Critical Success Factors for the Improvement of Requirements Engineering Process

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Abstract

The current software process improvement (SPI) standards have no specific section referring to requirements engineering (RE) process and they broadly treat it as a single activity in the overall development process. Research shows that in order to produce quality software greater attention must be given to the improvement of RE process. In order to improve the RE process we have extended the concept of critical success factors (CSFs). We have conducted 22 CSF interviews with 11 Australian companies. Our result show that factors that are generally considered critical for RE process improvement include: experienced staff, having clear scope up front, reviews, stakeholders involvement and using a combination of text and visual models to represent requirements. Our findings also show that there are more similarities than differences on CSFs across practitioner groups. It shows that RE practitioners are aware of what is imperative for the improvement of RE process.

Keywords: Requirements process improvement, Critical Success Factors, CMM

1. Introduction

Requirements problems are widely acknowledged to affect the quality of software and to impact on the effectiveness of the software development process [24]. Despite the importance of requirements engineering, little work has been done on developing ways to improve requirements process. We believe that efforts put into RE process improvement will ultimately produce high quality software, reduce cost and time and increase productivity. SPI standards such as the Capability Maturity Model (CMM) [17] and ISO 9001 [7] focus on process to achieve quality software. The importance of these standards is accepted but little attention has been paid to the improvement of RE process in these standards. There is no specific section referring to requirements engineering in these standards and they consider requirements engineering as a single activity in the development process. While "The importance of requirements engineering demands that it be recognised as a complex process in its own right and not simply as a phase of the software life-cycle" [25].

The CFS concept has been widely applied by both practitioners and researchers in several areas of information systems. The concept of CSFs was first introduced by Rockart [21], as a mechanism to identify the information needs of chief executive officers. CSFs are defined as those few key areas where things must go right for a business to grow [21]. If the management does not pay attention to these areas the organizational performance would suffer. CSFs method has been applied to different areas of IT and management and different studies have confirmed the value of the CSF approach [5, 6, 9, 20, 23, 27]. In order to improve the RE process this paper extends the concept of CSFs.

Our aim is to identify CSFs for RE process improvement for developers, project managers and senior managers. This should be useful in order to provide requirements practitioners with some insight into designing effective RE processes. We have analysed the experiences, opinions and views of practitioners about factors that have a positive impact on the improvement of RE process and come up with a list of critical factors. The research question being investigated is:

RQ. What factors have positive impact on RE process improvement?

This paper is organised as follows. Section 2 provides background. Section 3 describes the study design. Section 4 describes the CSFs

identified from analysing interviews data. Section 5 concludes this paper.

2. Background

Many software projects have failed because they contained a poor set of requirements [2]. No software process can keep delivery times, costs and product quality under control if the requirements are poorly defined and managed [26]. In order to produce software, which closely matches the needs of an organisation, an application domain and the stakeholders, great attention must be paid to the improvement of RE process [13, 14]. The RE process plays an important role in the software development process. It has been observed that one can achieve better quality in software and systems development process if the RE process is properly defined [2, 26]. Often the RE process is started without any planning, which results in poor quality requirements and less control over the management of the whole RE process. A mismatch has been observed between the problems experienced by industry and the techniques developed from research in requirements engineering [25]. It is also observed that many analysts have limited knowledge of the problem domain, which also results in poor quality requirements and cost overruns [10]. Some examples of fairly common problems with the RE process are as follows [3, 10, 25]:

- Vague requirements
- Undefined requirements process
- Lack of stakeholder involvement.
- Business needs are not considered
- Lack of requirements management
- The requirements do not reflect the real needs of the customers
- Requirements are inconsistent and/or incomplete
- It is expensive to make changes to requirements after they have been agreed
- Requirements growth
- Stakeholders communication problems

The fundamental problems in requirements engineering have been identified by many researchers e.g. [2, 3, 8, 12, 15, 16, 22]. To highlight a few of these, El Emam and Madhavji [2] described a field study and the results indicate that there are seven key issues of greatest concern that must be addressed in a successful RE process improvement effort: package consideration, managing the level of detail of functional process models, examining the current system, user participation, managing uncertainty, benefits of case tools and project management capability. Hall et al. [3] discussed the requirements process problems in twelve software companies. Their main findings show that the requirements process is a major source of problems in the software development process. Nikula et al. [15] analysed the requirements engineering practices in different organizations. They have conducted a survey with twelve small and medium enterprises in order to get some numerical data on the knowledge of current requirements engineering practices and the desire to improve them. They presented the results of an empirical survey showing that the problem is not in the practitioners' lack of desire for improvement but in the management not knowing that many requirements engineering issues can be solved with standard practices that are well documented in the literature. Nuseibeh and Easterbrook [16] outlined the ongoing research in requirements engineering and its future directions. Siddiqi and Chandra [22] mentioned a gap between current research and practice and in order to reduce this gap they suggested a continuous discussion between researchers and practitioners.

The Capability Maturity Model (CMM) [17, 18] and ISO 9001 [7] series of standards share a common concern with quality and process management. There is no specific section referring to requirements engineering in these standards. The CMM is a valuable model for SPI but it is very hard to gain benefits when it is applied to the requirements process. Only requirements management is treated in details and is identified as a KPA for level 2 (repeatable) processes. But requirements management is only one area of the requirements process. CMM does not provide any specific section for the other areas of the RE process, i.e. requirements elicitation, requirements negotiation and requirements validation. There is also no particular section to requirements engineering in ISO 9001 series standards and they do not say much about the activities involved in

eliciting, analysing, negotiating and validating the requirements

Some researchers have published their work in order to improve the RE process [25, 26, 13, 14]. Sommerville et al. [25] have published the RE process maturity model which has been derived from the existing standards and has three levels, i.e. Level 1-Initial, Level 2-repeatable and Level 3-Defined. This model can be used to assess current RE process and it provides a template for requirements engineering practice assessment. This model does not provide any general methodology for the improvement of the RE process. Little research evidence is available in order to judge its effectiveness. Niazi [14] has identified five key process areas from research literature in order to improve RE process. Niazi [14] has implemented these five KPAs and developed a requirements elicitation, analysis and validation method (REAVM). Although results of REAVM evaluation are satisfactory, however, REAVM needs further refinement and improvement.

Requirements engineering is an important process of the software life-cycle. As little work has been done in order to improve the RE process. And also current SPI standards do not adequately address the issues of RE process, therefore, research in the area of RE process improvement lies at the very core of requirements engineering research.

3. Study Design

This study aims to explore the different experiences and opinions of practitioners, it is therefore important to conduct empirical research because empirical research is based on observation and experiences, it reflects the world more fully than other research approaches [4]. Also, empirical research enables rigorous experimentation by encouraging multiple analysis, from multiple perspectives using different techniques [4]. Therefore a qualitative research method has been adopted as part of empirical study.

We have conducted CSF interviews with 22 practitioners from 11 Australian companies. Each interview lasted approximately 45 minutes. All the interviews were tape recorded and then transcribed. Content analysis technique [11] was used in order to analyse each interview. Nine developers, 7 project managers and 6 senior managers voluntarily participated in this study. By volunteering to participate they have become self-selecting sample. The target population in this research was the software producing companies and practitioners. The extent, to which the sample of participants in a research adequately represents the target population, gives the results validity [11].

Self-sampling as opposed to random sampling though more practical is often prone to bias. In this research because the sample of companies form an original self-selected group (that is software producing companies), it is important to ensure that one particular group is not over represented [1]. This research addresses the issue of over representation by using a sample of companies from varying complexities, size, nature of business, type of applications etc. A profile of the companies involved in this research is presented in Appendix A.

It is further important to acknowledge that the practitioners sampled within companies are representative of practitioners in organisations as a whole. In this research, one to three practitioners from each organisation, self-selected to participate. The sample of practitioners researched includes developers, business analysts, technical directors, project managers, senior management and so forth.

4. Findings

4.1. CSFs within practitioner groups

The tables presented show the CSFs cited by practitioner groups and the frequency they occurred. The percentage shows the proportion of practitioner groups that cited a particular CSF.

4.1.1. CSFs identified by developers. Table 1 shows the list of CSFs cited by developers. CSFs are listed in order of their importance. The results suggest that in developers' opinion experienced staff can play a vital role for the improvement of RE process. It also shows that developers consider training and reviews important for the improvement of RE process. Stakeholder involvement, having clear scope up front and using a combination of text and visual models to represent requirements are also important factors for RE process improvement. More than half of

the developers have cited clear and relevant goals, sharing of best practices and allocation of resources respectively. Other factors are less cited by the developers.

Table 1 CSFs identified by developers

Success Factors	Occurrence in interviews (n=9)	
	Freq.	%
Experienced Staff	8	89
Training	7	78
Reviews	7	78
Stakeholder Involvement	6	67
Having clear scope up front	6	67
Using a combination of text and visual models to represent req.	6	67
Clear and Relevant Goals	5	56
Sharing of best practices	5	56
Allocation of Resources	5	56
Assigning of Responsibility	4	44
Iterating through requirements	4	44
Mentoring	3	33
Automated Tools	2	22

4.1.2. CSFs identified by project managers. Table 2 shows the list of CSFs cited by project managers. Results suggest that project managers are more interested in defining scope of the system, i.e. the strongest CSF cited by project managers is 'having clear scope up front'.

Table 2 CSFs identified by project managers

Success Factors	Occurrence in interviews (n=7)	
	Freq.	%
Having clear scope up front	7	100
Reviews	6	86
Experienced Staff	6	86
Stakeholder Involvement	6	86
Using a combination of text and visual models to represent req.	5	71
Clear and Relevant Goals	5	71
Sharing of best practices	5	71
Training	4	57
Assigning of Responsibility	4	57
Iterating through requirements	4	57
Mentoring	4	57
Allocation of Resources	4	43
Using multiple models to represent requirements	2	29
Automated Tools	1	14

Three other strong CSFs are reviews, experienced staff and stakeholder involvement. It shows that, like developers, project managers are also interested in reviews and experienced staff. 71% of project managers cited using a combination of text and visual models to represent requirements, clear and relevant goals and sharing of best practices respectively. More than half of the project managers cited training, assigning of responsibility, iterating through requirements and mentoring.

4.1.3. CSFs identified by senior managers. Table 3 shows the list of CSFs cited by senior managers. It shows that, like project managers, senior managers are more interested in experienced staff. It also shows that, like developers and project managers, senior managers want clear scope of the system.

Table 3 CSFs identified by senior managers

Success Factors	Occurrence in interviews (n=6)	
	Freq.	%
Experienced Staff	5	83
Having clear scope up front	5	83
Clear and Relevant Goals	5	83
Iterating through requirements	5	83
Training	4	67
Reviews	4	67
Stakeholder Involvement	4	67
Sharing of best practices	4	67
Allocation of Resources	4	67
Mentoring	4	67
Using a combination of text and visual models to represent req.	5	50
Assigning of Responsibility	3	50
Using multiple models to represent requirements	2	33
Automated Tools	1	17

4.2. CSFs across practitioner groups

Table 4 shows the spread of CSFs cited by all three-practitioner groups. Our results show that there are more similarities than differences in CFS across practitioner groups. We suggest that by identifying both similarities and differences, RE practitioners can improve the RE process. Focusing on similar CSFs across all practitioner groups may offer RE practitioners cost-effective opportunities in order to improve RE process. This

is because a small number of CSFs can be implemented that have wide effect on the success of RE process. Our findings indicate that all practitioners emphasised experienced staff as a CSF for the improvement of RE process. It also shows the factors that are considered critical by more than one practitioner groups.

Table 4 CSFs across practitioner groups

Success Factors	Dev. (n=9)	P.M (n=7)	S.M (n=6)
Experienced Staff	89%	86%	83%
Training	78%	57%	67%
Reviews	78%	86%	67%
Stakeholder Involvement	67%	86%	67%
Having clear scope up front	67%	100%	83%
Using a combination of text and visual models to represent req.	67%	71%	50%
Clear and Relevant Goals	56%	71%	83%
Sharing of best practices	56%	71%	67%
Allocation of Resources	56%	43%	67%
Assigning of Responsibility	44%	57%	50%
Iterating through requirements	44%	57%	83%
Mentoring	33%	57%	67%
Automated Tools	22%	14%	17%
Using multiple models to represent requirements	0%	29%	33%

For example, developers and project managers consider reviews as a CSF; and project managers and senior managers are more interested in having clear scope up front and clear and relevant goals.

Table 4 also shows the opinion of each individual practitioner group. For example, developers are more interested in training; project managers consider involvement of stakeholders important; and senior managers have emphasised iterating through requirements.

Table 5 shows the summary of CSFs across all practitioner groups. As CSFs are a small number of important issues on which management should focus their attention [21]. So if we only consider top 5 factors for the improvement of RE process then our results show that CSFs for the improvement of RE process are: experienced staff, having clear scope up front, reviews, stakeholders involvement and using a combination of text and visual models to represent requirements.

Table 5 Summary of CSFs across all practitioner groups

Success Factors	Occurrence in interviews (n=22)	
	Freq.	%
Experienced Staff	19	86
Having clear scope up front	18	82
Reviews	17	77
Stakeholder Involvement	16	73
Using a combination of text and visual models to represent req.	16	73
Training	15	68
Clear and Relevant Goals	15	68
Sharing of best practices	14	64
Allocation of Resources	13	59
Iterating through requirements	13	59
Assigning of Responsibility	11	50
Mentoring	11	50
Automated Tools	4	18
Using multiple models to represent requirements	4	28

5. Conclusion

In this paper we have collected and analysed CSFs for RE process improvement from groups of software practitioners. Our aim of identifying CSFs is to understand the nature of issues that play a positive role for the improvement of RE process. We suggest that focusing on these CSFs offers RE practitioners short-term opportunities for implementing practices that impact on RE process improvement. Our findings also show that there are more similarities than differences on CSFs across practitioner groups. It shows that RE practitioners are aware of what is imperative for the improvement of RE process.

7. References

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Appendix A. Participant Company Information

Company Number	Primary Business	Australian or Multinational	Age (Years)	Size (People)	RE size (People)	Budget for current project (A$)
1	Services	Australian	11-20	>2000	5-7	1-2 M
2	Services	Australian	50	101-500	5-7	>2M
3	Services	Australian	50	>2000	5-7	1-2M
4	Software	Multinational	11-20	11-100	5-7	100-500K
5	Software	Multinational	11-20	11-100	<5	100-500K
6	Software	Australian	6-10	<10	<5	<50K
7	Software/Services	Australian	5	<10	<5	100-500K
8	Services	Multinational	50	>2000	8-10	>2M
9	Services	Multinational	5	101-500	11-15	Don't know
10	Software	Other	6-10	<10	<5	50-100K
11	Other	Australian	50	11-100	<5	<50K