Software Quality Assessment and Error/Defect Identification in the Italian Industry Preliminary Results from a State of the Practice Survey

Giuseppe Scanniello
University of Basilicata
Dipartimento di Matematica e Informatica
85100, Potenza, ITALY
giuseppe.scanniello@unibas.it

Fausto Fasano
University of Molise
STAT Dept.
86090, Pesche (IS), Italy
fausto.fasano@unimol.it

Andrea De Lucia, and Genoveffa Tortora
University of Salerno
School of Science
84084, Fisciano (SA), ITALY
adelucia@unisa.it, tortora@unisa.it

***Abstract*—In this paper, we present the results of a survey aimed at comprehending the relevance and the typology of the software quality assessment approaches and software error/defect identification methods/approaches used in the industrial practice. The context of this study was the IT industry. In particular, we involved industries/organizations that develop and sell software as a main part of their business or develop software as an integral part of their products or services. The results of a preliminary analysis indicated that software quality assessment and software error/defect identification are very relevant and regard almost the totality of the interviewed companies. Furthermore, the widely used and most popular practice is testing, while an increasing interest has been manifested in distributed inspection methods.**

***Keywords*-empirical investigation; quality assessment; error/defect identification; inspection; state of the practice survey; testing.**

I. INTRODUCTION

To construct high quality products engineering disciplines check intermediate and final artifacts so that defects can be identified and then removed. Similarly, software development needs complementary combination of design and verification/validation activities to produce and deliver high quality software products [24]. In fact, today it is widely recognized that verification and validation activities are needed to assess and maintain the quality of a software product.

In the software engineering community, there is a growing interest towards surveys investigating the state of the art and practice about the use of processes, methods, and tools within software products development and maintenance [12], [17], [19], [22] as well as for software verification, validation, and review [5], [14].

Surveys are investigations to gather data from respondents, using a questionnaire composed of closed or open questions [23]. Depending on the survey purpose, it may focus on opinions or factual information [16]. Data can be collected by: face-to-face and phone interviews, mail, e-mails, and web pages. E-mail surveys are both very economical and very fast. They are often best for sensitive items, and there is no interviewer bias. On the other hand, email surveys are limited to simple questionnaires. The data can be analyzed to derive descriptive and explanatory conclusions [2] that are applicable only to the selected population.

In this paper, we present the preliminary results of a survey organized by three Italian Universities – University of Basilicata, University of Molise, and University of Salerno – to understand the state of the practice of software quality assessment and software error/defect identification in the IT Italian industry.

The survey was conducted from the spring 2008 to the winter 2009. We invited to participate 70 companies/organizations that develop and sell software as a main part of their business or develop software as an integral part of their products. We received by e-mail 30 fully completed questionnaires from key people of the invited companies/organizations.

The main findings of the study can be summarized as follows:

> *Software quality assessment and software error/defect identification are very relevant and regard roughly almost the totality of the interviewed companies. The widely used and popular practice is testing. An increasing interest has been however manifested in distributed inspection methods.*

The remainder of the paper is organized as follows: Related work is presented in Section II, while Section III presents the design of the study. The preliminary analysis of the data and the threats that may affect the validity of the results are discussed in Section IV. Final remarks and future work conclude the paper.

II. RELATED WORK

Methods and techniques for software quality assessment and software error/defect identification have been largely experimented in case studies and controlled experiments [8], [18]. A number of systematic reviews and state of the art surveys have been proposed in the literature on these topics [4], [7], [15], [17]. On the other hand, only a few numbers of state of the practice survey have been conducted in the

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past [5], [14]. Accordingly, in the following subsections we describe state of practice surveys related to software review and to process and methods for software development and maintenance.

A. Software Reviews

The focus of the survey presented in [5] is the analysis of the current state of the practice in industry regarding the application of reviews and inspections. The major focus is on the concrete application of walkthroughs, peer reviews, and formal inspections. Similarly to our study, the results indicate that there are still many objections against the usage of the techniques considered in the study. The main highlighted concern is that these techniques are perceived as too time consuming and thus not applicable in practice. Differently from us, this state of the practice surveys is only focused on walkthrough and software inspections.

Based on the results discussed in [5] and [21], Jedlitschka et al. [14] conduct a survey to investigate the state of the practice of inspection technology in German software industry decision makers. They involved 92 companies and observed that information regarding the impact of technologies on product quality, cost, and development time, as well as on technology cost-benefit ratio is considered highly relevant for the interviewed decision makers.

B. Software Development and Maintenance

Hauge [12] explores and investigates the open source phenomena in the IT industry. He adopts both a literature study and a web-based survey. The sample is composed of companies from the Norwegian software industry. The results of this study show that the open source is widely used. In particular, he observes that about 50% of the Norwegian IT companies adopt open source code in the marketed software products.

Conradi et al. [19] presents a state of the practice survey on risk management in software development with off-the-shelf software components. The authors interviewed software companies from Norway, Italy, and Germany. The results show that off-the-shelf components normally do not contribute negatively to the quality of the software system. Furthermore, the study also reveals that issues such as the underestimation of integration effort and inefficient debugging remain problematic.

Torchiano et al. [22] reports on a state of the practice survey conducted among 59 Italian software companies. This survey is conducted within a research project [9] and aims at analyzing the state of the practice in software migration. The results of the survey indicate that about 66% of the interviewed companies have some experiences in migration tasks. The study also highlights the lacking of tools for the execution of migration tasks. This however does not seem to constitute a problem for the interviewed companies.

III. Definition and Design

The goals of the survey we have conducted in the IT Italian industry can be summarized as follows:

Primary goal: comprehending the relevance and the typology of the software quality assessment approaches and software error/defect identification methods/approaches used in the practice.

Secondary goal: identifying the main problems and the actual needs (methods, techniques, and tools).

With respect to the goals, the following research questions have been defined and investigated:

RQ1 What is the relevance of quality assessment and error/defect identification in IT Italian industry?

RQ2 What are the most popular and widely used practices?

RQ3 What are the main problems encountered to employ approaches/methods for quality assessment and software error/defect identification?

RQ4 Is there an interest in never used approaches/methods for quality assessment and software error/defect identification?

The survey has been conducted through the following three steps:

(i) Designing a common questionnaire that includes the main questions and perspectives;
(ii) Conducting the survey leveraging the industrial contact networks of the Universities involved in the study;
(ii) Analyzing the data and packaging the results.

A. Conceptual Model

The conceptual model clarifies the meaning of some terms (e.g., project and inspection) and describes all the entities of interest for the survey.

Project. It represent a completed software project.

Software artifact. It is a tangible product created during software development.

Testing. "The process of analyzing a software item to detect the differences between existing and required conditions (that is, bugs) and to evaluate the features of the software items" [1].

Inspection. "A static analysis technique that relies on visual examination of development products to detect errors, violations of development standards, and other problems" [13].

Distributed Inspection. It is a method to support geographically distributed teams in the inspection of software artifacts.

Pair Inspection. It is an informal method for inspecting software artifact. The author's artifact and an inspector are require to accomplish the inspection.

Walkthrough. "A static analysis technique in which a designer or programmer leads members of the development team and other interested parties through a segment of documentation or code, and the participants ask questions

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and make comments about possible errors, violation of development standards, and other problems" [13]

We identified three areas of interest for collecting the data:

Demographic information concerns the interviewed company/organization (company, the hereafter) and the respondents.

Relevance and typology regards information on projects on which the considered quality management methods and approaches have been used.

Main problems and needs is about the issues to adopt the software quality assessment approaches and software error/defect identification methods.

B. Identification of the Target Population

The target population consisted of IT companies that develop and sell software as a main part of their business (e.g., software house) or develop software as an integral part of their products or services (e.g., healthcare domain).

The selection of the companies (*sampling*) has been conducted using the network contacts (for convenience and opportunity) of the research groups of the authors. The contacts network included companies that participated to our research projects [9] and/or employed or hosted (for external stages) students with a Master or a Bachelor degree from the following Universities: University of Basilicata, University of Molise, and University of Salerno.

C. Questionnaire Design and Data Collection

We have developed the questionnaire following the standard schema proposed in [5]. Figure 1 shows the designed questionnaire. The questionnaire contains both open (some required just filling in a comment or text) and closed questions. According to the conceptual model, the questionnaire consists of different questions that depend on the usage or not of software quality assessment approaches and software error/defect identification methods and on the will of employing them in the future.

The questionnaire was introduced with a brief motivation sketching the general problem to be investigated.

The importance of this study and our objectives were inserted in an accompanying letter attached to the questionnaire. Great care was taken to ensure ethical requirements and privacy rules imposed by the Italian regulations. Furthermore, we also clarified that all the information was considered confidential and that the data were used only for research purposes and revealed only in aggregated form.

The respondents sent the answered questionnaires by e-mail. The rationale for using this communication medium was that the companies may consider sensitive the information treated in the survey.

IV. RESULTS

Among the 70 invited companies, 48 gave their availability to participate to the survey, while 32 correctly filled in the questionnaire.

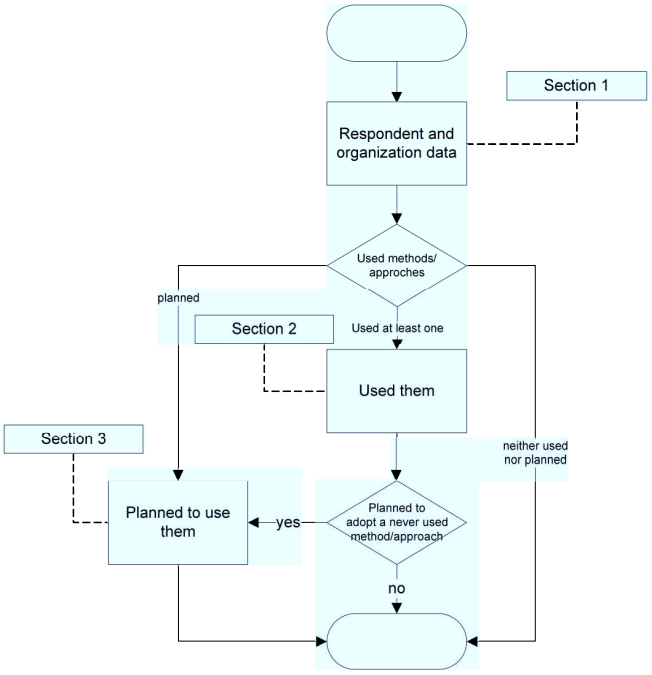

Figure 1. Designed questionnaire

A. Respondents' Background and Companies Characteristics

The age of the respondents ranged from 24 to 50 years old with an average of 35 years (only 2 were female). Regarding the role of the respondents, 73% of them stated that they had management roles (i.e., projects manager, IT manager, quality manager, or production manager) while 27% were developers or software architects. Among the respondents, 93% had a master degree, 7% had a bachelor degree. None of the interviewed had a PhD. 80% had a specific IT degree.

The interviewed companies were 60% independent and 40% subsidiaries (i.e., controlled by a larger and more powerful company). Among these companies, 67% were private companies and 33% were quoted on the Italian stock exchange. None was a government organization. 53% of the companies were either small or medium-sized enterprises (i.e., < 250 employees), while 47% were larger ones.

Note that larger companies were composed of businesses units. For smaller companies, the number of employees of the business unit coincided with the total number of the company employees. For the larger companies, the size of the business units of the respondents were distributed as follows: 13% were micro (< 10), 67% were small (between 10 and 50), and 20% were medium (between 50 and 250).

The companies come from different industrial domains. In particular, most of them worked in the area of software consultancy (40%). On the other hand, 33% of the companies worked on software development and 27% provided IT services to others.

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The typical size of the software systems handled/developed was: from 10 to 100KLOCs (7%), from 100 to 500 KLOCs (80%); more than 500 KLOCs (13%).

B. Relevance of the used practices and influential factors

All the respondents of the companies, that never used the methods/approaches considered in the survey, have planned to adopt at least one among: testing, inspection, distributed inspection, and walkthrough. These were 20% of the companies.

On the other hand, 40% of the companies regularly employed at least one of the considered methods/approaches, while 13% of the respondents declared that their companies often used testing, inspection, distributed inspection, and walkthrough. Finally, 27% of the companies occasionally used them.

Among the companies that have used at least one of the methods/approaches (i.e., 24 out of 30), most of them (i.e., 14 out of 24) regularly used testing techniques, while 4 companies stated that testing has been often used in the past. Only 2 respondents indicated that their company occasionally used testing.

Inspection methods (i.e., variations of the Fagan's process) to identify defects in software artifacts were already used in only 2 companies, while 10 out of 24 companies often used them. Inspection methods were occasionally employed within 6 companies, while 4 stated that these approaches have never been employed, but will be used in the future. Only 2 companies were not interested in using inspection methods in the future.

Distributed inspection methods have been rarely used within 6 companies. Moreover, 6 respondents stated that his/her company has never used distributed inspection, but this technique will be used in the future to identify defects in software artifacts. Finally, 12 out of 24 companies have never used a method for distributed inspection and did not plan to employ it in the future.

The pair inspection was regularly used in 6 out of 24 companies, while only 2 companies often used this technique. Pair inspection was occasionally used within 8 companies. The respondents of 8 companies stated that this technique was never used. Among these companies, 6 stated that were not interested in using pair inspection in the future.

Walkthrough was regularly used in 4 companies, while 6 companies often employed this practice within their projects. Walkthrough was occasionally used within 10 companies (i.e., 42% of the cases). Finally, 4 companies never used this practice and were not interested in using it.

We also asked to indicate the approach/method the respondents considered simpler, more effective, less expensive, and with a best cost benefit ratio. They identified the pair inspection as the simplest method to apply (i.e., 12 out of 24), while testing was considered the more effective and with the best cost benefit ratio. The less expensive approach/method was considered the pair inspection. Further details can be found in Figure 2.

The greater part of the respondents (16 out of 24) stated that the methodological aspect is the predominant factor to effectively identify defects and improve the quality of software artifacts. The human factor was indicated as the secondary concern (8 out of 24).

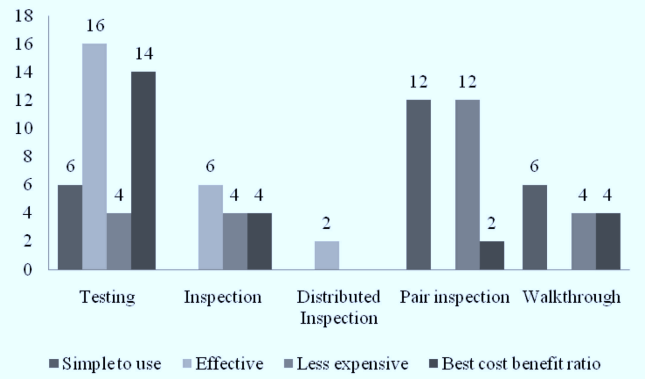

Figure 2. Results of the used practices with respondents considerations

C. Main Problems and Needs

We asked the respondents to indicate the methods they were interested in using among the never used ones. Distributed inspection was the method on which the respondents manifested greatest interest.

The main problems in the industry to adopt variations of the inspection process proposed by Fagan were (in increasing priority order): lack of specialized employees, technique not properly known, technique too much expensive, and lack of time. The companies that never used this method were 10 out of 22.

Similarly, the main problems to employ a distributed inspection process were (in increasing priority order): technique not properly known, short time to market, technique too much expensive, and trust in the technique. Anyway, 16 out of 22 companies were interested in this method.

Regarding, pair inspection 14 companies never used it. Most of them never used this practice since it was not properly known. The factors identified as less influential to use this practice were: technique too much expensive, short time to market, and lack of specialized employees.

The respondents were also asked to describe other techniques used in the company to identify defects within software artifacts. Nobody answered to this question, thus enforcing the assumption that the methods/approaches investigated in our survey are the only employed within the involved companies.

Finally, we asked the respondents whether their company were interested in experimenting inspection, distributed in-

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spection, and pair inspection. All of them generally manifested the same level of interest on these methods.

D. Findings

We summarize the main findings emerged from the conducted state of the practice survey according to the defined research questions.

RQ1. The data analysis showed that software quality assessment and software error/defect identification are very relevant in for the IT companies involved in the survey.

RQ2. Testing is the most employed practice. The second larger employed practice was formal inspection based on the original process proposed by Fagan.

RQ3. The main problem to use pair inspection and distributed inspection is related to their scant popularity. On the other hand, the main problem to introduce the other approaches/methods is the short time to market and the lack of properly skilled employees in the company.

Regarding distributed inspection, most of the companies never used this technique for the following three reasons: *(i)* team members are not geographically distributed; *(ii)* there is lack of tools for supporting distributed inspection processes; *(iii)* inspection tools (if available) are not integrated with Software Configuration Management [11] (SCM) systems.

Despite the scant usage of distributed inspection, it aroused great curiosity and interest. This is probably due to the fact that respondents perceived distributed inspection less expensive than traditional inspection. Further, distributed inspection avoids problems related to the different time zones, when synchronous discussions are not accomplished [8].

RQ4. Most of the companies were interested in using inspection, distributed inspection, and pair inspection within pilot projects.

E. Threats to Validity

Internal validity threats regard external factors that may affect the results. In industrial surveys, it is usually impossible to know whether the respondents truthfully answered the questionnaire. Scarce motivation to answer the questionnaire could also affect the results. To mitigate this threat we properly designed the survey. Another factor that may have influenced the internal validity is the number of invited companies that did not answer the questionnaire. Even, the interviewed within our industrial contact network may influence the internal validity. Another threat could be related to the difficulty of comprehending the questions (e.g., ambiguous, not clear, not well formulated). To mitigate this threat, the questionnaire was designed to *(i)* minimize comprehension problems; *(ii)* reduce complexity and memory overload; *(iii)* increase respondent's attention.

External validity concerns the generalization of the results. This threat is present in case of industrial surveys. In fact, we cannot be sure that our sample is representative of the Italian IT industry in general, and we are aware that Southern Italy is over-represented compared to Northern Italy. Accordingly, replications are needed to increase our confidence in the achieved results.

Construct validity threats concerns the metrics used in the study. In our case, the questionnaire was designed using standard ways and scales [20]. The questions were formulated to minimize possible ambiguities.

V. Conclusion and Future Work

The survey presented in this study aims at studying and understanding the state of the practice of software quality assessment and software error/defect identification in the Italian industry. Accordingly, we invited 70 companies to participate and received 30 fully and correctly completed questionnaires.

The target population consisted of decision makers in software development. Indeed, we considered IT Italian companies that develop and sell software as a main part of their business (e.g., software house) or develop software as an integral part of their products or services (e.g., commerce in the healthcare domain).

The main results of the presented study show that software quality assessment and software error/defect identification are relevant and regard roughly almost the totality of the interviewed companies. Among the practices considered in the study, software testing is the widely used and popular one. The greater part of the companies that regularly uses software testing is not interested in the approaches/techniques we have investigated in the survey presented here. Future work will aim at investigating this point.

Furthermore, the state of the practice survey and the subsequent interview, in particular, highlighted some further discussion points with respect to the global software development and the quality of software artifacts produced by geographically distributed software engineers:

(i) First of all, the business units of the respondent are often geographically co-located. This indicates that global software development is only marginally applied in the interviewed software companies. However, in case a company has more distributed business units, they communicate using standard synchronous (e.g., instant messaging) and asynchronous communication media (e.g., email and/or forum).

(ii) Secondly, there is lack of tools that effectively support distributed teams during software inspections. Despite a number of distributed inspection processes and tools have been proposed [9], [16], the industrial practice is still far to adopt them. This indicates a gap between research laboratories and industrial reality that deserves a concrete cooperation between academy and industry based on technology transfer projects.

(iii) Finally, the proposed distributed inspection tools are not integrated with the SCM system used in the company. This point is the most critical. Indeed, most of

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the software companies use SCM systems to access the level two of CMM and to get ISO 9000 certification, while distributed inspection tools are not widely employed in the industrial practice despite they are recognized useful to improve software quality. We think that the integration of these tools within widely known systems for the management and version control would significantly increase their diffusion, thus improving the quality assurance of software systems developed in distributed contexts. This conjecture needs to be further investigated conducting industrial user studies within industrial software projects.

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