialized Italian SME (Small Medium Size Enterprise). As research institutions, the department of Computer Science of the University of Alcalá (www.cc.uah.es) and CINI with researchers of the University Federico II (http://www.unina.it) with an industrial SME partner in Spain, DEISER (www.deiser.com), specialized in software quality and engineering.

This project is aimed at producing a Cost of Poor Quality (COPQ) Iceberg model. The idea is that many of the costs of quality (fig. 1) are hidden and difficult to be identified by formal measurement systems and only a minority of the costs of poor and good quality is quite obvious – i.e. appear above the surface of the water. Three major categories of costs of poor quality exist in organizations:

- Appraisal and inspection costs.
- Internal failure costs.
- External failure costs.

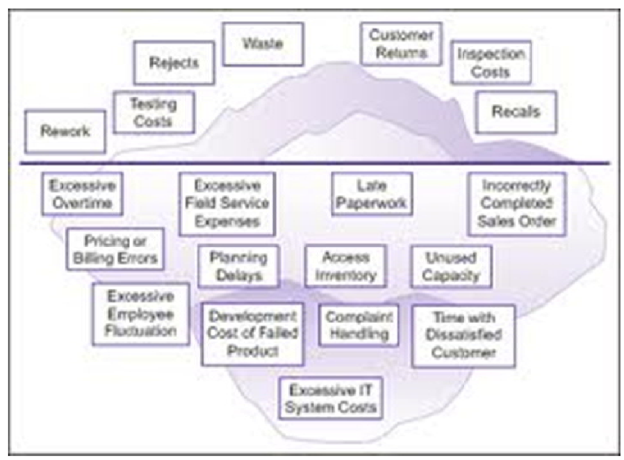

FIGURE 1. HIDDEN COSTS OF QUALITY

But there is a huge potential for reducing costs under the water, since identifying and improving these costs will significantly reduce the costs of doing business. When evaluating projects, data on poor quality help identify charter and support projects with the greatest potential for reducing costs. Some studies show how much the investment in the V&V phase can lead to significant gains: (Black, 2002) highlights that the gain obtained within an organization may range from 20% up to even 70% of the total cost of production, depending on the ability of the company of setting up long-term policies, accounting for an appropriate planning in the early phases of the development cycle, instead of a mindset that considers testing as an activity starting only after the implementation.

In order to reduce these costs (the iceberg submerged part), extra effort must be applied. Quantifying such effort in relation to how many defects (i.e., how much of the iceberg) out will be exposed is extremely difficult, due to the unknown relations and the intrinsic non-linearity between (non-) quality and cost. Also, identifying the activities to be carried out most suitable for the specific system under evaluation (and thus to the "iceberg" features) is an issue currently left to the Quality Assurance (QA) experts and testers relying on intuition and subjective expertise: no systematic method is known for tailoring QA activities to the product, accounting at the same time for the effort allotted to each subcomponent.

Advances in software engineering and quality have lead to many techniques, methods, and tools such as process models and methods and QA methods. This has led to improvements in some projects. However, the above mentioned challenges for project managers remain, especially when working with SME-Techniques or processes which work well in large organizations in traditional one-site projects may be extremely difficult in some SMEs or GSD (Global Software Development) settings. But the fact is that many European software companies outsource implementation to other countries (EU and non-EU) to cut costs, impeding communication with the requirements sources. Thus, wider and deeper analysis is needed to offer practical knowledge to industry. Absence of more comprehensive data implies a lack of guidance for managers and organizations to organize and optimize the performance of resources and decisions on QA activities.

The main EU research frameworks, such as ESF, ESA, EUREKA! or FP7 have not targeted efforts on these aspects for practical software quality. In fact, activities funded by the EU tend to address specific technical issues (e.g., QUAREM, SMSCOM, etc.) or are focused on Open Source Software (e.g., FLOSSMETRICS, QUALOSS, etc.): there is little work covering a wide perspective on software quality decisions for project management, including the ones on the human and organizational side of QA and the adaptation to specific settings. Some results and actions are dispersed among different areas and projects in EU projects. Although there is not a structured corpus of facts and data related to quality costs and benefits, it is clear that there is at least a number of studies on the factors which influence software quality and economics although usually they are dispersed. Of course, not all the studies are equally solid, addressing significant samples and using correct inference methods. This is one of the goals of the project: compiling, reviewing and structuring information of applicable studies.

The structure of this paper is the following one: Section 2 shows the structure of the ICEBERG project while Section 3 presents some conclusions.

2. THE ICEBERG PROJECT

The structure of the research programme of the ICEBERG project is summarized in the following workflow according with a classification in Work packages (WP) and Phases. One special characteristic of this project (defined by its allocation to IAPP Marie Curie programme) is the goal of promoting Transfer of Knowledge (ToK). The ICEBERG project proposers intend to carry out a sound in the SW Quality Assurance domain, with these twofold main objectives:

- Boosting the researchers of the future:
    - creating a long lasting research network involving both the commercial and non-commercial sectors to foster co-operation based on joint research projects;
    - promoting innovation and knowledge transfer through secondment of researchers;
    - providing diverse career possibilities & research experience for researchers, knowledge sharing/exchange.
- Starting from the Iceberg analogy, investigating, defining and implementing models-based process able to:
    - identify activities resulting from poor quality,
    - define how to estimate costs associated with i) testing activities in relation with a given quality and ii) missing, incomplete or wrong implementation of testing activities/phases,
    - collect data iteratively, and use it to estimate costs;
    - analyze results and support on decision-making on the next steps at quality management level.

The whole activity is structured through several work packages. In the first phase, covering WP2, the consortium will define the preparatory actions as a basis for the goal of ToK programme and preliminary studies, such as:

- analysis of software QA standards and models;
- state of the art analysis of product\process metrics, process analysis strategies and modeling technologies;
- analysis of the decision-making processes on software quality assurance investments in several sectors (Telco and Finance as primary targets but also automotive);
- definition of product/process quality attributes of

interest, of relevant product/process metrics;

- definition of validation scenarios and assessment metrics.

The second phase will concern with the core research activities and transfer of knowledge. In this phase the new innovative and effective models, the database (concerning WP3) and the ICEBERG proof of concept tool (concerning WP4) will be developed and refined, through "continuously" re-focuses research activities as a consequence of the preliminary testing results. Then the refined models will be applied and evaluated in past and on-going projects provided by the industrial partners, with qualitative assessments.

The third phase will proceed in parallel with the aforementioned research (covering WP5), because it deals with i) dissemination and outreach activities, ii) best practices collection and iii) the production of handbook and training materials, to be widely disseminated.

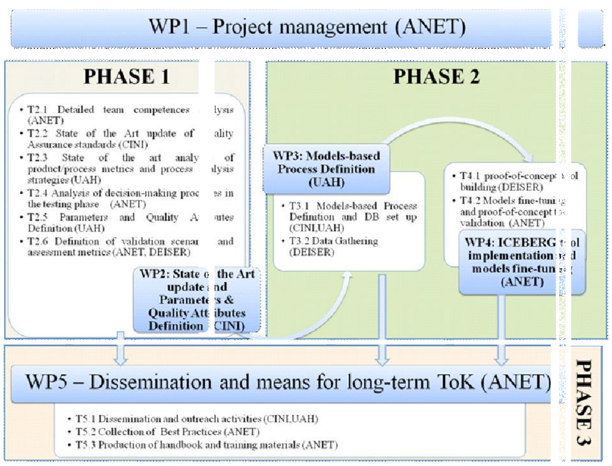

FIGURE 2. WORKFLOW OF THE ICEBERG PROJECT.FOR TWO AFFILIATIONS.

The ICEBERG partners forecast immediate benefits of the proposed collaboration such as:

- Know-how transfer and gain of new knowledge.
- Conferences and academic events. Expertise in public speaking.
- Experience of industrial research and training on the job for all researchers.
- Researchers learn to manage Intellectual Property (IP) and possibility for registration of patents.
- Attract interest of stakeholders on current and future project results through dissemination actions and eventually outreaches activities.
- Investments in people via specialized on-the-job trainings that lead to the creation of new competence and synergies within the consortium.
- Structure a quality framework for research, development and innovation, improving efficiency.
- Availability of the formalized project models-based process in terms of ICEBERG handbook and the proof of concept IT tool.

For the expected long term, the most clear benefits expected from the project are:

- Higher reputation in the research field and reinforcement of the partners international profile.
- Improving the European scientific excellence in the area of software QA.
- Develop new and lasting research intersectoral collaborations (i.e. expectations of further European research projects)..

3. CONCLUSIONS

The ICEBERG project is aimed at supporting the 'Innovation Union' flagship initiative by strengthening research and business performance and by promoting innovation and knowledge transfer throughout the EU. Stronger cooperation between universities and business via staff exchange will encourage entrepreneurship and help to turn creative ideas into the innovative projects results that can efficiently address European and global societal challenges. ICEBERG action contributes also to meet all these challenges and raise employment rates focusing on the key priority of boosting more skilled researchers, capable of contributing and adjusting to technological change with new patterns of work organization. This is a considerable challenge, given the rapidly-changing skills needed by the market and the persistent skills mismatches in EU labor market.

The crisis has underlined the importance of the more skilled workforce: it has accelerated the pace of economic restructuring, displacing many workers from declining sectors to unemployment due to a lack of the skills required by expanding sectors. Serious deficits in qualified professionals, in management and technical, job-specific skills are hampering Europe's sustainable growth objectives. As reported in (European Commission, 2010) there will be a shortage of ICT practitioners by 2015 estimated at 384,000 to 700,000 jobs, jeopardizing the sector itself but also the ICT dissemination across all sectors of the economy. Furthermore, within quality assurance applied to specific domains (Telco, Finances, Automotive…), this lead to a lack of competences that causes increase of costs of investments.

Going beyond the research goal of providing tools and management decision mechanisms for software quality in projects, ICEBERG will create a repository of expertise which might help European software organizations to be more competitive and productive by addressing both correct decisions and skilled specialists in the discipline of software quality.

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