An Evaluation of the RAPID Assessment-based Process Improvement Method for Small Firms

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Abstract

With increasing interest by the software development community in software process improvement (SPI), it is vital that SPI programs are evaluated and the reports of lessons learned disseminated. This paper presents an evaluation of a program in which low-rigour, one-day SPI assessments were offered at no cost to 22 small Australian software development firms. The assessment model was based on ISO/IEC 15504 (SPICE). About twelve months after the assessment, the firms were contacted to arrange a follow-up meeting to determine the extent to which they had implemented the recommendations from the assessment.

Comparison of the process capability levels at the time of assessment and the follow-up meetings revealed that the process improvement program was effective in improving the process capability of many of these small software development firms. Analysis of the assessment and follow-up reports explored important issues relating to SPI: elapsed time from assessment to follow-up meeting, the need for mentoring, the readiness of firms for SPI, the role of the owner/manager, the advice provided by the

assessors, and the need to record costs and benefits. Based on a meta-analysis of the program and its outcomes, advice and recommendations are provided to small firms and assessors. As well as providing validation of the assessment model and method, the outcomes from this research have the potential to better equip practitioners and consultants to undertake software process improvement, hence increasing the success of small software development firms in domestic and global markets.

1. Introduction

Assessment-based software process improvement (SPI) programs are based on formal frameworks and promote the use of systematic processes and management practices for software engineering [1]. These approaches identify best practices for the management of software engineering. When applied, SPI programs enable organisations to understand, control and improve development processes.

Faced with an enormous choice of methods, tools and techniques, software development managers need evidence that their investment in new practices will produce benefits [2, 3]. Unfortunately, many approaches are adopted 'based on anecdotes, gut feelings, expert opinion and flawed research, not on careful, rigorous software engineering experimentation' [2]. Therefore, researchers are urged to undertake evaluative research involving realistic projects with sufficient rigour to ensure that any benefits identified are clearly derived from the concept in question [2]. Although past studies have indicated factors which inhibit adoption of SPI, empirical research on software process innovation is largely lacking. Consequently, there is insufficient knowledge about which innovations are effective, and which factors influence their adoption. It is vital to understand the processes currently used, and to

evaluate the effectiveness of process improvement programs, or investments in SPI are wasted [4]. This paper provides a meta-analysis of an assessment-based SPI program which was carried out in 22 small software development firms in Australia. The next section (§2) explains the background of the SPI program, the assessment model and method. The outcomes of the program are summarised (in §3), and then the discussion considers issues related to the SPI program. Finally, recommendations are provided to improve the method, and advice is given to small firms and assessors to ensure maximum benefit is gained from investment in SPI programs.

2. Background

Software Engineering Australia (SEA) (Queensland) provided funding for the Software Quality Institute (SQI) to deliver a process improvement program to 22 small software development firms. Each firm participated in an initial process assessment and the progress of 20 of the firms was reviewed at a follow-up meeting 7 to 16 months after the assessment.

2.1 RAPID Model

The process improvement program used the Rapid Assessment for Process Improvement for software Development (RAPID) model and method [5]. The RAPID method is based on Technical Report (TR) version of the emerging international standard for software process assessment ISO/IEC 15504 (SPICE) [6]. The ISO/IEC 15504 standard has been validated through an international series of trials. As the available funding restricted the assessments to one day each, the scope of the assessment was limited to eight key processes: requirements elicitation, software development, configuration management, quality assurance, problem

resolution, project management, risk management, and process establishment. As shown in table 1, all five process categories of ISO/IEC TR 15504 are represented.

Table 1 RAPID processes and process categories

Process		Process Category	ISO/IEC TR 15504 ID
RE	Requirements elicitation	Customer-Supplier	CUS.3
SD	Software development	Engineering	ENG.1
CM	Configuration management	Support	SUP.2
QA	Quality assurance	Support	SUP.3
PM	Project management	Management	MAN.2
PR	Problem resolution	Support	SUP.8
RM	Risk management	Management	MAN.4
PE	Process establishment	Organisation	ORG.2.1

The process capability dimension of the model was also constrained to meet the limitation of one-day assessments. Although SPICE provides for capability levels from zero (incomplete) to five (optimising), only questions relating to levels one to three were included in the RAPID assessment model, enabling rating levels of level 0 (incomplete), level 1 (performed), level 2 (managed) and level 3 (established). The RAPID method collects evidence only by interview, but participants may illustrate issues under discussion by reference to documents.

From a pool of nine qualified SPICE assessors, 2 assessors performed each RAPID assessment, one in the role of team leader and the other as support assessor. A set of procedures and templates was used including a demographic questionnaire,

assessment plan, assessment instrument, assessment report, feedback form, follow-up meeting and final report.

2.2 RAPID assessment procedure

The team leader and support assessor conducted on-site interviews at each firm with key people involved in managing the software development effort of the organisation. For each of the eight processes examined, the assessors followed the script of the assessment instrument to determine the extent to which the process attributes have been achieved using a four point scale: not achieved; partially achieved; largely achieved; and fully achieved. The capability level (0, 1, 2 or 3) for each of the eight processes was then determined, based on the organisation's achievement of the process attributes.

For each firm, an assessment report was compiled including strengths, weaknesses, process attribute ratings and capability levels, and recommendations for improvement to the organisation. A follow-up meeting was held 7-16 months after the assessment. For nine of the firms, the follow-up meeting included a formal reassessment; the other follow-up meetings were less formal. After the follow-up meeting, a final report was compiled detailing the extent to which the recommendations had been implemented.

3. SPI program outcomes

Software engineering researchers are urged to use quantitative analysis focusing on statistical analysis of numerical data, as well as qualitative analysis focusing on textual and numerical data [7]. In analysing the outcomes of the SPI program, quantitative methods focused on statistical analysis of numerical data from the context

questionnaire and assessment ratings, while qualitative analysis was conducted on the textual content of the assessment and final reports. The use of qualitative techniques with software process research is recommended [7, 8] to provide opportunities for triangulation and synergy.

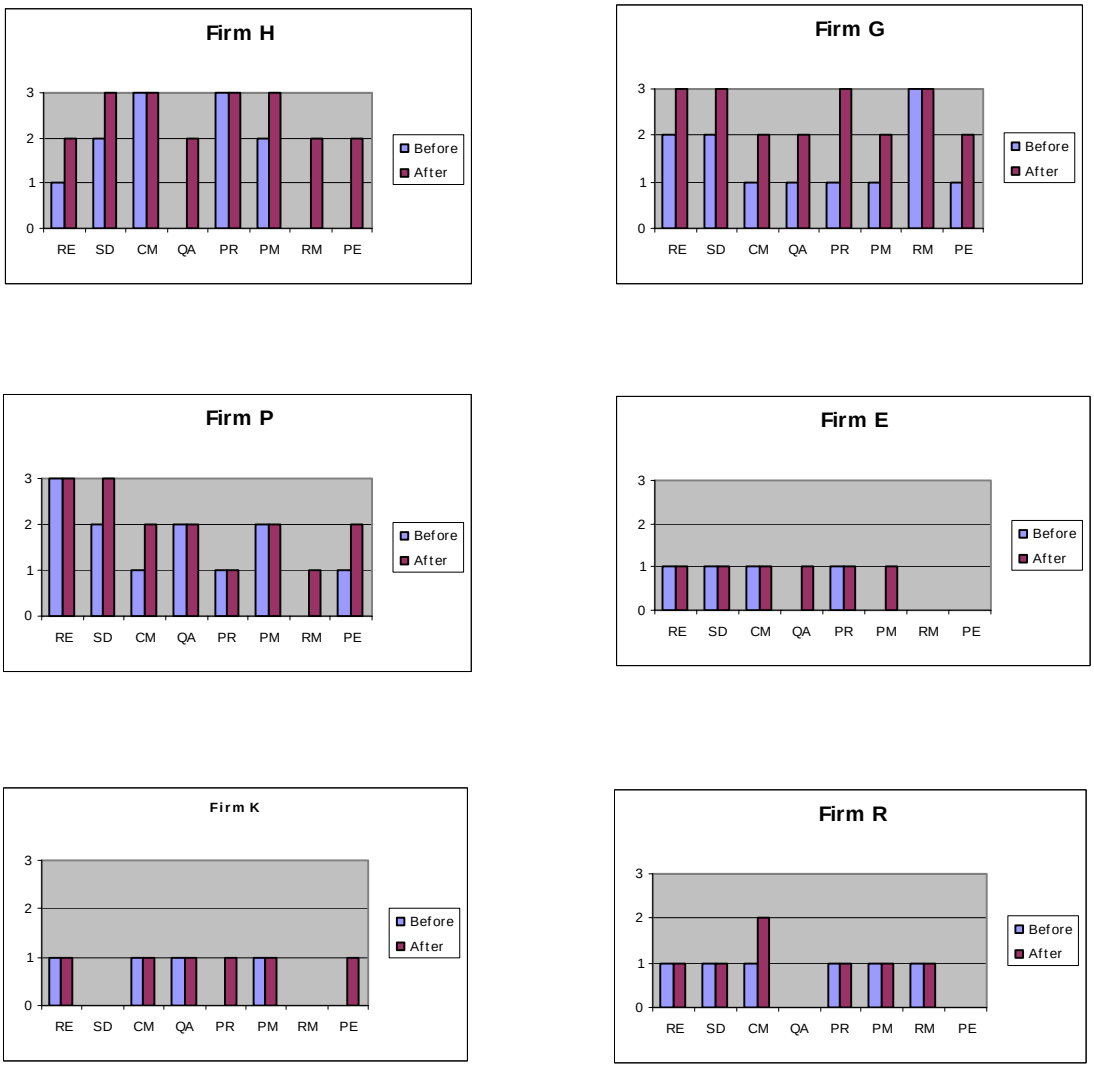
As summarised in table 2, nine firms were formally reassessed, and six of these had improved their process capability levels, the other three exhibited improvements, but not enough to gain a higher capability level rating. A further 11 firms participated in the follow-up meetings, but were not formally reassessed. Of this group (informally reassessed), six firms reported that they had implemented some of the recommendations; and five firms did not report any improvement, but provided reasons why the recommendations had not been actioned. A detailed account of the experiences of these firms was reported previously in [9].

Table 2 Extent of improvement by firms grouped by outcome

Follow-up meeting	Formal reassessment			Informal		None
Group #	1	2	3	4	5	6
Extent of improvement	Capability level improved	Attribute achievement improved	Specific processes improved	Limited improvement	No improvement	Withdrew from program
Firm ID	E, G, H, K, P, R	T	L, N	A, C, F, O, Q, V	D, I, J, M, S	B, U

The six firms in Group 1 increased the capability level of at least one process as shown in figure 1. The extent of improvement varied from the most improved firm (firm G) with seven of the eight processes improved, to firm R which improved one process.

Figure 1 Process capability levels at initial assessment and follow-up meeting for group 1 firms



Examining the extent of improvement across all eight processes, capability levels improved in all processes, with the process exhibiting the lowest capability at the time of the assessments, process establishment, improving more than the other processes. The process with the highest capability at the initial assessments, requirements elicitation, showed the least improvement. As shown in **Error! Reference source not found.**, 22 process instances improved providing a total improvement of 26 levels.

4. Evaluation and discussion

The qualitative analysis of the assessment and final reports identified many issues related to SPI for small firms. In this section, insights gained specifically related to the firms participating in the study are explored (§4.1), followed by a discussion of the issues relating to the plan and execution of the SPI program (§4.2).

4.1 Issues specifically related to these firms

Detailed qualitative analysis of the 22 assessment reports and 20 final reports prompted further investigation of specific issues related to the 22 firms. This section discusses the elapsed time from the assessment to follow-up meeting, the need for mentoring, the readiness of firms for SPI, the role of firm owner/manager, and finally the advice provided by the assessors.

Elapsed time from assessment to follow-up. In formulating the SPI program, it was envisaged that the follow-up meetings would be conducted 6 months after the initial assessment to evaluate the effectiveness of the program. When the firms were contacted by the assessors for the follow-up meeting, many wished to defer the meeting due to current workloads. In fact, the time period from the initial assessment to the follow-up meeting ranged from 7 to 16 months, with a mean of 12 months and standard deviation of 2.4 months.

The follow-up meetings conducted were either formal reassessments of the capability of some or all of the processes, or an informal follow-up meeting discussing the

extent of adoption of the recommendations. To evaluate the relationship between the type of follow-up meeting and the time period from the initial assessment to the follow-up meeting, an analysis of variance was performed. Firms which were formally reassessed held their follow-up meetings after a shorter time period than firms not formally reassessed (p=.026). The extent of elapsed time could have been influenced by how promptly the assigned assessor contacted the firm to arrange the follow-up meeting, but in many cases, firms deferred the follow-up meetings, citing work commitments and pressing deadlines.

To further explore the relationship of time period and program outcome, Spearman rank correlation tests were performed for the process capability levels of the nine formally reassessed firms. The statistical analysis indicates that longer time periods (from assessment to follow-up) are associated with lower process improvement for two of the processes: quality assurance (r_s=-.608, p=.042) and project management (r_s=-.644, p=.031).

The finding that a shorter follow-up period was more effective in this program is in contrast to the conclusion reached by Varkoi [10] in Finland. After analysing results from a SPICE-based SPI program involving 20 small firms in Finland, Varkoi [10] decided to extend the time-frame from 6 months for the pilot phase to 12 months for the harvesting phase, although the participants in the study considered two years to be the optimal length for an improvement program.

The RAPID assessment report provided recommendations to the firms based on a 6 month time-frame. This is consistent with the view held by Debou and Kuntzmann-Combelles [11] who urge that a 3-5 month time-frame for action plans be considered,

and that it is better to adopt a narrow focus of improvement actions. The problem with a 6 month time-frame is that many firms (such as C, G, N, T) had designed new processes, but had not yet used them at the time of the follow-up meeting. This confirms the view of Paulk et al. [12] and Krasner [13]: it can take two years for process changes to demonstrate results.

It appears that more research is needed to investigate the optimal time period from assessment to reassessment. Although planning needs to encourage achievement of short term goals, many rewards are not evident until a much longer time-frame.

Mentoring. Small firms need external assistance in planning and implementation of the improvements as they have scarce resources and limited possibilities to keep up-to-date with the state-of-the-art research and practice [10, 14]. On-going mentoring was not provided to firms although three firms mentioned that lack of mentoring inhibited their SPI progress (firms F, G, M).

To facilitate the necessary technology transfer for SPI, the role of mentor may be critical to the success of SPI programs. The effectiveness of mentors in SPI programs has been documented with the role of mentors promoted to include 'motivating, advising, supporting, encouraging, teaching, listening, solving problems, calming fears, and assisting in artefact collection' [15]. Herbsleb and Goldenson [16] analysed 138 survey responses from CMM assessed organisations and found that three quarters of these organisations understood what needed to be improved, but needed more guidance about how to improve, and more than half needed more individualised mentoring and assistance. An analysis of 37 high maturity organisations revealed that

half of these successful organisations have a ‘formal mentoring program to impart skills and knowledge’ [17].

The analysis of the process improvement program reported here supports the view put forth by Thong, Yap and Raman [18]: for small businesses operating in an environment of resource poverty, high quality external expertise is even more critical than top management support.

Readiness for SPI. After analysing reports which indicate that the vast majority of organisations in the US and UK are at the initial level of maturity, Smith et al. [19] assert that it is clear that only a handful of companies are ready for SPI ‘because their software health is so bad (that is if they have any development process at all)’ [19]. They go on to warn that in order to be ready for SPI, a visible and defined software process must already be in place. The opinion that low maturity organisations find it much more difficult to change and implement SPI is shared by Diaz and Sligo [20] based on these reasons: low maturity firms do not collect metrics; they focus on defining core processes, not on improvement; and it takes a lot of effort to get started to overcome scepticism and to be sure of management support and long term commitment. Other researchers also believe it is pointless to try to implement high maturity processes into low maturity projects [21, 22]. Recently, Rainer and Hall [23] determined that factors impacting on SPI adoption varied for low maturity and high maturity organisations.

It is interesting to consider the performance of the five firms (D, F, G, P, and S) which, at the time of the initial assessment, were rated level 1 or higher for at least

seven of the eight processes. In this discussion, these five firms are classed as high capability and the remaining 17 firms are referred to as low capability firms. As shown in table 2, two of the high capability firms (G, P) are included in Group 1, having achieved sufficient improvement to increase the capability level of some of the eight processes. Two of the other highly rated firms (D, F) experienced seriously disruptive events which they reported prevented them from implementing the recommendations from the assessment. The remaining high level firm, firm S expressed the opinion that the RAPID assessment was too brief to be of any value.

However, some of the firms with low initial capability were also successful in the program. The gains achieved by the four low capability firms (E, H, K, R) in Group 1 were certainly more modest than those of the higher capability group, but still a notable achievement. Furthermore, seven low capability firms (A, C, N, O, Q, T, and V) reported that they had successfully implemented some of the recommendations, citing improvements in terms of defining their methodologies, developing templates, recording problem reports, and formalising testing procedures.

Therefore, this research indicates that low-rigour SPICE-based assessments are effective for small firms with poorly defined processes.

Role of firm owner/manager. An interesting aspect of the SPI program was the high involvement by the owner of the firm. In 14 of the 22 firms assessed, the ‘managing director’ or ‘company director’ was explicitly recorded in the assessment report as attending the assessment. This owner/manager role is a characteristic of small business, for example, 70 percent of Australian small business operators were

classified as full-time operators [24]. However, the program outcomes in this study did not vary significantly depending on whether the managing director was present or not.

Lack of senior management commitment is recognised by Debou and Kuntzmann-Combelles [25], Abrahamsson [26], El Emam et al. [27], and Wilson, Hall and Baddoo [28] as a major bottleneck to the success of SPI initiatives, but for most small firms, the business operator is often involved in all aspects of the business and would therefore instigate the SPI and participate heavily in it.

Advice provided by assessors. Nine assessors were involved in the SPI program and all had completed the SPICE certification training course, ensuring the consistency of capability levels ratings. However, the various assessors provided a valuable and diverse range of advice to the firms, drawing on their personal knowledge and expertise. The specific advice provided most frequently was MS Project (8 instances), Visual Source Safe for configuration management (7 instances), and the Project Management Body of Knowledge (PMBOK) (5 instances).

4.2 Meta analysis of SPI program: lessons learnt

In this section, issues relating to the RAPID method are raised, and improvements to the procedures are suggested. In the conclusion section, specific recommendations are made to practitioners and consultants.

Comments from the firm sponsors were gathered through feedback questionnaires and by the follow-up assessors. Most of the firms enthusiastically commended the

process improvement program, commenting that it was an effective introduction to SPI; that it provided an accurate review of the current status of development processes; and that it motivated them to improve their planning and documentation. Many expressed regret that they were unable to put more resources into implementing the recommendations, but the timing of the program clashed with two urgent deadlines: the modifications for year 2000, and the introduction of the Australian Government's Goods and Services Tax legislation.

Negative comments were made by only one firm (S). With 60 full-time staff, 2 part-time and 8 contractors, Firm S was the largest included in the program, and felt that the one-day assessment was too brief to be of any real value.

Role of assessor. It was intended that the follow-up assessments be conducted by one of the assessors who performed the initial assessment, but due to limited SQI staff availability, this was not always possible. In three of the Group 5 firms, the follow-up assessor was not one of the initial assessors. If one of the initial assessors had contacted the firm for the follow-up, then the follow-up may have been more effective in terms of providing feedback about improvement progress or lack thereof. The people at the firm had formed a relationship with the two initial assessors, and a level of trust may have been established. To introduce someone new at the time of the follow-up meeting may have caused some anxiety for the firm sponsor, and the staff at the firm may have felt that the new assessor would not understand how the firm operates. They may resent the need to explain everything again, and may also be worried about confidentiality.

Research has shown that ‘small firms are averse to consultants and reluctant to seek external help’ [29]. This was confirmed by Hall, Rainer and Baddoo [21] who found that companies did not highly value the input of external consultants. Therefore, the assessors, as external consultants, need to develop a relationship with the developers in small firms. One of the lessons learnt in the SataSPIN project [10] was the need for continuous contact, as well as contacting the firms at least once per month. Varkoi [10] recommended that assessors also make contact with more than one person at each firm.

Cost benefit analysis. Only one of the follow-up meetings recorded an estimate of the investment made by the firm. Firm O reported that the program consumed 155 hours of staff time and included the purchase of Visio software. Most of the firms did not know the extent of resources involved because they did not have a measurement process in place. Low maturity firms typically do not have metrics for effort or defects. Each firm invested time in preparation and involvement in the RAPID assessment and follow-up meetings. At each firm, senior members of the development teams worked with the sponsor to review the recommendations and formulate action plans. The effort of each firm in implementing the actions varied. Some firms released staff to attend training courses or to evaluate software development tools; others incurred costs to purchase and implement tools.

As evident from the follow-up meetings, the main benefits included improved quality assurance, configuration management, project management and testing. Most firms improved the standard of their documentation, a move which has already returned dividends for one company which lost a key developer. A further important benefit to

one company was the competitive advantage provided by quoting the capability ratings in promotional material.

The program could be improved by including a procedure for the follow-up meeting in the RAPID method. Although a template for the final report was included, limited guidance was provided to the follow-up assessors. It is also recommended that firms are requested to keep a record of SPI effort, costs and benefits. Such a record could be summarised in the final report, and published as success stories of SPI for small firms. These accounts of SPI success would encourage other small firms to embark upon process improvement. Managers are loath to adopt standards without information about trade-offs between increase in quality and cost of achieving that quality [30].

5. Conclusion and recommendations

From the analysis of the current literature and also the assessment and final reports, the following recommendations are made to assist small firms undertaking SPI, and also assessors involved in such projects:

- Before commencing SPI, ensure the organisation is stable and not undergoing major disruptions from internal or external events.
- Firms should draw on expertise of external assessors/consultants as mentors.
- The SPI action plan, derived from the assessment recommendations, should be realistically achievable within the evaluation time-scale.
- Plan the evaluation from the start of the SPI program. This will be a source of motivation.
- Ensure that managers and development staff receive adequate training specific to the SPI model and areas of improvement.

Recommendations to assessors

The evaluation of the SPI program highlighted areas of improvement and the following recommendations are made to improve assessments:

- Provide detailed information to the sponsor about the method and model prior to the assessment.
- Assessors should meet the sponsor prior to the assessment, not just plan by phone/email. Need to nurture a relationship of confidence and trust.
- Ensure that the follow-up assessor is one of the initial assessors.
- Include a template for sponsors to record all costs and benefits from the time of the initial assessment to the follow-up assessment.
- Provide documented guidance to the follow-up assessors for the procedure for the follow-up meetings.
- Devise a feedback form for the sponsor to complete at the time of the follow-up meeting.
- During the time period from the initial assessment to the follow-up assessment, encourage the assessor to contact the sponsor at least on a monthly basis to provide ongoing support and develop trust.

This research answers the call to reduce the scepticism and uncertainty which exists in relation to the accuracy and usefulness of software process assessments and the improvements based on them [31]. Although there are many published accounts of assessments, there is little reported about reappraisals or follow-up assessments except for large high maturity organisations [32]. Furthermore, this meta-analysis has provided recommendations to improve assessment-based SPI programs, especially for small software development firms. As well as providing validation of the assessment model and method, the outcomes from this research have the potential to better equip practitioners and consultants to undertake software process improvement, hence increasing the success of small software development firms in domestic and global markets.

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