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A DISCUSSION ON ASSURING SOFTWARE QUALITY IN SMALL AND MEDIUM SOFTWARE ENTERPRISES: AN EMPIRICAL INVESTIGATION

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Subject review

Under the studies of general core activities including software inspection, review and testing to achieve quality objectives in small-medium size enterprises (SMEs), the paper presents a contemporary view of such companies against quality measures. The results from a local empirical investigation of quality standards in the Turkish software industry are reported. Around 150 software companies have been approached from which 17 detailed feedback inform that in order to ensure software quality, standards including internationally recognized International Standards Organization (ISO) and Capability Maturity Model Integration (CMMI) are given credit. However the substantial workload and resources required to obtain them are also reported as serious; downscaled frameworks of such large models proposed in the literature are not well known by the SMEs either. The paper also discusses "work around" that bypasses such standards to ease delivery of products while keeping certificates as labels just to acquire new jobs for the business.

Keywords*: quality standards, small-medium size enterprises, software quality assurance (SQA)*

Rasprava o osiguranju kvalitete softvera u malim i srednjim poduzećima za proizvodnju softvera: empirijsko istraživanje

Pregledni članak

U okviru proučavanja osnovnih aktivnosti uključujući ispitivanje, pregled i testiranje softvera prema postignutom nivou osiguranja kvalitete u malim i srednjim poduzećima (SMEs), članak daje suvremeni pogled na takve kompanije u odnosu na mjere u osiguranju kvalitete. Iznose se rezultati lokalnog empirijskog ispitivanja standarda kvalitete u turskoj industriji proizvodnje softvera. Istraženo je stanje u oko 150 softverskih kompanija od kojih se 17, da bi osigurale kvalitetu softvera pridržava standarda, uključujući međunarodno priznate International Standards Organization (ISO) i Capability Maturity Model Integration (CMMI). Međutim za stvarne se ukupne obveze i sredstva potrebna za dobivanje standarda izvještava kao o teškim i ozbiljnim pitanjima; srednja i mala poduzeća nisu upoznata ni s osnovnim postavkama takvih velikih modela kako ih se predlaže u literaturi. U radu se također raspravlja o "radu sa strane" koji zaobilazi takve standarde kako bi se olakšala isporuka proizvoda dok certifikati predstavljaju tek etikete potrebne da bi se dobili novi poslovi.

Ključne riječi: *mala i srednja poduzeća, osiguranje kvalitete softvera, standardi kvalitete*

1
Background on software quality and assurance
Popratna literatura o kvaliteti i pouzdanosti softvera

Discussions on the software quality keep this topic one of the most contributed subjects in the software literature since late 1960's; early and initial examples include [1], [2] and [3]. The discussions are not only how to achieve/argue quality in software products but also how to delimit its definition, because defining the quality is not an easy task for generic use, either.

For instance, Reeves and Bednar [4] find that defining quality may be achieved when it is specification focused; however the challenge remains as quality is seen/evaluated as "excellence", usually. This argument is also supported in the software domain along with the following attempts to define quality:

"...what something is like or how good or bad something is" [5]

"software quality assurance (SQA): making sure that software will perform as intended" [5]

"...the totality of features and characteristics of a product or service that bears on its ability to meet stated or implied needs" [6].

"quality assurance: defining the level of compliance with requirements and incorporating continuous quality improvement into the test processes." [6]

In addition, there are books (e.g. [7]), which give complied sets of definitions from a variety of software sub-branches addressing software quality and assurance. Along with those definitions from recent publications we have identified a remarkable overlap on the customer satisfaction and software quality. However, how to generalize customer defined quality keeps itself away from general formulae, which is still a question. Given remarkable importance in the literature, expressing software quality by numbers still remains a challenge; one of the first attempts is reported in as early as the years of "software engineering" field is proposed to the computer community. Another remarkable study is given by Boehm, Brown and Lipow [8], where the following quote is stated:

"The current software state-of-the-art imposes specific limitations on our ability to automatically and quantitatively evaluate the quality of software."

Although 35 years have passed, this argument stands as acceptable. Additionally, the same study argues that comprehensive quality metrics may be more suggestive than conclusive or pertaining to giving directives; hence prospective users are the ultimate deciders of the quality.

Coming back to the customer defined quality, Parzinger and Nath [9] note that retrieving requirements from customer at the beginning of development is problematic and may deprive quality in the end. This communication/articulation gap between the developers and the end-users has not been newly emerged; when we have a look back to the beginning of the software engineering, in 1968, Rubey and Hartwick [1] address the software quality as "black box", which accommodates fuzzy criteria usually difficult to nominate by the users. Meanwhile, the same research reports that software quality needs to be acknowledged between the parties (user/developer/distributor) and should be promoted against the increasing development cost due to additional programming effort.

SQA is accepted as one of the most important activities in software development process and several organizations have developed their own standards. Among the famous ones, National Aeronautics and Space Administration (NASA) and European Space Agency (ESA) have produced their own standards [10, 11]. According to ESA standards

the definition of SQA is "planned and systematic pattern of all actions necessary to provide adequate confidence that the item or product conforms to established technical requirements". This guide suggests starting with the evaluation of user requirement by checking technical activities, management plans (software project management (SPM), software configuration management (SCM), verification and validation (V&V)). Those activities i.e. (SPM, SCM and V&V) should be repeated for design, coding, testing and finally implementation/transfer phases.

SQA combines various activities and tasks together. Earlier and well known works include [12] in which common activities for SQA including formal technical review examining the task of various activities in software development process is proposed. Similarly, use of appropriate metrics for various tasks also helps in controlling the quality. In fact, there are several steps, metrics and reviews for each phase of software development process for enhancing the quality in the process and product.

What we have visited so far is only a representative fraction of discussion in the literature. Keeping this in mind, the role of internationally recognized standards, which is generally accepted as a "necessary" part of quality, cannot be skipped as there is also a remarkable amount of discussion on how those standards help to raise the quality of software products in the industry. In a recent study reported by Subramanian and colleagues [13], which finds strong links between information systems implementation strategies, CMM and software quality is just an example to this discussion.

While such discussion exists from the earliest years of the software engineering, implementation of proposed structured framework models to achieve standards and uphold the quality of code (hence system) is reported in the literature as the next section visits. However, implementing models in all software development companies is naturally not an easy task for several reasons including acknowledging on a common ground, approving body and encouraging/enforcement. The problem becomes more complicated with the resources required to spare for the sake of adopting structured frameworks. Although such a task is seen as a “heavy” load for smaller companies, scaled (not necessarily official) versions of large models are reported as successful in the references (Section 2.4). Our motivation of this study comes with the existing of such examples in the literature and the customer satisfaction, which is given high role in the software development as we discussed it earlier in this section i.e. *are the companies happy as long as their customers are happy or do they adopt any structured framework to achieve a minimum standard along with customer satisfaction?* As the scope of the study we have chosen SMEs as they are larger in number in the industry.

As discussed previously there are several activities in SQA. Most of the activities (such as metrics and reviews) are accumulated in different ways in various standards. It is supposed for a software company to adopt these standards for SQA activities. We have discussed the common and popular standards in Section 2. Research instrument and interpretation of results are given in Sections 3 and 4. Discussion and drawn conclusions that there are other research avenues to support this work are given in Sections 5 and 6, respectively.

2
A quick review of quality standards applicable in the software industry
Brzi pregled standarda kvalitete primjenjivih u softverskoj industriji

With the Fagan's proposition of *"anything that can be created and described can also be inspected"* [12], works on SQA including standards, their adoption in the industry, their necessity and suggestions to find a common way to build a consensus keep the topic hot since 1980's. The following subsections 2.1, 2.2 and 2.3 visit popular standards while section 2.4 acknowledges that there are more standards for quality assurance in the software industry.

2.1
ISO/IEC 9126 Quality Standard
Standard kvalitete ISO/IEC 9126

ISO and International Electrical Technical Commission (IEC) proposed ISO/IEC 9126 Quality Standards [14-17]. ISO/IEC 9126 standards provide a comprehensive specification and evaluation model for the software quality. This standard of product quality in software engineering consists of four parts.

Quality model (QM): This provides a comprehensive specification and evaluation model for software product quality.

External metrics: describe the external metrics used to measure the characteristics and sub-characteristics identified in QM and behavior of the system of which it is a part. The metrics applied during testing and operational stages fall in this category.

Internal metrics: describe the internal metrics used to measure the characteristics and sub-characteristics identified in QM. These metrics are basically for non-executable software and provide the users' means to measure quality of intermediate deliverables. Metrics for requirement, design and source code fall in this category.

Quality in use metrics: identifies the metrics used to measure the effects of the combined quality characteristics for the user. More specifically, these metrics care about the quality in satisfaction of customers. The metrics for effectiveness, performance, productivity and safety in real environment fall in this category.

Further, a framework for quality definition is provided in the ISO-9126 standards. This framework is organized into quality characteristics and sub-characteristics including functionality, reliability, usability, efficiency, maintainability and portability as the top level quality characteristics. Those terms should be considered with additional -ability terms for a more comprehensive coverage as discussed in the literature (for example [18]); similarly, quality is not limited to those terms as maturity, fault tolerance, recoverability, understandability, learnability, operability, analyzability, changeability, stability, testability, adaptability, installability, conformance, and replaceability which are covered and discussed as sub-characteristics of them in [19].

2.2
SPICE/ ISO/IEC TR 15504:1998
SPICE/ ISO/IEC TR 15504:1998

Software Process Improvement and Capability Determination (SPICE) [20] is an international standard for the software process assessment. Since the release of its first version in 1995, SPICE provides a framework for the assessment of software process. This framework provides the complete evaluation and guidelines for "proper" planning, managing, monitoring, controlling, and improving the acquisition, supply, development, operation, evolution and support of software. Later, these documents were published in the form of ISO/IEC TR 15504:1998 - Software Process Assessment. Currently, SPICE is under the guidance of International Committee on Software Engineering Standards ISO/IEC JTC 1/SC 7.

Similar to other standards, SPICE aims to promote software product quality; for this, it adopts a framework to develop a working draft for a standard in software process assessment, conducts industry trials of the emerging standard and promotes the technology transfer of software process assessment into the software industry world-wide.

2.3
Capability Maturity Model Integration (CMMI)
CMMI softver

Another internationally recognized certificate is CMMI [21], which is emerged by the Software Engineering Institute of Carnegie Mellon University. This certificate is treated as one of the highest level of standards in the software industry hence seen as a benchmark in the industry. CMMI is an extended version of CMM (also called software CMM), which was developed during 1987-1997, targeting software industry to improve performance.

The CMMI is designed for several disciplines/bodies of knowledge such as: systems engineering, software engineering, integrated product and process development, and supplier sourcing. Since the release of its first version in 2002, CMMI's goal is to improve the quality of software companies and it still promises to focus on it with the announcement of the recent version, 1.3 in November of 2010.

Briefly, CMMI provides a model of five steps each describing a level of maturity of an organization. In fact, this model provides software developing companies to improve their processes by following the levels of maturity given in the CMMI. These levels are named initial, managed, defined, quantitatively managed and optimized levels, which are from informal and ad hoc development of the processes to higher quality with low risk continuous process improvement along with organizational innovation in software development.

Commitment to obtain and benefit at the end makes it "pride" for any organization to certify by CMMI. However, obtaining a CMMI level requires considerable effort. A recent report [22] published by SEI summarizes that median time to move from one maturity level to the next is 4, 18, 19 and 13 months.

To obtain ISO and/or CMMI is not an easy task; despite considerable resources spent to obtain those certificates, there are reports e.g. [23], giving signals of keeping those certificates as "selling points" and not using them for actual improvement of the quality of software products as priorities. To investigate the validity of this argument, locally we have constructed a research instrument, which is explained in Section 3.

2.4
Other selected models developed for SMEs
Drugi odabrani modeli razvijeni za mala i srednja poduzeća

As defined in the Turkish Official Paper, enterprises with less than 10, 50 and 250 employees are accepted as micro, small and middle size enterprises, respectively [24]. While these numbers are for all the employees working in companies, software professionals are naturally less in number.

Apparently, SMEs are less expected to adopt structures methods, such as CMMI due to their financial and employee constraints. However, there are other quality methods proposed for quality assurance for SMEs, which are basically based on one of the above models or combination of some of them with (more or less) a common method of downscaling large quality methods for they can be adopted by SMEs. A quick survey would yield: TAPISTRY [25], Adept [26], software process matrix [27], self-diagnosis [28], process improvement for SMEs [29], customizing CMMI for a process evaluation for SMEs [30], software quality model [31], software process improvements [32, 33], and an adoption of goal question metric for SMEs [34].

SMEs have limited resources to implement the CMMI or even ISO due to several constraints such as limited staff and resources and vulnerable financial conditions; accordingly, a common point in most of those models is to promote quality with less effort. In fact considerable amount of work has been reported in the literature to achieve the quality objectives in SMEs, examples include [35, 36]. On the other hand, the implementation of these quality model(s) in the industry is limited.

3
Research instrument
Instrument istraživanja

This report is a complementary research of a broader study and in conjunction with [37] on measurement activities in SMEs. Hence, the instrument is the same for both studies. However, investigation phases (interviewing) are different for both the studies and for this particular study it was relatively longer. Briefly, the research adopts a two stage approach; forming a body-of-knowledge focusing software quality definition and its interpretation and preparation/modification of the interview questions on the literature gap; following that, conducting semi-structured interviews with local SMEs firms.

As the qualitative nature of the research, we have selected to conduct semi-structured interviews to collect data from SMEs. The preliminary questions are based on the literature survey and gaps that we have identified to our knowledge.

As the starting point, local SMEs provided a potential as software developer firms in Ankara; later, we have approached potential key informants, employees/managers with reasonable knowledge and experience on software engineering in the industry to discuss validity of those preliminary interview questions. We became confident and stopped aligning questions with the forth and fifth key

informants adding smaller recommendation to the questions.

Second stage of the research is based on conducting those aligned semi-structured interviews from the previous stage. The interviewees were selected from different SMEs with a selection criterion of being senior professionals in their fields. We have approached around 150 SMEs. However most of the companies were either too busy to respond or were doing almost nothing about structured frameworks; nevertheless, our observation even at such a start was that most of the companies do not care that much about such frameworks. We could establish discussion session with 17 SMEs from which we had detailed information beside interviewees with short answers without any discussion.

The following are some of the questions, which opened discussions with the interviewees.

In terms of software development, are you using any internationally recognized standards, for example, ISO, IEC, CMMI, for achieving quality objectives and to improve your business?

If you already have any of those standards, did they help you to improve your company up to your expectations; if so, in what aspects?

Do you think CMMI is a criterion to assess a company's quality and reputation?

It is worth to mark that the questions were not rigid and have changed with the every interviewee; however those modifications are only minor and were beneficial to keep the focus on the research. For this reason, we have put "gentle" pressure (such as promising to share the results of the study with them while protecting privacy) to the interviewees for face-to-face conversation instead of leaving the question paper at their office and waiting for a reply.

4
Interpretation of the results
Interpretacija rezultata

Although we aimed at SMEs for this study there were a few relatively bigger companies (but still considered as SME according to [24]) among the interviewees; this gave us an opportunity to see that internationally recognized standards (ISO and CMMI) are beneficial in such firms.

"ISO and SPICE are beneficial indirectly. Measuring and time frame provide essential benefits" (interviewee 11, number of employees (noe): 20-50)

However, adopting such a way requires time and patience as suffered by smaller companies:

"...increase in quality but slowing in development due to procedure" (interviewee 4, noe: 1-5)

As mentioned in Section 2, obtaining an internationally recognized certificate requires considerable amount of resources both in time and money. However, those certificates are not always obtained just because the company would like to make the work place "better" and/or "up to a standard" but because they are required in specifications/requirements of potential projects, which is a major motivator.

A remarkable feedback has emerged while discussing the role of CMMI, which is a warning about leaving the certificate on the wall, a concern already reported in the literature e.g. [23].

"CMMI is a very important criterion but not sufficient alone. The course could be left after obtaining CMMI" (interviewee 5, noe: 20-50).

While this feedback is reported, it is surprising that to obtain CMMI certificate and advance in levels of maturity requires more time than ISO.

"...we have spent several months and several thousands (USD) to get ISO; but I have seen some examples in the industry where the certificate is used just to get the job" (interviewee 16, noe: 10-20).

"...about 100,000 USD we have spared to start with the CMMI" (interviewee 17, noe: 5-10).

"... it (CMMI) may stay as a label and not applicable logically and efficiently for small companies" (interviewee 6, noe: 10-20).

"CMMI cannot be followed always; company can flex it according to internal dynamics" (interviewee 14, noe: 10-20).

4.1
Observations
Zapažanja

The survey regarding the quality issues in SMEs reflects a picture far from an industry that adopts a planned system or order i.e. a systematic series of procedures. In fact our study reveals an overlapping picture of all those developing countries where software industries are not matured as expected in the literature i.e. against all those works reported in the literature, the implementation is quite limited. Some of the important observations regarding our survey are as follows:

Opinion of the companies

1) Quality issues in their products are not the prime objective during development process.
2) Many of them, especially when they are of micro-size do not know the names of the common quality standards to be applied in the industry.
3) It is hard to convince them to apply quality standard techniques.
4) For many of them, achieving these standards (except ISO and CMMI) is only a "show-off" for a company.
5) Through these practices (quality standards), there is no guarantee that they can produce quality software; this is another reason why they are not interested in quality issues as anticipated.
6) Some of them argue that satisfaction of customers is their primary priority; although the quality standards may help them to achieve this goal the customer can be satisfied with some "work-around" or ad-hoc activities to save the day, which may leave the presence of those certificates not necessary.

Problems in SMEs while implementing SQA models:

7) In small companies, the number of employees is quite limited, most of them are relatively young in development process and they work in those companies only for gaining experience and quit fast with a better opportunity. A common complaint from such companies is the difficulty to implement and maintain quality standards with such employee profile.
8) Limited software quality engineers in the industry makes the management hard to get motivated to consider applying long term standards such as CMMI.
9) Returns on investment and payback period are not

clearly enough understood by SMEs so that they could decide on going for a "big" standard such as CMMI. Being conservative in spending money is also common behavior of the owners of small companies, leading to the idea that implementing these standards may reduce their profit. In fact they do not know how their profit can increase after obtaining such standards.

10) Lack of proper technical education/knowledge of the owners/people in management is also a hindrance for achieving quality objectives. Some of them entered this industry only because it is one of the most profitable businesses.

Observed intensions:

11) Our observations show that some companies are interested in standard quality models, e.g. CMMI, ISO, and they may think to adopt those models not only to help them in achieving quality but also to improve the reputation of the company in the market.
12) On the other hand most of the small companies are not aware of the names of the models such as software process matrix, PRISM, which are specifically scaled for SMEs.

5
Discussion and recommendations
Rasprava i preporuke

Based on the above rationale, we strongly feel that it is not always possible for a SME to follow the main standards like CMMI and ISO. An alternative to those standards is to opt for less expensive and simplified models e.g. [25-34]. However our investigation reflects that most of the companies are not interested in these models, either. One of the reasons for not adopting these models is that although they help in achieving quality they may not be helpful in increasing the reputation of the company or bringing more money.

An earlier suggestion could be that a more practical approach should be applied in SMEs. Specially where the number of employees is limited and most of the jobs are done by those few software professionals, implementing specific and limited SQA activities may provide better options. More specifically, instead of following a specific model to achieve SQA, they may concentrate on implementing more specific metrics [38-41] and reviews [42] on the developer level. For example if the developers are working on Document Definition Type language then they may adopt any appropriate metric, which evaluates the complexity of DTD language e.g. [38]. For a software review, the developer may choose one of the various types of review processes as per circumstances and availability [42], in which numbers of practical solutions e.g. self review of the code with the help of available tools, static analysis of the code etc for software review have been suggested.

In addition to the "popular" constraints of time, money and human resources in SMEs, we would like to add another limitation in increasing the awareness of SQAs activities amongst the management of the SMEs and developers. Once they become aware that it is not a forced job but a helpful way in producing good quality products and promoting their professional curriculum, adopting quality driven processes and activities may become easier and faster in such workplaces.

6
Conclusion
Zaključak

This paper presents a view on the status of the implementations of quality standards in software industry of Turkey in a local scale. It is not uncommon to require standards such as ISO or certificates such as CMMI as a prerequisite in project specifications. To have a chance of entering into competition for those projects, companies are motivated to apply such standards/certificates, especially ISO. However, after getting involved in projects, certificates may stand on the walls and the company may not necessarily follow their directives.

We believe/expect that this study will attract attention of professionals and management personnel for improving the awareness of quality issues and their proper implementation in the software industry.

Coming back to the research question of *"are the companies happy as long as their customers are happy or do they adopt any structured framework to achieve a minimum standard along with customer satisfaction?"*, we can cautiously say that SMEs are more inclined to the first choice i.e. if the customer is happy then there is no need to "bother" about a framework as underlined in observations (1), (2), (3) and (6). As it is expected, adopting large programs such as CMMI might be seen as a "luxury to increase reputation" for small companies as given in result (11); however, we have seen that it is not easy to find any SME which investigates and follows tailored programs as (12) reports.

While this result is quite pessimistic in the adoption of models, it is still early to recommend a "silver bullet" to make the SMEs to promote the quality either; however, this study reveals that we can motivate such companies to raise the quality to a higher rank. For this, the following research avenues emerge: current study gives signals that although some companies have obtained internationally recognized certificates and standards, they may not follow them as summarized in result (4). The reluctance becomes more solid with the fear of risking resources and not having anything considerable in return as reported in result (5). As we observe that standards may be used only as labels, we see potential of future studies more focused on revealing more concrete and itemized reasons for delaying to obtain those standards. Result (9) requires a focused study on economical aspects of the investing on standards and certificates.

Results (7), (8) and (10) may demand a depth analysis of the industry to reveal the supply and demand of the more focused staff i.e. specialists of software equality engineers.

7
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