

Initiating Software Process Improvement in Small Enterprises: Experiments with Micro-Evaluation Framework

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Abstract

For many years, industry and the research community have studied software process improvement in an organization. However, that research applied mainly to large organizations. In 1998, the University of Namur began a research project on software process improvement in small organizations (fewer than 60 employees), mainly in Wallonia, where improvement is evident and where experimentation by this university and the CETIC (Centre d'Excellence en Technologies de l'Information et de la Communication) is being conducted. Their work has been followed more recently by research at ÉTS (École de technologie supérieure) in the Province of Québec, the results of which are presented in this paper.

Keywords: software process improvement, maturity model, process evaluation, CMM[®], CMMISM¹, SPICE, OWPL, Micro-Evaluation.

1 INTRODUCTION

In the context of the global market, large organizations which depend on Information Technology (IT) are aware of the importance of productivity, quality and development time. As a result, many invest time and resources into improving their software products. Some have created their own reference model, but most are using models developed by organizations such as the CMMISM from the Software Engineering Institute (SEI) or the ISO/IEC 15504 standard from the International Organization for Standardization (ISO) [15] also know as SPICE. The models can be applied to almost any field of activity where IT is present in a more or less strategic way. However, those models are not readily usable by small and very small businesses, as they are much too complicated and too expensive to implement.

¹ CMM and Capability Maturity Model are registered in the U.S. Patent and Trademark Office. CMM Integration, CMMI are service marks of Carnegie Mellon University.

A solution to this problem was needed, in particular in regions where the industrial actors are mainly small enterprises subject to the same constraints of the global market as larger companies. Wallonia (Belgium) and Québec (Canada) are representative of such regions. At the University of Namur, a software process improvement approach dedicated to small development structures has been developed during the years 1998-2000. It has then been used and improved in collaboration with CETIC (Wallonia, Belgium) and ÉTS (Québec, Canada). This paper relates the results experienced with this approach. The next section (section 2) presents the framework used. Then the context, use and lessons learned from its usage in Belgium and Québec are presented in detail (section 3). At last, conclusions are drawn for the whole experience.

2 Micro-Evaluation Framework

The Micro-Evaluation used in this experiment is part of the “*OWPL gradual framework*”[5], which will be described in section 2.1 below, while the Micro-Evaluation framework itself will be described in section 2.2, and its relationships with CMMISM summarized in section 2.3.

2.1 Summary of the OWPL Gradual Framework

The gradual software process assessment framework *OWP²L* is aimed at supporting VSEs³ in a targeted manner in their efforts to initiate software process improvement (SPI). The framework takes into account the particular context of small enterprises in order to quickly progress within a limited budget and, eventually, reach a higher maturity level [6].

The hypothesis behind this approach is that the organizations typically targeted have little time, and little or no experience with either quality concepts or software process improvement but are motivated in improving their products or processes. Moreover, their typical weaknesses include a limited number of processes and practice maturity levels, which are uneven within the same organization, but also dependent on the project, the client, the project manager and the development team concerned. So, it is often possible to identify and point out some efficient and effective software practices, which can be easily generalized to other teams or projects. Hence, the objective behind using the *OWPL* gradual framework is twofold: first to sensitize small enterprises to quality issues and then to initiate a continuous mechanism of software process improvement which will produce rapid but tangible results with a minimum of effort (“quick wins”).

The approach is gradual, and based on a three-stage software process improvement framework. In the first stage, a simplified questionnaire, called the *Micro-Evaluation* is used to collect information about current software practices. This questionnaire covers six key axes that have been selected as the most pertinent and the most important to the targeted organizations on basis of previous experience with small enterprise evaluations. The Micro-Evaluation involves one person in the organization being evaluated, as one person is interviewed. The conclusions of the Micro-Evaluation lead to a action plan to be undertaken. A second Micro-Evaluation could be performed a few months later to evaluate progress made. The information collected and the conclusions drawn as a result of the analysis can also help to determine the scope and goals of a more accurate evaluation, which will be performed according to the *OWPL* model [7]. In the second stage, the central component of the methodology, the *OWPL* model, is applied. Even though it is a light and low cost SPI model that uses simplified vocabulary, *OWPL* allows VSEs and VVSEs to perform an assessment providing a broad and complete view of their software processes. It was developed on the basis of our knowledge of the target audience by carrying out a large number of micro-evaluations and of the focus goals of the approach. Like Micro-Evaluation, the *OWPL* evaluation

² *OWPL* stands for Observatoire Wallon des Pratiques Logicielles (Walloon Observatory for Software Practices)

³ VSE acronym means Very Small Enterprise with less than 25 employees. We used the acronym VVSE (Very Very Small Enterprise) for organizations with less than 10 employees.

can be carried out several times to measure improvement, and can serve as an entry point for the next and final step of the methodology, stage 3. Eventually, when the size or the context of a company justifies the need for standard labeling and when the company reaches a sufficiently high quality level, a SPICE [9] or CMM® [14] evaluation can be undertaken. At that point, the improvement will be implemented according to that reference model. This approach is not linear. Organizations loop at the most appropriate level according to their size and maturity level. For more details on the *OWPL* methodology, see [7].

2.2 The Micro-Evaluation Framework

The Micro-Evaluation framework has been designed to be as low cost as possible while providing an initial assessment of the software practices. The rationale is twofold: to make the VSE and VVSE aware of its strengths and weaknesses and potential improvement it can expect, and to determine the priorities of improvements on the other. The Micro-Evaluation uses an interview based on a questionnaire that covers six axes selected as the most pertinent and the most important to the organizations on the basis of previous experience with SME and VSE evaluations. These axes are:

1. Quality management,
2. Customer management,
3. Subcontractor management,
4. Development and project management,
5. Product management, and
6. Training and human resources management.

Our software quality people performed the evaluation. The individuals interviewed should have sufficient knowledge on the IT activities of the organization.

The interview is more efficient than a self-assessment, as it allows the interviewer to adapt the vocabulary according to the interviewee and prevents questions from being misunderstood. In this way, the interview can be considered as an exchange of information rather than as an audit exercise.

The questionnaire covers the 6 axes listed above. The questions are open, and each one is associated with one or more sub-questions, allowing the interviewer to adjust and refine the information as necessary. There are two types of questions: those that address essential practices related to the organization. They are rated on a linear scale according to the quality of the practice assessed. The second type of question address software practices which are rated in a double-entry grid (Figure 1) according to the quality of the practice and to its effective implementation in the organization. That is, some practices could be present, but used only on some projects and not systematically for all projects.

Do you use document templates for your work products ?		
Proposition	Projects	
	Some	All
Some templates for some project phases	score=1	score=2
Templates for most of the products	score=2	score=4

Figure 1 Example of double-entry evaluation grid

Both scales are using values ranging from 0 (the practice is absent) to 4 (best practice met).

Evaluating practices according to a reference grid makes it possible to draw a maturity profile for each practice (Figure 2) and eventually measure the progress made between two evaluations of the same practice (Figure 3 and Figure 4). The interviewee is also asked whether or not existing practices are efficient and provide expected results. This information is helpful in drawing conclusions in the evaluation report in the appropriate context.

Micro-Evaluation results are presented in a 12-page report, which contains an introductory section in which the VSE environment and the circumstances that led to the Micro-Evaluation are described. It then briefly presents the approach and the results of the questionnaire, summarizing them according to the six axes. Subsequently, these results are analyzed according to the context of the organization concerned (age, history, declared goals, results obtained, etc.) A list of the main strengths and weaknesses according to SPI principles is also drawn up. Finally, recommendations are proposed to help the assessed unit to improve. The report is confidential and sent to the individual who participated to the Micro-Evaluation.

2.3 Mapping between the Micro-Evaluation and the CMMISM Model

There is a strong relationship between the six axes of the Micro-Evaluation and some of the Capability Maturity Model Integration (CMMI) [14] process areas. The mapping is illustrated in Table 1. The Micro-Evaluation questionnaire has been mostly designed based on the Software Capability Maturity Model (SW-CMM) and on SPICE [9] reference model. However, the degree of details is different from CMMISM in terms of the objectives of the Micro-Evaluation [12].

Table 1 Mapping between Micro-Evaluation axes and some CMMISM Process Areas

Micro-Evaluation Axes	CMMi Process Areas
Quality management	Process and Product Quality Assurance
Customer Management	Requirements Management & Requirements Development
Subcontractor management	Supplier Agreement Management
Development and Project Management	Technical Solution & Project Planning, Project Monitoring and Control
Product Management	Configuration Management
Training and Human Resources Management	Organizational Training

3 The experience with Micro-Evaluation

3.1 The context

Although the approach was designed for VSEs and VVSEs in Wallonia (Belgium) and trials of the first releases of the models were carried out there, it appears that the methodology is largely applicable to any VSE/VVSE. Since the Province of Québec (Canada) is similar in many ways to Wallonia in terms of the existence of a large number of VSEs and VVSEs, in particular in the IT domain, it was natural to expand the experimentation to include the two regions.

The Centre of Excellence in Information and Communication Technologies (CETIC) was founded with the mission of serving as a link between the University as a research centre and a knowledge repository on the one hand and the emerging regional IT industry on the other. Charleroi is an old industrial region with aging heavy-industry structures (e.g. iron and steel, coal-mining), while at the same time it is undergoing a phase of slow conversion towards modern industrial companies. These include a large number of small businesses active in the Information Technology (IT) domain, among others. These small IT service businesses, as well as small IT departments in bigger businesses, constitute the main target of CETIC's technology transfer actions.

In fact, various studies on regional enterprises (see, for example, [1]) have shown that a great majority of the businesses concerned have very small software teams and very limited resources. They are also highly dependent on projects, actors and/or technical capabilities, although they can sometimes be very innovative in their domains. Moreover, the fact that these small businesses are evolving in an open European market with increasing competition makes software quality a crucial issue for them all. Thus, a key mission of CETIC is to support software process improvement in small and medium-sized regional organizations. To this end, CETIC and the University of Namur have developed the SPI framework adapted to small structures [5].

In the Province of Québec, over 140,000 employees work in 3,000 organizations in IT and communications. As illustrated in table 2, in the Montréal area, where Micro-Evaluations were performed, close to 80% of the software producers have less than 25 employees (VSEs). Also, around 50% of the 80% have less than 10 employees (VVSE).

Table 2. Size of software producers in the Montréal area.

Size (employees)	Enterprises		Jobs	
	Number	%	Number	%
1 to 25	540	78 %	5 105	29 %
26 to 100	127	18 %	6 221	36 %
over 100	26	4 %	6 056	35 %
TOTAL	693	100 %	17 382	100 %

A few years ago, a picture of the software process maturity profile in Québec was published [10 11], at that time, most enterprises, active in process improvement, were on the higher side of the small enterprise spectrum (i.e. a few hundred employees) and mainly in the defense and aerospace industrial sectors. Many organizations, after being formally assessed, using an approved SEI evaluation method, were developing level 2 and level 3 CMM-compliant processes. In the early 1990s, when most VSEs and VVSEs were not yet aware of the need to improve their processes, a software engineering technology center was established, by the federal and provincial governments

in Montréal, to provide technology awareness and transfer services. Organizations were offered assessment and improvement services. Since then, many presentations have been made by vendors, but also by non-commercial organizations like Montréal-SPIN (Software Process Improvement Network) which holds a monthly conference at ÉTS.

ÉTS, a French engineering school located in Montréal (www.etsmtl.ca), offers, among others, undergraduate and graduate degrees in software engineering and IT (www.logti.etsmtl.ca). A research project, called APPEQ (Amélioration de la Performance des Petites Entreprises Québécoises), was instituted in 2004. The aim of the project is to help software VSEs and VVSEs improve their quality and productivity performances. In the summer of 2004, a number of evaluations were performed in small enterprises (i.e. most with fewer than 25 employees) using the Micro-Evaluation framework developed by the CETIC and the University of Namur.

3.2 Results of the first round of Micro-Evaluations in Wallonia

The Micro-Evaluation was first tested on a sample of twenty organizations, small IT companies, IT services in other businesses, public administrations using, in 1998 and 1999.

We were able to draw the following conclusions after the first round of micro-evaluations:

- In most of the assessed organizations (2/3), there was a lack of formalism and, in particular, a poor planning process or none at all. In the majority, there was no training program and success was highly dependent on individual skills
- In the remaining companies (1/3), there was an awareness of the quality aspects of software, and a quality system with a Manual of Quality and other well-defined and documented procedures were in place. Some were preparing for ISO 9001 certification [8] and several of their practices were highly efficient, notably those related to customer/client management and product management.
- The difference in maturity level between IT companies and IT departments in non-IT companies was not significant.
- The Micro-Evaluations performed after 1999 yielded no better results, evidence that there was still a need for information and of enhanced sensitivity on the part of IT professionals.

Figure 2 shows the global maturity profile of the small enterprises involved in the first round of Micro-Evaluation in Wallonia.

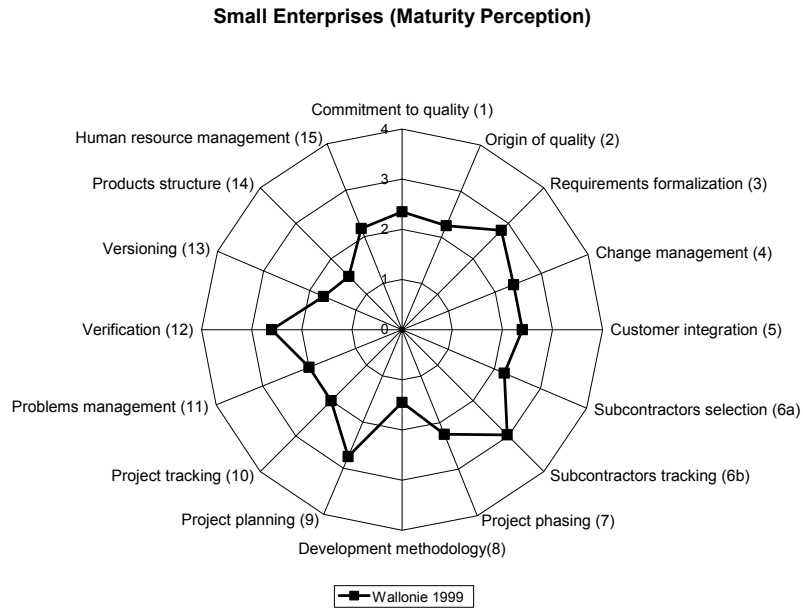


Figure 2 First round of Micro-Evaluation in Wallonia

3.3 Results of the second round of Micro-Evaluation in Wallonia

Seven of the companies contacted in 1998 and 1999 have re-evaluated their practices using the Micro-Evaluation (Figure 3).

Significant improvement has been achieved in the practices, notwithstanding the difficulties encountered by some in maintaining a constant SPI effort (there being a slight retreat on a single axis)

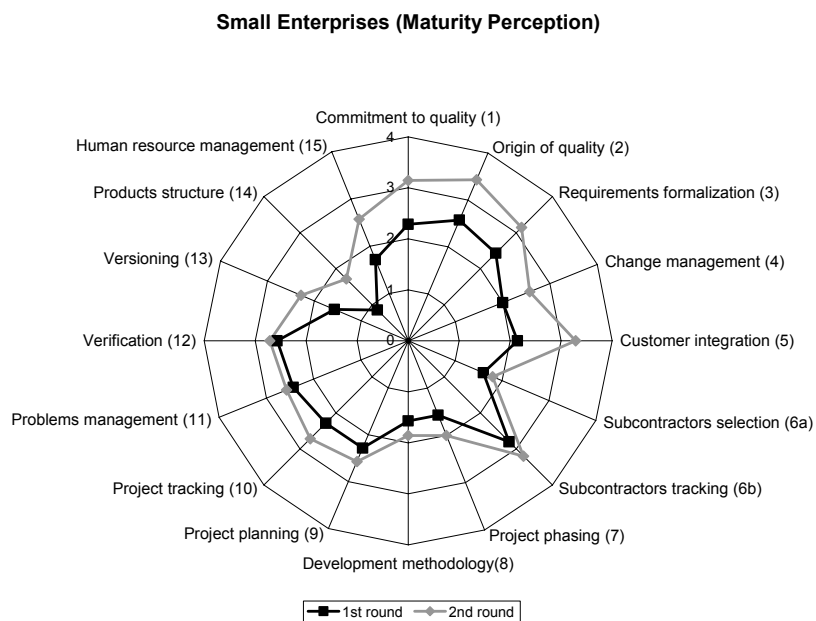


Figure 3 Results from the second round of Micro-Evaluation in Wallonia

The second round of micro-evaluations, in the seven organizations, allowed us to draw the following conclusions:

- Overall, an effort has been made to take our recommendations into account. People are willing to improve, even though resources (human) are still limited.
- In most cases, good practices observed, included in the first report, have been enhanced and spread to all ongoing projects. Assessed VSEs and VVSEs began to define some procedures in order to reuse the outcome of this SPI initiative.
- VSEs and VVSEs are now aware of SPI. Micro-Evaluation has had a sensitization effect on people. There is now a real culture of quality.

One of these organizations (Figure 4) has completed a third Micro-Evaluation⁴ with outstanding results. This highlights the fact that the Micro-Evaluation can be used as is to structure SPI project on a small development team with low maturity profile.

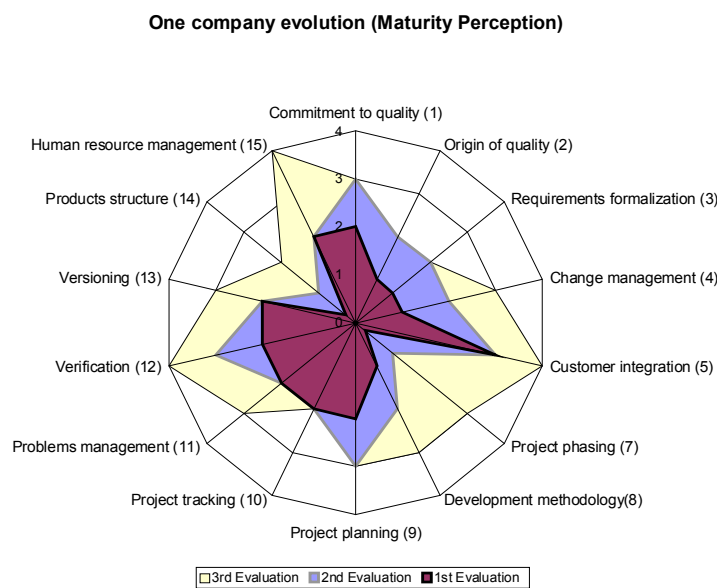


Figure 4 Evolution after 3 micro-evaluations

3.4 Results of the first round of applications in Québec

Twenty-three micro-evaluations were performed in the summer and fall of 2004, by two IT graduate students under the supervision of their professors. The average number of employees in the companies concerned was about 13 and the average number of years the companies had been producing software was about 12. Twenty percent of them were less than 5 years old.

Figure 5 shows that small organizations were performing, with a score of about 3 out of a maximum of 4, requirement formalization, project planning, problem management, and verification and versioning activities. One can also note a certain number of weaknesses: very low scores on commitment to quality (score=1.4), change management (score=1.9), product structure (score=2.1), human resources management (i.e. training) and project tracking (score=2.0). It is interesting to note that project planning scored significantly higher (3.0) than tracking. It seems

⁴ N.B.: this enterprise has no subcontractor

that VSEs and VVSEs develop a plan, and then, once in development, the plan is forgotten in order to “fight the fire” of the day.

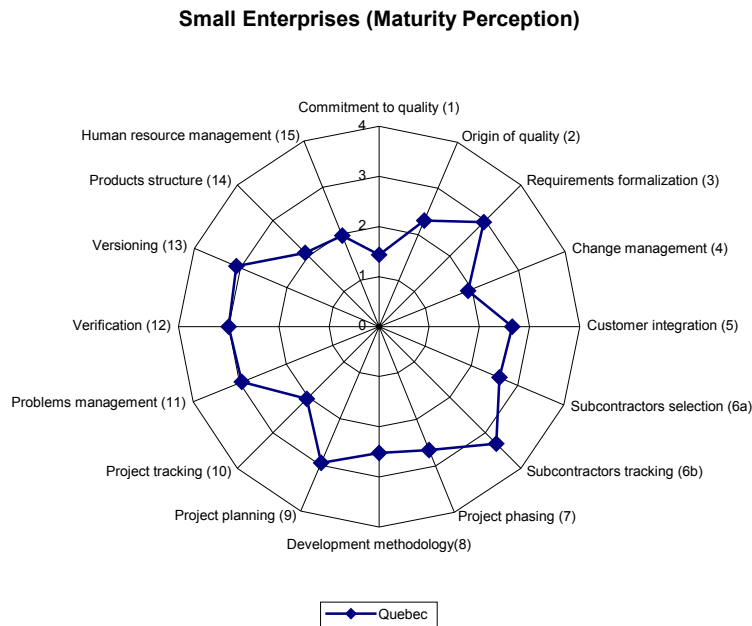


Figure 5 First round of Micro-Evaluation in Québec

We are currently conducting experiments with some software engineering graduate students of ÉTS. As part of their graduate courses (Software Quality Assurance and Technology Transfer), they are required to perform micro assessments, identify one or two practices to improve and transfer the practice(s) to the organization in a twelve-week time frame. Since some of the students already work for VSEs and VVSEs it was easy for them to sell to their management on the idea of a small team of two or three students investing a few hundred hours, of their own time, into improving an area of the development process. So far, the results of this experiment look promising. In 2005, we are also planning to conduct a second evaluation on a number of the organizations that were evaluated in 2004 in order to measure improvements to their software activities. We are also experimenting with third-year software engineering students in conducting micro-evaluations. As part of their measurement course, teams of two students have selected a VSE or a VVSE and performed an evaluation. We are planning to push the experiment further next year by having students perform an evaluation during their four-month internship. Students should have enough time to perform a micro evaluation, identify a few needed practices, implement them and perform a second micro evaluation in order to measure progress. If other students go to these companies for their internships, they will pick up the improvement results and repeat the process.

3.5 Lessons learned

This section draws some lessons from our dual experience in Belgium and Québec. Recent experimentations in Québec does, in fact, confirm the lessons learned from earlier experience in Belgium, the main lesson being that Micro-Evaluation is very attractive as a tool for our VSE and VVSE targets. It offers an optimum ROI (Return-on-Investment) for small development teams with a low maturity level. Specifically, we can point to several positive features:

- ◆ A simplified and low cost evaluation approach: the obvious merit of a simplified approach lies in its low cost, which makes it affordable for small organizations with few resources, enabling them to achieve concrete and significant process improvement without the utilization of a

disproportionate amount of resources. In practice, this appears to be the only way to counter the natural trend, which is to give absolute priority to development tasks and indefinitely postpone process improvement or quality tasks in general.

- ◆ Accurate insight into assessed organizations: Micro-Evaluation was shown to be a very attractive tool to start with, giving a sufficiently clear view to allow the organization either to begin light improvement action or to go further, into a deeper evaluation. The small size of the organizations concerned allows such simple analysis to remain sufficient.
- ◆ A gradual approach based on continual assessment-improvement cycles: the fact that the global underlying approach is gradual allows different kinds of tailoring to be performed. For example, evaluation can be tuned to match the available resources, so that even very small structures can use the Micro-Evaluation and organize their SPI action plan around it, while larger structures can start their SPI cycle with a Micro-Evaluation to identify weak processes, and then go on to an initial OWPL evaluation.
- ◆ A context-sensitive approach: an improvement action plan cannot be set up without accurate insight into the way an organization runs. This is even (and maybe more) true for (very) small structures, where every single actor has a sound impact on the whole mechanism.
- ◆ A simplified vocabulary: the simplified vocabulary used makes the Micro-Evaluation affordable by different actors who are not always software engineers or quality specialists. The improvement process concerns management people as well as technicians at different levels. As the number of actors actually involved in software process improvement increases, the improvement is more likely to be effective if the actors are already sensitized and actively participate in the improvement process.

However, this experience has also highlighted some weaknesses of the approach. These weaknesses will have to be addressed in order to make the Micro-Evaluation easier to use. Improvements to the approach will be made based on the following observations:

- ◆ Almost all micro-evaluations were performed on a single project or team, so that the effectiveness of the implementation for the others teams or projects was not evaluated.
- ◆ Evaluation reference grids are too vague, so that it is sometimes difficult to properly rate the answers collected.
- ◆ Inheriting from traditional reference models such as the CMM[®], the Micro-Evaluation ignores non-“disciplined” development practices such as the Agile methods.

4 Conclusion

Current software practices in most VSEs and VVSEs are far from being well defined, and the lack of available resources compromises the success of any SPI approach based on a model like CMMISM or SPICE. However, it is possible to undertake an SPI process and to make real progress without too great an investment.

The experience showed that the Micro-Evaluation framework is very attractive as a tool to start with, mainly because of its simplicity, and also because it helps draw people's attention to the problem of quality in the field of software engineering. Also, it can help in drawing up a list of recommendations to guide small enterprises in the first steps of improvement. For those small enterprises looking for a more exhaustive model, the OWPL model should be the appropriate answer, as it has been developed taking CMM[®] and SPICE as references on one hand, and the VSE's specificities, which are highlighted thanks to the Micro-Evaluation framework, on the other.

Finally, the evolution of the Micro-Evaluation will be reflected in the next release, as follows:

- ◆ Abandoning the evaluation of a practice implementation level with all questions being rated on the same linear scale.
- ◆ Refining the evaluation scale to attribute four quality levels to each practice, favoring mapping of the answers collected to evaluated practices.
- ◆ Adding references to “agile” development practices to obtain a better representation of the reality met.
- ◆ Modifying axis labels so that direct interpretation drawn from the charts themselves will be more understandable.

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