

A Framework for Validating Process Improvement in Requirements Engineering

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Abstract

The objective of this research is to arrive at a framework of activities and measurements to improve and validate Requirements Engineering (RE) processes. My research aims at measuring some low-level parameters and relating them to the effectiveness and efficiency of RE processes. The proposed improvement framework, when successful will measure the RE processes and improve them hence enhancing the RE Return On Investment (ROI).

Keywords: requirements engineering, requirements processes, causal analysis, process effectiveness, process efficiency, RE-software relationship chain.

1. Introduction

This doctoral research is aimed at a measurement driven examination of various RE processes, ascertaining the need for improvements based on metrics, applying improvements and validating such improvements to observe the increased effectiveness and efficiency of the improved RE processes.

2. Research Problem

RE processes and their implementation can have a profound impact on the success of the Software Development Life Cycle (SDLC), and in turn on software systems. Although there are many RE processes suggested by researchers, there is no agreed standardized basis on which RE processes are measured and categorized as effective and efficient. While some practitioners and RE researchers have found that well-defined RE processes can lead to clear, unambiguous and complete specifications, and thus to successful software systems, most view RE processes

of large projects as too complex and variable to predict their effectiveness and efficiency to any useful degree [1, 2, 3, 4, 5, 6]. This viewpoint predominates the context of large and complex software development, and in general, is clearly reflected in the published evidence of software failure analyses [7]. Often, new RE processes are introduced, when existing processes fail to produce expected results. This method, besides introducing new process problems, does not guarantee the elimination of existing ones.

There are several reasons for neglecting RE process improvements. Firstly, many RE process users claim that RE processes cannot be improved to optimize their effectiveness and efficiency. This is because there appears to be no sustainable basis for addressing process improvement issues, although there are some candidate process improvement methods. These ad hoc methods are often specific to few processes and may fall short of providing a pragmatic solution grounded by a strong conceptual theory. Secondly, there are no effective mechanisms to measure process shortfalls, since RE processes do not provide feedback in real-time about their effectiveness and efficiency. Process improvements are difficult to apply, if measurement based shortfalls of processes are nondeterministic. Due to intrinsically human-centred and the domain specific nature of RE, such measurement is difficult to determine [8]. Further, there is no consensus on the definition of RE effectiveness and efficiency.

My research attempts to resolve this situation. I define RE effectiveness as valued emergent properties of the stakeholder's needs per cost; and RE efficiency as the ratio of the total number of validated requirements that are useful to the overall total number of requirements. I examine how appropriate RE processes can identify system requirements and facilitate the acceptance of only those that are unambiguous, unique and meaningful; and also what scientific underpinning is necessary to make RE processes axiomatically sound enough to produce

meaningful and correct systems by reducing the opacity of the needs-to-requirements mapping. In particular, I draw on the importance of measurement, since neglecting the role of measurement may lead to incorrect and inaccurate conclusions about the effectiveness and efficiency of RE processes, thus to observed inconsistent and unrepeatable results. This suggests a need to identify the variables that determine the effectiveness and efficiency of RE, and to further examine the mechanisms that impact these variables.

I propose a tailorable and reusable framework to identify the problems in a given RE process and to apply improvements. The framework will be tested in large and complex real life RE situations to address the research questions: What is wrong with RE processes; how can RE processes be improved to increase their effectiveness and efficiency; and how can such improvements be validated?

3. Related Research Work

A detailed literature survey suggests the following:

1. Often, RE process improvement methods are suggested for specific processes that have a particular approach, for instance, those that follow Quality Function Deployment (QFD) [9], or Systems Dynamics (SD) [6]. It may be difficult to generalize such improvements to extend their applicability to any RE process.
2. Quality models like CMM and ISO define RE as a small part of the SDLC, and they do not have any explicitly recommended RE process improvements [6, 10].
3. There is no consensus on how to achieve the two common objectives for RE process improvements, namely, reducing the requirements defects, and increasing software quality [5].
4. Each software system may be a separate model operating in its own environment, parented by another system, and containing within itself other sub-systems [11]. This may force the RE of such systems to have some general attributes and some specific attributes. Neglecting this, may not only create irrelevance in improvements, but may also exclude some important improvements needed.
5. RE processes can reach a state of maturity based on the capability and experience of mature RE process users [12]. At this stage, any improvement can be applied only by changing the context of the process, without which, an attempted improvement can result in process disturbance, in effect, achieving just the

opposite. Such a context change, for instance, may be new technology insertion, or changes in the inputs to the process.

6. Improvements should essentially be linked to failures or to carefully measured problems [8]. Sometimes, improvements are suggested without such links. Such improvements may not have the opportunity to take effect.
7. Sometimes, RE process improvements are suggested, assuming RE to be an independent process. In reality, it may be difficult to apply RE improvements, since such actions may impact upon other SDLC processes, which may resist change [13].
8. Often, there is an inconsistent definition of the RE-software relationship chain, and the variables that determine this relationship. This clouds the RE objective, and may create confusion about whether the objective of RE is to produce better requirements or better software [14, 15, 16, 17, 18, 19, 20].

In summary, a literature survey suggests that RE improvements are often viewed informally, and that there is a need for establishing significant metrics-based standards in RE with a degree of formality.

4. Research Model

The research model I am proposing is:

1. Examining the ‘problem identifiers’ that indicate the need for process improvements.
2. Applying process improvements to counteract the problems.
3. Measuring the ‘benefits’ of process improvements.

Diagrammatically, this model can be represented as in figure 1.

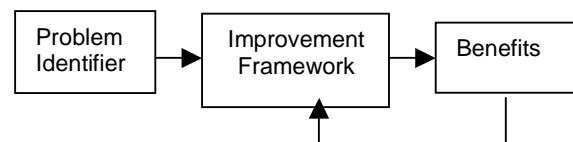


Figure 1. Process Improvement Research Model

Problem Identifiers are metrics based and are related to process outcomes, as well as symptoms of process gaps. The outcomes of a poor RE process are, for instance, requirements defects, re-work, and schedule/cost overrun. Symptoms of RE process gaps

are, for instance, communication breakdowns, and non-conformances.

Proposed Improvement Framework observes problems in RE outcomes and identifies RE process gaps, measures them against the pre-determined optimum values, and if it finds them deficient, subjects the RE process to causal analysis driven by a decision matrix, linking problems to causes. Problems are usually poorly expressed requirements that are incomplete, ambiguous, inconsistent or complex, or requirements defects. RE process gaps cause these problems. The quality of the RE process thus influences the quality of the requirements [10]. Identifying the causes of the requirement defects, prioritizing these causes and eliminating the causes based on their priority can eliminate the problems in requirements. Thus, eliminating RE process problems will reduce the number of poor requirements and increase the percentage of useful requirements. Further, such process problem elimination will increase the number of useful requirements per cost, enhancing the ROI of RE. The decision matrix supports such cause elimination decisions [21]. Figure 2 represents a typical problem causal analysis model.

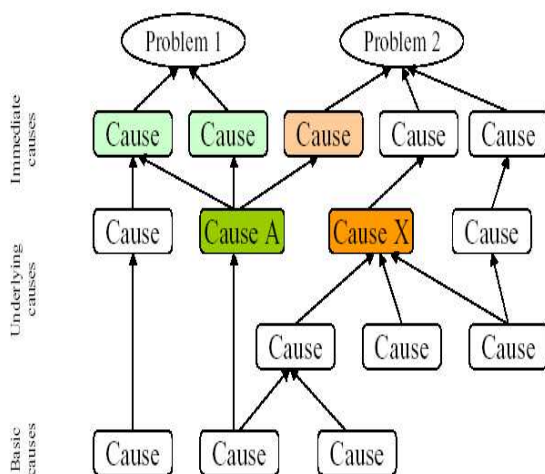


Figure 2 Problem Causal Analysis Model

Cause A is a good choice to address Problem 1. By resolving Cause A, both the immediate causes of Problem 1 are at least partially addressed. In contrast, tackling Cause X is a less practical choice for addressing Problem 2, as Cause X is itself caused by three more underlying causes, and the resolution of Cause X only marginally contributes to resolving Problem 2.

Benefits are measured to check if the underlying RE processes increase in effectiveness and efficiency by relating them to low-level requirements measurements, such as, requirements completeness, consistency, simplicity and traceability. If required, process improvements are iterated until significant, cost-effective results are achieved.

5. Proposed Empirical Study and Validation Plans

Theoretically, visualizing and uncovering all RE problems and relating them to a conceptual process improvement research framework, and necessitating the required changes and aggregating them to measurable improvements may prove less than practical. The explosion of theoretical parameters that are meant to indicate success or otherwise of RE, when researched theoretically, can generate a seemingly unmanageable complexity.

Theoretical study represents strictly controlled conditions, and by its nature may exclude some important conditions of real life RE. It is important that real RE practitioners of large and complex projects are involved in this research to obtain accurate evidence of RE process gaps and the proposed improvements. Empirical research methodology will involve obtaining SDLC and RE details to measure if an RE process needs improvement or not. Further, if an RE process needs improvement, determining the process problems and their influence on each other, and prioritizing them for elimination will reveal the immediate causes that effect the requirements problems. Finally, eliminating such immediate causes in an iterative improvement-measurement cycle will provide an opportunity to measure the improved processes for increased effectiveness and efficiency of RE.

The success of this research depends to a great degree on the accuracy of empirical data, results and successful replications. In principle, it is important for RE process improvement research to rely on empirical study in real RE situations of large and complex projects in organizations with diversity of RE issues. Such research when successful, will allow a straightforward testing of the research problem, and cautious application of research outcome in real life, thus suggesting proposed solution. Hence, this research demands a careful empirical research design.

6. Conclusion

My research attempts to identify RE process problems and improve RE processes by problem elimination using a simple, measurement driven

generalized framework. The framework, if tested in large and complex RE project situations, and found to be successful will bring robustness to RE processes and provide them with a measurement dimension, such that practitioners are assured of ROI on RE.

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7. References

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