

Short and Long-term Impacts of SPI in Small Software Firms

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Abstract

Software process improvement for small firms is a significant challenge. The RAPID method provides a way for small firms to participate in process improvement programs without the enormous expenditures usually associated with such initiatives. There are successes but unfortunately it is not always just software processes that need improvement; business processes are also problematic. This paper reports on an Australian experience with the RAPID method and, in a retrospective, reviews the outcomes for five small firms. Their stories provide a range of experiences, and highlight the concerns in implementing improvements within this class of organisation.

Keywords

Software development; software process improvement; process assessment; small enterprises.

INTRODUCTION

Many small firms hesitate to implement a software process improvement (SPI) project as they are afraid of initial direct and indirect costs since resources are scarce (Kautz 1998). Concerns such as those raised almost ten years ago by Brodman and Johnson are still valid today: “documentation overload; unrelated management structure; inapplicable scope of reviews; high resource requirements; high training costs; lack of needed guidance; unrelated practices” (1997 p.661).

In 1999-2000, 22 small software development firms participated in a SPI program in Australia. The Software Quality Institute (SQI) delivered the process improvement program to the firms and the program was funded by Software Engineering Australia (SEA). The RAPID (Rapid Assessments for Process Improvement for software Development) process improvement initiative provided each firm with a one-day on-site process assessment, then about 12 months later, a follow-up meeting was held to determine the extent to which the assessment recommendations had been implemented. Recently, a retrospective review of the SPI outcomes was held with five of the firms that participated in the RAPID program. This report considers the short-term and long-term impact of the RAPID program and discusses specific challenges for small software development firms.

LITERATURE REVIEW

Researchers have used various theories and concepts from many disciplines to explain concepts related to process improvement frameworks. Since the advent of the Total Quality Management (TQM) movement, many organisations have used this approach. Regardless of the particular flavour of TQM implemented, process definition, control and improvement is always included since it is a core TQM principle (Hackman & Wageman 1995). The main idea

behind process control is that organisations are sets of interlinked processes and improvement of these processes is the foundation of performance improvement (Dean & Bowen 1994).

The RAPID model, a subset of ISO/IEC 15504 (SPICE), is based on a maturity model. Staged maturity models have a long history from Plato's four stage ascent of the mind, through Marx's four stages of society development and Rostow's five stages of economic growth. "Stage models, whether of philosophers, economists, quality gurus, or software engineers, can be seen as occupying a respectable place in that utopian tradition" (Tully et al. 1999, p. 56). Following on from the work of TQM pioneers such as Deming and Juran, Crosby (1979) developed the quality management maturity grid and encouraged managers to use the grid to assess the current situation and to identify actions needing to be taken for improvement.

Since Crosby's work, maturity models have gained popularity and have been proposed for a range of activities including quality management, software development, supplier relationships, research and development effectiveness, product development, innovation, product design, product development collaboration and product reliability (Fraser et al. 2002). However, many organisations struggle with effective implementation of assessment-based SPI initiatives. A review carried out by Niazi, Wilson and Zowghi (2003) of SPI research highlighted five critical success factors: senior management commitment, staff involvement, staff time and resources, training and mentoring, and process action teams.

Faced with an enormous choice of methods, tools and techniques, software development managers need evidence that their investment in new practices will produce benefits (Fenton et al. 1994, Wood et al. 1999). Unfortunately, many approaches are adopted "based on anecdotes, gut feelings, expert opinion and flawed research, not on careful, rigorous software engineering experimentation" (Fenton et al. 1994, p. 87). 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 (Fenton et al. 1994). Although past studies have indicated factors which inhibit adoption of SPI, empirical research on SPI 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 (Mustonen-Ollila & Lyytinen 2003). This research provides evidence of the long-term outcomes of software process innovation in five software development firms.

The lack of theory-based empirical research pertaining to SPI adoption has been noted, but nowhere is the research shortage more acute than in relation to small software development firms. In the Australian and international software development industry, there is a large proportion of small software development firms. There have been many calls to recognise the importance of small business, to increase the attention given to the small business sector, and to develop government policies appropriate to the needs of small business (Johns et al. 1989). It is also recognised that to date, business research in general, and software process improvement research in particular, is biased towards large corporations (Attewell & Rule 1991), and that empirical research into the rate and success of implementation of process improvement initiatives in small and medium enterprises is largely considered to be inadequate (Xydias-Lobo & Jones 2003).

Recent research has raised doubts about whether traditional SPI models are appropriate for small software development organisations. An increased research effort has seen the publication of suggestions in the form of lessons learnt and critical success factors to overcome the challenges of SPI for small firms, for example, Gresse von Wangenheim et al. (2006).

This study responds to demands for more research to evaluate the long-term effectiveness of assessment-based SPI programs within small development firms (Brodman & Johnson 1997, Kautz 1998). In particular, there have been few reports on the long-term benefits that may have been derived from improvement initiatives (Fenton et al. 1994). This work answers the call to evaluate the implementation of a culture of improvement in organisations which took part in improvement programs long enough ago to call these long-term benefits, in particular in small or medium-sized organisations, a part of the software community for which we have few statistics (Sanders & Richardson 2005).

RAPID METHOD FOR PROCESS ASSESSMENT

The RAPID model and method (Rout et al. 2000) define an approach to assessment that delivers consistent evaluations of process capability based on an intensive investigation of the operations of the organisation. The approach is based on five principles:

- The assessment is conducted within a one-day timeframe to minimise the cost and investment of time and resources required by small to medium sized companies;
- The assessment is based on an assessment model of limited scope, with a standard set of eight processes drawn from ISO/IEC TR 15504-2 (1998); the high level software development process is assessed as a whole, without disaggregation into its component processes;
- The competence and experience of the assessors is of primary importance. An assessment team is comprised of two experienced qualified assessors;
- Data collection is limited to moderated discussion by the management team and other members of the organisation who perform the process;
- Capability ratings are generated by a process of consensus-gathering involving all of the participants in the discussion, rather than solely by judgement of the assessors.

The RAPID method employs a defined assessment model of restricted scope, based on and compatible with the Process Reference Model of ISO/IEC TR 15504-2. The basic structure of the RAPID Model is shown in Figure 1.

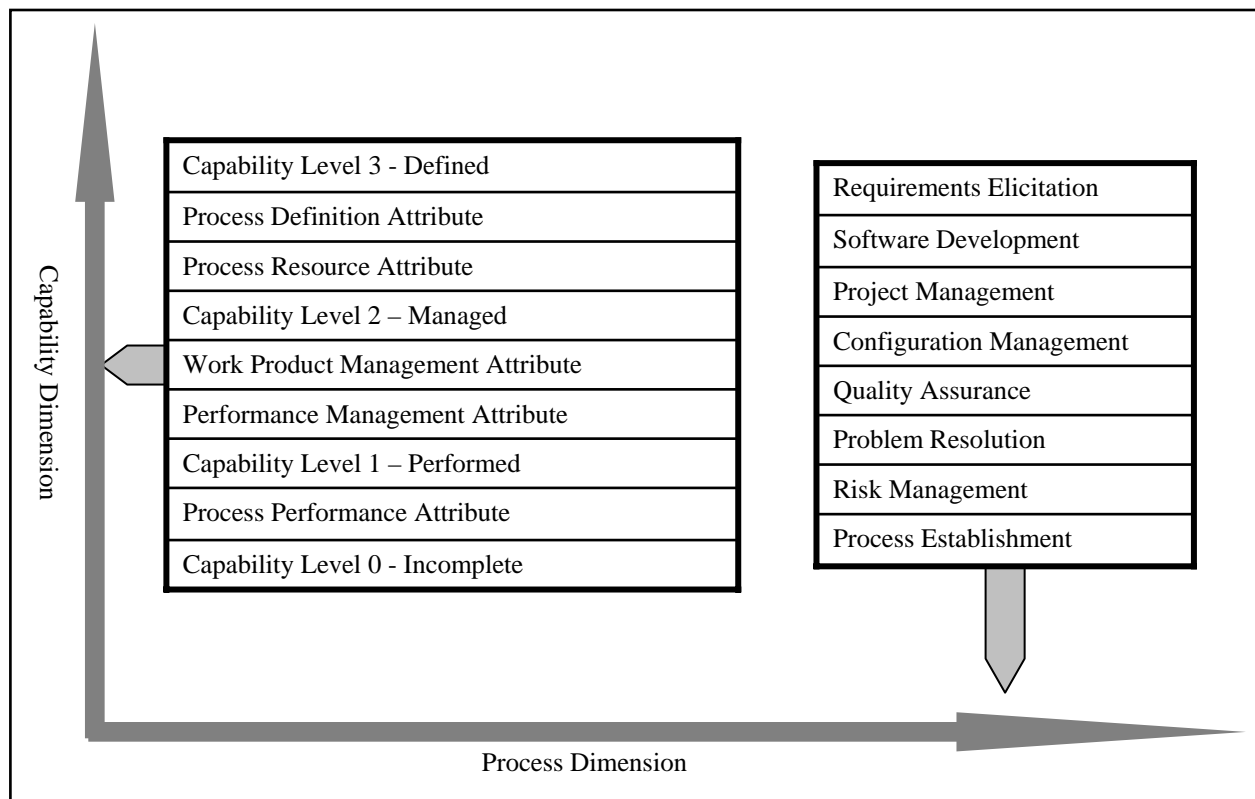


Figure 1: RAPID Process Assessment Model

In the RAPID assessments, each Process Attributes within the model scope was rated, so that the output from each assessment comprised a profile of five attribute ratings for each of the eight processes. Following the assessment, a report was prepared, identifying strengths, weaknesses, process attribute ratings and capability levels, and an action plan with recommendations for improvement to the organisation.

About six months after each assessment, an assessor contacted the organisational sponsor of the assessment to arrange a follow-up meeting for each firm. During each follow-up meeting, the assessor reviewed the action plan with the sponsor to determine SPI progress since the assessment.

RAPID PROGRAM OUTCOMES

In 1999-2001, 22 firms were involved in the performance of RAPID Assessments of capability. Each assessment resulted in a series of proposals for action to improve the efficiency and effectiveness of processes in the companies. Most of the firms were small: 20 of the 22 firms had less than 50 full-time staff, the other two had between 50 and 60 staff. The software developed by these firms was targeted predominately to the public sector, with many firms also providing to other sectors such as information technology; manufacturing, automotive and distribution/logistics; and telecommunications and media.

About 12 months after the assessment, follow-up meetings were held with 20 firms – one firm had withdrawn from the program, and one could not be contacted, and was presumed to have closed down. The focus of the follow-up meetings was to evaluate the extent to which the recommended actions had been successful and to gain a view of the extent of process improvement.

The results of the program are shown in Figure 2. Fifteen of the 20 firms reviewed reported achieving some degree of improvement as a result of the assessment; in six cases, the extent of improvement could be quantified in terms of increases in rated process capability levels.

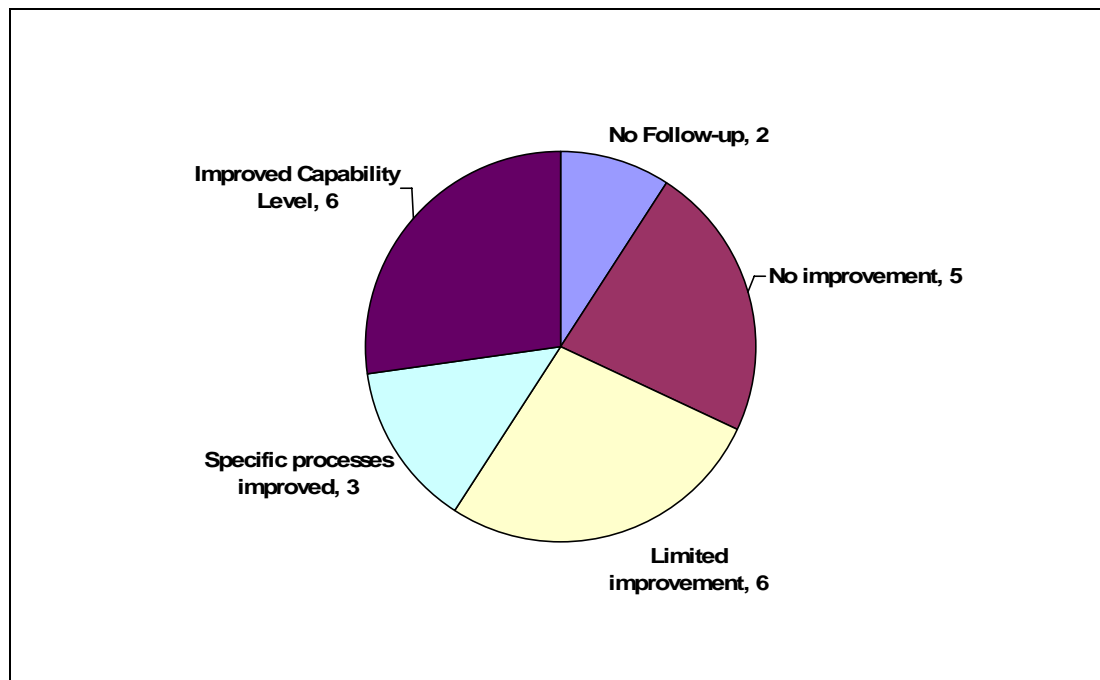


Figure 2: Results of RAPID-Based Improvement

Most of the firms enthusiastically commended the RAPID 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 (GST).

LONG TERM IMPACT

In early 2005, motivated in part by follow-up reports from the SPIRE project (Sanders & Richardson 2004), the authors decided to contact the firms that had participated in the RAPID program. Of the 20 firms involved in the follow-up meetings, four had ceased to operate and one had merged with another firm. At many of the still-existing firms, the staff who had been involved in the RAPID program had moved on to other organisations, making it difficult to establish a contact for a retrospective interview.

To conduct the retrospective interviews, a questionnaire was developed to ensure that the data would be collected in a standard format to enable collation and comparisons. The first part of the questionnaire contained general questions about the performance of the firm since the assessment, the impact of the RAPID program on the firm, and the sponsors' perceptions about the value of SPI. The second part of the questionnaire contained specific questions for each firm based on the prioritised actions from the initial assessment report and the review of these actions at the follow-up meeting.

Each retrospective interview was conducted face-to-face between one of the authors and one representative from each firm with a duration of 30 minutes to 1 hour. Each interview was transcribed from audio recording and validated with the respondent. For competitive reasons, the firms wish to remain anonymous, but are probably typical of many of the myriad of small software development firms in Queensland. In this paper, the firms are referred to as Firm A to Firm E.

Between January 2005 and May 2006, five retrospective face-to-face interviews were conducted between one of the authors and one representative from each firm. These are their stories...

Case A

Firm A develops a software package for the agricultural sector. In November 1999, when the initial assessment was conducted, the firm employed ten staff and was enjoying a sales growth phase due to the introduction of the GST. By the time of the follow-up meeting in August 2000, the number of staff almost doubled, but then reverted back to the earlier level. The firm has coped with major staff changes: since the initial assessment, at least three key developers left the firm.

At the initial assessment, project planning existed, but activities were only tracked informally. The first step to improve project management involved recording the staff assignment of tasks. At the time of the follow-up meeting in August 2000, actual effort was not being recorded, but by the time of the retrospective interview in January 2005 the firm was recording actual effort to manage projects.

Firm A implemented a help-desk system to manage client registration, despatches and problem reports, and later supplemented it with a problem tracking system. The firm has also added a component to assist in trouble-shooting to intercept exceptions and enable quick identification and resolution of problems.

Configuration management continued to improve with all the help files, and technical support documents placed under version control. The need for a more formalised testing process was identified as a major issue at the initial assessment however, market and financial concerns and lack of resources make it infeasible to address.

As well as improvements resulting from the assessment, the retrospective interview found that Firm A has adopted an Agile development approach with less documentation done at the start of each project, and development in shorter cycles. Many advantages have resulted: the managers can see the product as it is developed, they can provide more input as they are not working from abstract specifications and designs, they are able to respond to market pressures, and they can tailor the features to be included in response to the market.

Case B

Firm B was founded to commercialise an information systems development methodology developed by the owner/manager. Its principal business was the delivery of professional services to the government and semi-government sector; most projects involve database solutions, with an emphasis on Ingres applications and development tools. The initial assessment, performed in October 1999, revealed that Firm B had a remarkably mature process for a small business. There was exceptional control of requirements, and changes were well handled, although on an individual project basis. Firm B effectively addressed financial risks through undertaking work on a "time and materials" basis. Project management was limited in scope but effective. As a result of relatively rapid growth in recent years, Firm B faced challenges in ensuring consistent application of its defined process across the life cycle. Many of its approaches to project management, while appropriate to its current environment, were limited in their use in less well-controlled environments. Firm B also needed to take more advantage of its strengths by developing effective measures for monitoring performance in terms of both productivity and product quality.

The follow-up meeting was held July 2000 and established that the changes implemented by Firm B impacted on the capability of four of the target processes: software development, configuration management, risk management, and process establishment. The configuration management tool and error-tracking software had made it easier to manage

multiple developer projects, and testing had been enhanced. Firm B considered that the assessment provided valuable motivation to review and improve the software development processes and was convinced the improvement actions resulting from the assessment would return great value in the future by ensuring it was better placed to bid for large projects.

Towards the end of 2003, although Firm B was performing well, the owner/manager decided he no longer wished to continue with the business. He became “bored” after 12 years in the same role and felt he needed a new challenge. As efforts to sell the firm did not produce a buyer, it ceased to operate in November 2003. The owner/manager assisted staff to find alternative employment and is now employed in a senior IT position in a large organisation.

Case C

Firm C shows a pattern of evolution towards a larger organisation, with the small business employing strategies for growth. At the time of the initial assessment, four of the 14 staff were actively involved in product development. Seven years later, when the retrospective interview was conducted, the firm had changed its trading name, and now employed over thirty staff; however, its basic product domain was the same, although extended.

In the initial assessment, seven action items were identified, and the follow-up meeting showed that positive steps had been taken in respect of five of these. The critical actions involved the adoption of an explicit project-based approach to development, with both methodological and tool-based support. At the time of the retrospective interview, this action was still seen as critical to the survival of the firm through difficult market periods, and remained the basis for the product development approach: “I think it was a very big plus to move to multi-disciplinary project-based teams rather than discipline teams so that team members could identify much more with the project. I guess that the other major thing ... is the project management structure, where everybody gives their estimates and re-validates or calibrates those estimates on a regular basis, and so we are able to know how the project is performing” (owner/manager Firm C).

From the retrospective interview, three dominant themes emerge as key factors in the survival and success of the company:

- The availability of additional working capital led to expansion of market opportunities.
- The company was strongly affected by the “dot com crash” of 2003, and the lack of market demand for one of the key “strategic” product lines was a cause of some frustration. However, the proven strength of the basic product set, and the company's proactive approach to product improvement, provided strengths to weather the variations in the market.
- The company had progressively implemented organisational infrastructure to support continuing improvement. Executive management groups focussing on both product quality and process effectiveness had become established and operated on a continuing basis.

Case D

Firm D specialised in developing process control systems for manufacturing firms. Its three staff were skilled in client-server and real-time systems as well as object-oriented methodologies. The initial assessment was held in November 1999 and found the firm used a strong engineering philosophy with a professional approach to requirements gathering and analysis. The software development processes, based on Rational Unified Process and Universal Modelling Language were sound, but could be enhanced by minor improvements in work product management.

Configuration management was performed informally with Visual SourceSafe used to manage source code during development and after release. Scope for improvement in software quality assurance was recognised with the need for quality objectives, targets and audits.

At the initial assessment, it was recognised that the major risks for the company related to developing the business and winning new development contracts. At the time of the follow-up meeting, October 2000, the number of full time staff had reduced to one – the owner/manager. A personal issue with a staff member of a key client resulted in the loss of major contracts. The administrative staff member of Firm D was sacked for dishonesty and one of the developers left the firm and took some clients with him. The second partner was not prepared to invest in business development and marketing and also left Firm D. Disheartened by the impact of these “betrayals”, and faced with

excessive travel commitments and a growing family, the remaining owner/manager decided to put the company on hold rather than employ additional staff. Currently he is contracting to large firms in the area of quality assurance and project management. The owner/manager of Firm D realised that although robust software processes are important, it is vital to support them with excellent business processes and he is optimistic that Firm D will recommence operations in a few years.

Case E

The initial assessment in November 1999 revealed that the three staff at Firm E showed excellent capability in requirements gathering, due to the expertise of the owner/manager in the domain of the mining industry. Whilst software development was very strong, it was noted that implementation of proper testing procedures and traceability procedures, together with actual implementation of the defined process would improve this capability rating greatly. Problem resolution relied heavily on a locally developed tool, and by managing this process its capability would improve.

The two weak areas identified were quality assurance and risk management. Implementation of the checklists and proper recording of the QA activities would improve this process. Recommendations were made for improvements to risk management, tracking of actual effort on project tasks, planning and definition in configuration management activities, testing procedures and traceability between specifications, design and implementation.

In November 2000 the follow-up meeting found an early warning system for cost and scheduling variations was in place with actual task effort tracked. Testing had been improved with the implementation of QA checklists.

At the time of the retrospective interview, Firm E had diversified into developing software for a financial planning company and the agricultural sector with two new major clients and a number of smaller clients. However, the firm had come perilously close to financial disaster. Firm E had partnered with a large company to bid for a complex system for a material handling facility at a port. After Firm E had committed excessive resources to develop a prototype system, it became clear that the partner firm was not developing the complementary equipment. The purchaser recognised that Firm E's proposed system was superior to the competition but would not award the contract on account of the poor performance of the partner firm.

The owner/manager of Firm E is convinced of the benefits of SPI: "These days the whole changing infrastructure of software engineering and software development is such that unless you have a documented software quality process I don't think you're going to survive. I truly don't. There's so many fly-by-nighters ... it's just been a disaster and they come to us".

DISCUSSION

The RAPID process improvement program was effective for most of the firms: not only did 15 of the 20 firms provide evidence of improvement, but the improvement for six firms resulted in improved process capability levels. The retrospective study revealed that of the five firms interviewed, two firms have grown and succeeded (Firm A and C), one firm is rebuilding after being on the brink of closure (Firm E), one firm was folded (Firm B), and one has suspended operations (Firm D). The authors do not claim that the RAPID program was the sole cause of the effects reported as it is impossible to eliminate disturbing influences in the business environment (Seaman 1999).

Role of Owner/Manager

From the retrospective interviews, it is clear that SPI success depends on the motivation of the owner/manager and their plans for the firm's future. In Australia, only 33 percent of all small businesses survive more than 10 years. Firms B and D are interesting cases in that their closure was caused by life-style concerns rather than market forces. In fact, for many small organisations, their existence is dependent on the motivations of the owner/manager, and their continued existence may depend on lifestyle decisions taken by the owner. Given this, traditional views of "success" and "failure" can be seen as not applying to many small firms, and caution should be applied in trying to assign issues of organisational survival to "failure" to adapt to the business environment.

Need for Mentoring and Government Support

Small companies need external assistance as they have scarce resources and limited possibilities to keep up-to-date with the state-of-the-art research and practice (Kautz 1998). The RAPID program would not have happened without

government funding to SEA for the assessments. SEA also offered training and opportunities for small software developers to network.

This constitutes an obvious opportunity for effective government support. Many national governments have recognized that their local software development industry is made up of a myriad of small firms and have provided funding for SPI programs, for example, results from government funded projects have been reported from Ireland, Brazil, Italy, Chile, and Hong Kong.

Small Software Firms Face Unique Challenges

Small firms should not be considered to be scaled down versions of large firms, as they differ in terms of formalisation, centralisation, complexity and personnel ratios (Richardson 2002). In relation to SPI, small software firms are different in many respects from development groups in large organisations. The retrospective interviews highlighted the view that all the critical management decisions such as finance, accounting, personnel, purchasing, servicing, marketing and selling are made by one or two persons, without the aid of internal specialists, and with specific knowledge in one or two functional areas. Although it has been claimed that the personal involvement of employees in small firms encourages motivation and commitment, problems with staff or partners can have a devastating impact in a small firm. In small firms, attention needs to be paid to the business processes. Some of the owner/managers of small software development firms find this difficult because they are software engineers first and business managers second.

Some factors that have attracted much attention by researchers in respect to SPI adoption by small software development groups in large firms do not appear to be issues for small firms. These include senior management commitment, organisation politics, and communication within the development group.

“Readiness” for SPI and Validation of RAPID Method

Earlier researchers have asserted 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)” (Smith et al. 1994 p.207). Three of the eight firms which exhibited higher capability levels compared to the other firms increased the capability level of some processes and one of the firms with relatively high capability was close to achieving higher capability levels. Two of the other highly rated firms experienced seriously disruptive events which curtailed their improvement activities.

Although it may appear that the firms with higher initial process capability were more successful in improving their processes than firms with lower initial capability, some of the firms with low initial capability were also successful in the program. The gains achieved by the three low capability firms which improved their capability levels were certainly more modest than those of the higher capability group, but still a notable achievement. Furthermore, seven low capability firms 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.

Evaluating the RAPID program and its associated outcomes against the critical success factors previously compiled by other researchers provides the opportunity to validate these factors, and learn lessons from this program. Although the RAPID model was not tailored individually for each firm, it is an adaptation of the more complex ISO/IEC 15504 model to suit small firms. The trained assessors were respected by the firms, with three firms stating that further improvement would have realised if mentoring had been made available. As far as resource issues, many firms commented that they were unable to allocate sufficient staff to the SPI program or to attend training. If the program had not been externally funded by SEA, it is unlikely that any of the firms would have embarked on SPI.

The RAPID assessments were carried out with clearly assigned and documented roles, responsibilities and resources, but two firms explicitly mentioned some change management issues: one firm found it difficult to unfreeze the current processes; and another firm encountered difficulties in promulgating the improved processes to development teams in distributed locations. In most firms, senior management commitment was evident although waned in two firms due to management restructure and change in business direction. The value of unanticipated side effects of the RAPID program was mentioned in terms of providing the opportunity to review the business goals of the firms.

CONCLUSION

The consensus from the firms involved was that the RAPID program provided a practical introduction to formal SPI and provided a solid foundation for further SPI initiatives. This conclusion challenges the view that SPI is not feasible unless the firm has visible, defined processes. In this program, ten firms with low initial capability benefited from the RAPID assessment and exhibited improvements. The success of this program validates the RAPID method and indicates that a SPICE-based mini-assessment is an appropriate way for small organisations to get started on SPI.

The long-term impact, gauged from interviews six years after the program commenced, has shown that changes made in an organisation, driven by a framework of model-based improvement, can have long-term impacts even in small organisations. Even where specific initiatives are lost as a result of failure to effectively institutionalise the changes, or there is loss of key staff, the positive impact of change may remain and have a long-term impact on the way that the firm conducts its business.

We can also see, however, that there is no necessary link between success in implementing improvement and survival of the organisation. Firm B in this study was the most successful of the five in implementing improvements, and in using these improvements to satisfy business objectives; but in the end it is Firms A and C that have enjoyed the most success. Concepts of success and failure for small enterprises need to be re-examined, especially where the role of the business owner is active rather than simply the supplier of capital. Future work will add to the number of retrospective interviews to validate the patterns discerned thus far. For firms still in business, it may be possible to triangulate the interview findings with documentary analysis and interviews of additional staff members.

These investigations show the value of long-term studies of improvement, even in small firms. It is of particular interest that the impact of the improvement initiatives can be seen at the individual level as well as in the organisations as a whole. The results also show clearly the variety of experiences typical of small enterprises, and highlight the specific concerns of this class of organisation.

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