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A theoretical framework for requirements engineering and process improvement in small and medium software companies

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Abstract

Purpose – Requirements engineering (RE) and process improvement has been identified as one of the key factors for improving software quality. Despite this, little scholarly work has been done on developing ways to improve the RE process. The situation of RE and process improvement is even worse in small and medium enterprises that produce software. Consequently, the quality of software being produced by these companies has kept deteriorating. The purpose of this paper is to design a framework that will help small and medium software companies improve their RE processes in order to compete favorably with larger software companies, more especially in terms of software quality.

Design/methodology/approach – A qualitative research approach was adapted. Four software companies in Uganda were purposively selected to participate in the study. Data were collected using questionnaires. The requirements for designing the framework were gathered and refined from both primary and secondary data.

Findings – The key requirements for process improvement in small and medium software companies were identified as user involvement, use of evolutionary requirements engineering process improvement (REPI) strategy, change management, training and education, management support and commitment.

Practical implications – The designed framework was validated to ensure that it can be applied in RE and process improvement in small and medium software companies. Validation results show that the proposed framework is applicable and can be used to improve RE and process improvement in small and medium software companies.

Originality/value – The paper presents an improvement of the systematic approach to REPI by Kabaale and Nabukenya which is decomposed for easy understanding by non-technical readers and users.

Keywords Process design, Process, Process analysis, Software engineering, Process improvement, Reengineering

Paper type Research paper

1. Introduction

Requirements engineering (RE) has been identified as one of the key factors for improving software quality (Sommerville and Ransom, 2005). Research shows that RE problems negatively impact on the effectiveness of the software development process thereby greatly reducing the quality of software (Sommerville, 1996; Davey and Cope, 2008). Despite the importance of RE in systems development, little scholarly work has been conducted on developing ways to improve the RE process (Niazi, 2002). Moreover, there is evidence that inaccurate, inadequate or misunderstood requirements are the most common causes of poor quality, cost overruns and late delivery of software systems (El Emam and Madhavji, 1995; Davey and Cope, 2008). Additionally, there is no software process that can keep delivery times, costs and product quality under control if the requirements are not properly defined (Sommerville and Ransom, 2005). Hall *et al.* observe that the requirements process is a major source of problems in the

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software development process. In the same way, Nuseibeh and Easterbrook (2000) point out that effective RE will continue to play a key role in determining the success or failure of software projects and determining the quality of software systems produced.

Software process improvement (SPI) in the software industry has been used for some time as a way of changing the current inefficient software processes in order to better achieve stated goals in terms of quality, systems development life cycle time and productivity. However, this situation is worse with small and medium enterprises (SMEs), given that most of these organizations operate on small budgets and usually have limited skilled manpower (Kituyi and Amulen, 2012; Mishra and Mishra, 2009). Although some positive results have been posited, majority software projects implemented by SMEs have turned out unsuccessful.

Most researches in RE have tried to address RE issues in large software companies. Some of these studies include Paulk *et al.* (1995), Sawyer *et al.* (1997), "A flexible and pragmatic RE framework for SMEs" (Olsson *et al.*, 2005) and Requirements Capability Maturity Model (R-CMM) (2003). Kabaale *et al.* (2014) argue that SMEs still have difficulties in using these models to improve their RE processes. This situation is unfortunate given that of late, the majority of software development companies globally fall under SMEs (Kituyi and Amulen, 2012; Pino *et al.*, 2007; Gorschek and Wohlin, 2003a). Kituyi and Amulen (2012), Kauppinen *et al.* (2001) and Dorr *et al.* (2008) suggest the need for custom-made frameworks that will help SMEs improve their RE process in order to compete favorably with larger software companies, more especially in terms of software quality. This was our main motivation behind the study. Specifically, we sought to determine the requirements for designing a framework for requirements engineering process improvement (REPI) in SME software companies; design a framework for REPI in SME software companies; and validate the designed framework for REPI in SME software companies.

2. RE as a key component of business process management (BPM)

Information systems have been used to support business processes for a long time. Before information systems and any other software products are developed, several activities are carried out to examine how the systems and/or software will fit into the existing business processes. One of these activities is called requirements analysis (Martin and Bevan, 2002). Sometimes, deployment of an information system may necessitate changes in the business process to ensure there is proper information flow. Hence, there will always be realignment of system requirements and business processes to ensure they are in synchronization. This process is a conduit of business process reengineering (BPR), which in essence looks at improving business processes by ensuring that system requirements are derived from the same processes the system is intended to support. Traditional approaches to BPR generally follow this sequential order: first, a business strategy is proposed; second, the business structures and processes are planned; third, business structures and processes are implemented with the support information technology (IT). This implies that the source for both BPR and RE lies in the business strategy. BPR is then implemented using IT based on the requirements elicited through the RE process. According to Weske (2007) all these activities culminate to what is commonly referred to as business process management.

Crabtree *et al.* (2001) suggest that BPR offers a very important and increasingly influential solution to the requirements problem in system engineering by identifying core processes that are used to redesign work activities and generate requirements for potential IT solutions. One of the main activities of RE process is requirements management due to changes in requirements over time and it has been established that one of the causes of changes in requirements is due to changes in business processes that have been reengineered.

Business and IT alignment is achieved through BPM and RE to achieve organizational objectives which are enshrined in the organizational strategy. Ullah and Lai (2011) suggest that service-oriented architecture (SOA) can also help to align business and IT strategies by SOA services that realize business processes. A business process is essentially a semi-formalization of business needs that form the basis of systems requirements.

Dragicevic *et al.* (2011) attribute the development of information systems that meet business expectations to an appropriate RE process that is supported by the organizational business processes. The specification of the business requirements that business processes must respond to and those that follow from the enterprise's strategic decisions is not fully integrated with the design of the business processes themselves. Hence, it can be established that BPR and RE work together to achieve organizational goals. RE is used to support the BPR process in any organization. Changes brought about by the BPR are captured through RE process thereby causing BPM.

3. REPI frameworks applicable to SMEs

Software companies do work with development processes because of the different people involved. There is an opinion that using these processes can facilitate the work and make it easier to meet deadlines and produce high-quality software products (Sommerville, 2001). Despite that, these processes can always be better, more effective and more tailored to every specific company through continuous PI. There are various benefits of PIs that can help software companies reduce development cost and time, meet deadlines as well as finding errors early enough in the software development process.

Many SME software companies are interested in improving their RE processes because of their confidence that RE can be the key to developing successful software systems (Mishra and Mishra, 2009). However, SMEs find it difficult to implement these PIs because they cannot bear the cost of implementing these SPIs as well as the limited resources and the strict time constraints in which they operate (Mishra and Mishra, 2009). Olsson *et al.* (2005) point out that where SMEs have in place RE process, it is always very difficult to improve such practices because it has an economic implication to the organization. Any REPI plan requires an assessment about the current status of RE process development in the software companies and a description of the strengths and weaknesses identifying potential areas for improvement (Damian *et al.*, 2004; Mishra and Mishra, 2009). Hence, Kauppinen *et al.* (2004) suggest that improving organization's RE processes should not be taken lightly because it may not lead to sustainable success in REPI. Gorschek and Wohlin (2003b) point out that one of the challenges in RE is the ability to improve the process and establish one that is compatible with the company. The current RE and PI frameworks are based on a general principle of four fairly straightforward steps; "evaluation of the current situation," "plan for improvements," "implement the improvements," "evaluate the effect of the improvements" and then the work takes another cycle (Gorschek, 2004). This framework can also be applied in the context of REPI.

Other RE process models suggested by literature such as the "A flexible and pragmatic RE framework for SMEs" (Olsson *et al.*, 2005) and the R-CMM (Beecham *et al.*, 2003a) are based on the "Good practice guide" by Sawyer *et al.* (1997). The "Good practice guide" in RE Adaptation and Improvement for Safety and

Dependability (REAIM) project (Sawyer *et al.*, 1997) gives basic guidelines on how to improve the RE process. A list of good practices is provided when dealing with RE process activities. These are categorized in basic practices which are the fundamental measures of any process of RE intermediate practices which make the process of RE more systematic and formal. These are more effective with basic practices as a basis and advanced practices that support the continuous RE improvement in the organization. Sommerville and Ransom (2005) argue that for any REPI to take place, there should be a base to measure the current and the intended process. The RE process maturity model which is part of the REAIM project can be used for process assessment. It was derived from the existing standards Capability Maturity Model (CMM) and it has three levels as compared to five levels of CMM, i.e. Level 1-Initial, Level 2-Repeatable and Level 3-Defined. This model can be used to assess current RE process in SME software companies and it could provide a template for RE process assessment for REPI.

"A flexible and pragmatic requirements engineering framework for SMEs" (Olsson *et al.*, 2005) is perhaps the best scholarly contribution toward RE and PI by SMEs. Based on "Good practice guide" of Sawyer *et al.* (1997), this framework extends the application of the good practice guide to suit the needs of SMEs with simple practices and techniques. Olsson *et al.* (2005) state that many of the existing frameworks and assessment methods are too big and cumbersome to use, while they often lack the necessary details for the requirements process. This framework has been designed and modified to suit the needs of SMEs particularly in REPIs. SMEs can use this framework for RE process assessment, solve requirements problems and REPIs as well as using the framework to make their own requirements decisions.

The R-CMM (Beecham *et al.*, 2003a) is another contribution toward RE and PI. It bases on CMM with respect to requirements and a tool for REPI. It focusses on highlighting the strengths and weaknesses in the RE process in order to help organizations agree on a strategy for RE improvement. This model suggests process assessment in adherence with SW-CMM while placing requirements best practices in a framework to help identify possible areas for improvement. However, just like the CMM model the R-CMM model is a general model for REPIs, hence, it may need modification if it is to be used in SMEs. The R-CMM model follows the CMM model and therefore using it would mean that all the levels of CMM will be adhered to. This may be costly in terms of finance and time to SMEs (Olsson *et al.*, 2005).

As observed from the proceeding discussion, the R-CMM is founded from the CMM. The CMM (Paulk *et al.*, 1993) was developed by the Software Engineering Institute at Carnegie Mellon University in the mid-1980s. During this time, software catastrophes were common. Many projects were late and over budgeted (Paulk *et al.*, 1993). CMM is a framework that describes key elements of an effective software process. The main idea is to focus on a limited set of activities, and try to improve them. It guides developers on how to effectively gain control over their processes. It also helps them to select a PI strategy by determining the maturity of the organization. The purpose of the CMM is to help organizations reach a higher level of maturity. It consists of five maturity levels where the first is the Initial level and the fifth is the Optimizing level. To reach a higher level, an organization takes many small steps. Each of the five maturity levels consists of their own key process areas (KPA). These indicate on which areas an organization should focus their improvement efforts. The KPAs identify the issues that have to be handled to achieve a maturity level.

CMM has been used by different software companies to improve their processes and it has been found to be both workable and economically beneficial to SPI (Sawyer *et al.*, 1997).

However, the experiences of some SMEs find it true that the benefits are harder to gain when applied to the RE process because CMM is not clear about the composition of the RE process and what is to be expected out of it (Sawyer *et al.*, 1997). Kituyi and Amulen (2012) argue that the five levels posited in CCM are too many and make it complicated for SMEs to apply due to limitations in skills and other resources. The only aspect of the RE process treated in detail is requirements management which is identified as a KPA for Level 2 (repeatable) and this is only one area of the RE process. The other problem is the extensive time and financial resources taken to reach maturity level and yet SMEs are always constrained by time and money.

A system approach for RE and PI for SMEs (Kabaale and Nabukenya, 2012) is also another initiative solution toward addressing SME challenges in SPI. The approach presents three faceted steps in RE and SPI. These include assessment of the RE process, requirements and RE improvement steps. The approach yields to a set of outputs including a simple and easy RE processes, RE project risks minimization among others. Just like CCM (Paulk *et al.*, 1993), the biggest challenge with this approach is being too congested. Most SMEs employees do not have much knowledge and skills to conceptualize models and/or frameworks. This is even worse given that they do not comprehend and appreciate scholarly works. Therefore, for a given framework to be easily applied it has to be as summarized as possible (Kituyi and Amulen, 2012).

From the above discussion, we observe that the REPI models are used to understand the current RE processes and practices being used in SMEs through process assessments of the current situations as well as being used to evaluate the status of existing requirements practices in SMEs (Kauppinen and Kujala, 2001a). The assessment made through the use of these models provides information that is used to set realistic improvement goals, PI planning and practical actions for SMEs (Kauppinen and Kujala, 2001b). These models are also used to guide SMEs toward optimizing their RE processes as well as measuring the process strengths and weaknesses (Beecham *et al.*, 2003b). Sawyer *et al.* (1997) suggest that REPI models provide guidelines for the adoption of RE good practices based on assessments of the state of organizations' current processes and the likely benefits to be gained from adopting new practices.

In this study, the reviewed REPI models and frameworks provided a theoretical basis on which the proposed RE and PI framework for SMEs was designed. The strengths of these frameworks were adopted, whereas their weaknesses were eliminated. To alleviate the fears of SMEs about REPI, the benefits of REPI are used as incentives to lure SMEs toward improving their RE processes and practices.

4. Research design

A qualitative research design was used. Qualitative data collection techniques (interview, questionnaires and document reviews) were used to collect data from the case organizations. These were considered most appropriate given the research strategy (inductive) and other factors such as cost and time implications.

An inductive research strategy was followed in conducting the study because the RE processes and practices in Ugandan SME software companies were not known at the moment. Inductive research strategy is described as building theories from empirically established facts in a given situation (Sedmak and Longhurst, 2010). It can be used to derive theories from observations made about a given phenomenon (in our case RE process and practices in SMEs). According to Trochim (2006), inductive research strategy moves from specific observations to broader generalizations and theories. It is sometimes referred to as bottom up framework or (feature detecting).

Given that inductive research strategy is open-ended and exploratory in nature, there was room for feature detecting for knowledge. The strategy is most appropriate when using qualitative data with open-ended research questions, like in this case.

The major phases of inductive research that were followed included: observation phase, where we collected data regarding the status of RE process and practices in SMEs both from the exploratory study and existing literature and the pattern and tentative hypothesis phase, where we analyzed data to derive requirements that were used to guide the designing of the REPI framework for SME software companies. The designed REPI framework was tested and validated as a theory using case studies.

To achieve the above, four case organizations in Uganda were selected. These included:

(1) The Department of Innovations and Software Development, Makerere University. This enabled us to study and evaluate the different RE processes and practices being used at the center.

(2) Socket Works Project, Makerere University Business School. This project is one of the many failed IS projects in recent years. Practical information was got about the possible causes of failure, how such failures can be treated through REPI models.

(3) Digital Solutions Uganda Ltd. This is a software company dealing in the provision of custom software solutions to the Ugandan market. The company has been in existence since May 1998. It aims at providing customized software solutions with the development of local software developers.

(4) Crystal Clear Software Ltd. This company is the sole developer of Loan Performer, the award winning software for microfinance institutions in Uganda since 1998. The company employs about 27 staff.

A total of 60 respondents were purposively selected from these four institutions to participate in the study as shown in Table I. According to Roscoe (1975) rule of thumb, this sample is adequate for the study.

Out of the 60 sample, 54 questionnaires were returned. However, during the data cleaning exercise, two questionnaires were found to be incomplete and inconsistently filled-in. These were removed from the final analysis. Hence a response rate of 87 percent was achieved.

Descriptive statistics were used to analyze data so as to identify the requirements for designing the framework. SPSS was used to analyze the data, whereas MS Word 2007 was used to draw the framework.

Organization	Number of respondents	Sampling method
Socket Works Project, Makerere University Business School	20	Purposive sampling
Department of Innovations and Software Development, Makerere University	20	
Crystal Clear Software Ltd	10	
Digital Solutions Uganda Ltd	10	
Total	60	

Table I.
Sample distribution

4.1 Framework validation

Case study and expert judgment techniques were used to validate the framework. A sample of 40 experts was selected from the four case organizations that had participated in the explorative study. Out of the 40, 36 responses were obtained. This translates to a 90 percent response rate, which is very good. This sample is also within Roscoe (1975) rule of thumb that states that a sample size between 30 and 500 is sufficient. According to Hakim (1987) and Beecham *et al.* (2005), small samples can be used to validate explanations and support model development. Small samples can also be used to get expert feedback to evaluate models and frameworks. This formed the basis of our motivation to use small samples to validate the designed framework for REPI more especially in SMEs were there are few experts in the RE area.

A questionnaire was used to collect validation data. Both survey and validation questionnaires were pre-tested for validity and reliability before administering them. The validation respondents comprised of experts from each case organization. These were requirements engineers, systems analysts, software developers as well as project managers. The criteria for selecting the experts were mainly experience, level of education and area of expertise as shown in the validation results.

5. Findings

This section presents the findings from the exploratory study with respect to REPI practices in Ugandan SME software companies. The findings presented hereafter were the main basis upon which the REPI framework for SME software companies was designed.

5.1 Pre-testing of the questionnaire

Carcary (2008) argues that validity and reliability tests help in determining the fitness and consistency of a given research instrument used for data collection. Table II presents validity and reliability results.

According to Cronbach (1951), the results obtained in Table II indicate that the questionnaire was reliable given that all variables under the study had a Cronbach's α coefficient <0.7. A Content Validity test on study variables revealed that all variables scored 0.6 and above, hence the questionnaire was valid (Krishnaveni and Ranganath, 2011).

5.2 REPI models

REPI models form a basis for assessing the current RE process practices used in the organization. It is upon which REPI can be based. Respondents were asked about their awareness about REPI models as seen in Table III.

Table II. Validity and reliability

Variable	No. of items	Cronbach's α coefficient	Content Validity Index
Requirements elicitation methods	9	0.702	0.724
Sources of requirements in SME software companies	6	0.781	0.624
Requirements management tools	9	0.755	0.682
Benefits of REPI	9	0.704	0.611

From Table III, respondents reported that they were not aware of the available REPI models (53.8 percent) despite their interest in improving the RE processes. On the other hand, 46.2 percent were aware of the availability of REPI models.

5.3 *Benefits of REPI*

The respondents were further asked about the benefits of REPI. Table IV shows the results obtained.

From Table IV, results reveal that respondents considered improved quality and productivity (30.8 percent) as the most important benefit of REPI to their companies. Others considered time saving and reduction in development costs as beneficial to REPI (17.3 percent).

5.4 *Challenges to REPI*

Data were also collected to examine the major challenges faced by software SMEs in RE and PI using a five-point Likert scale where 1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree and 5 = strongly agree. Table V shows the results.

Results in table in Table V show that respondents strongly agreed that software users were not fully involved in REPI (mean = 4.56), REPI was costly (mean = 4.47), staff resisted changes in adapting REPI (mean = 4.62), staff lacked the necessary knowledge and skills to use REPI (mean = 4.33) and that top management did not support REPI activities in the organization (mean = 4.72).

6. Discussion of findings

Regarding REPI models, respondents reported that management was not aware of any available REPI models despite their interest in improving the RE processes. Surprisingly, the respondents were aware of the benefits of REPI and willing to start any PI in order to tap the benefits. However, they did not know any REPI models available in practice and a few were using customized models to help in the

Awareness of REPI models	Frequency	%
Yes (aware)	24	46.2
No (not aware)	28	53.8
Total	52	100.0

Table III. Awareness of REPI models

Benefits of REPI	Frequency	%
Time saving	9	17.3
Reduction in development costs	9	17.3
Improved management control	3	5.8
Client satisfaction	2	3.8
Better software	2	3.8
Improved quality and productivity	16	30.8
Shared understanding	3	5.8
Solid foundation	3	5.8
Early error detection	5	9.6
Total	52	100.0

Table IV. Benefits of REPI

Table V.
Challenges to REPI

Challenge	Min.	Max.	Mean	SD	Meaning
Software users are not fully involved in REPI	2	5	4.56	0.02	Strongly agree
REPI is costly	1	5	4.47	0.06	Strongly agree
There is staff resistance to change in adapting REPI	2	5	4.62	0.01	Strongly agree
Our staff lack the necessary knowledge and skills to use REPI	2	5	4.33	0.01	Strongly agree
Top management does not support REPI activities in the organization	1	5	4.72	0.09	Strongly agree

improvement of the RE process. Despite their low levels of software maturity, SMEs in existing research (see e.g. Nikula and Sajaniemi, 2000; Kauppinen *et al.*, 2004; Sommerville, 2005) used one or two REPI models in their PIs. Majority of the SMEs did not have any specific approach to REPI. This was largely caused by lack of knowledge of the improvement models available for use. This further indicates the low levels of RE process maturity in these SMEs. This situation is consistent with Kamsties *et al.* (1998) study in which REPI was among the top to PIs ranked by the respondents from different SMEs in Germany.

Furthermore, the findings largely agree with literature on the challenges faced by SMEs in using RE and PI. For example, Baddoo and Hall (2003) indicate that most software companies did not fully involve users in the RE and PI process. Similarly, Salimifard *et al.* (2010) decried the lack of management support and Pino *et al.* (2007) and Wiegers (1996) revealed that lack of relevant knowledge and skills were the most pressing challenges to RE and PI. The findings further agree with Pino *et al.* (2007) and Kamsties *et al.* (1998) that RE and PI was an expensive exercise such that most SMEs would not afford it. In addition, scholars such as McFeeley (1996), Damian *et al.* (2004) identified resistance to change as a hindrance to RE and PI. In light of this, all the challenges listed in Table V were considered valid and constituted part of the problem analysis in the elicitation of framework requirements.

7. Framework design

This section presents a description of how the framework was designed and how it can be applied for successful RE and PI in SME software companies.

7.1 Requirements for designing the REPI framework

The requirements for the design of the REPI framework for SME software companies were derived from the challenges observed in the exploratory study. This was on the understanding that these requirements could be used as measures to overcome the challenges. Apart from the derived requirements from the results presented in Table VI, we also adopted the steps from existing generic frameworks as suggested by Dominic (2009) to manage the requirements. This is because they are considered important in the REPI plan.

7.2 Framework for RE and PI by software SMEs

The framework for RE and PI by software SMEs has a cycle of four phases including assess current REPI strategy, elicit requirements, refine requirements and implement requirements. Software SMEs are urged to always examine their existing REPI strategies in order to harmonize their conflicts and come up with the most appropriate strategy for the organization. After a strategy has been chosen, the SMEs can elicit requirements from users, clients, management, developers and other stakeholders involved on a given software project. These requirements should then be refined through a rigorous process of addition and elimination. Various data analysis techniques and tools can be used at the stage. Once the requirements have been refined and agreed upon by all stakeholders, they can be implemented in the design of the software. Figure 1 shows the proposed framework for RE and PI by software SMEs.

7.3 Application of the framework

For successful RE and PI in SMEs, the proposed framework should be used in consideration of the following.

Support user involvement. There is a need to support user involvement in REPI if new processes are to succeed and be institutionalized (Wiegers, 1996). Users should be involved in the assessment of the current state of the RE process in terms of its strengths and weaknesses. This can serve as a starting point for REPI. The assessment made helps users to build a shared understanding of the improvement goals, planning and practical actions for these SMEs (Kauppinen and Kujala, 2001b). Users should also be involved while defining RE processes – this step follows the assessment of the current RE processes and practices. Simplicity and ease of use in REPI can be a determining factor for any REPI efforts. Involving users in defining simple processes and practices makes it very easy for users to learn and work with the new improved processes, as well as integrating new processes incrementally and gradually.

Use evolutionary improvement strategy. Sawyer *et al.* (1997) recommend organizations to introduce cheap small-scale improvements with a high benefit/cost ratio before expensive new techniques. Where SMEs are budget constrained then small incremental processes can help in alleviating the problem. This is enabled through piloting the new small RE process, i.e. use the evolutionary improvement strategy while piloting the new RE processes in the organization. This will help in avoiding unnecessary project risks that may be caused by rapid changes in the organization. Improved processes and practices should be introduced gradually and blended with existing practices. This will help to create RE process acceptance throughout the organization.

Challenges	Derived requirements	Adopted step	Output
Lack of user involvement	Support user involvement	Define a simple RE process	Simple and easy RE processes
Expensive	Use of evolutionary REPI strategy	Pilot the new RE process	Unnecessary project risks avoided
Resistance to change	Support change management	Adapt the new RE process	Tailored RE process adapted
Lack of skills	Provide training and education	Create awareness and promotion of the new RE process	New RE process is promoted in the organization
Lack of management support	Encourage management support and commitment	Promotion of systematic use of the new process in the organization	RE process integrated in the organization

Table VI. Matrix of challenges, derived, co-opted requirements and output

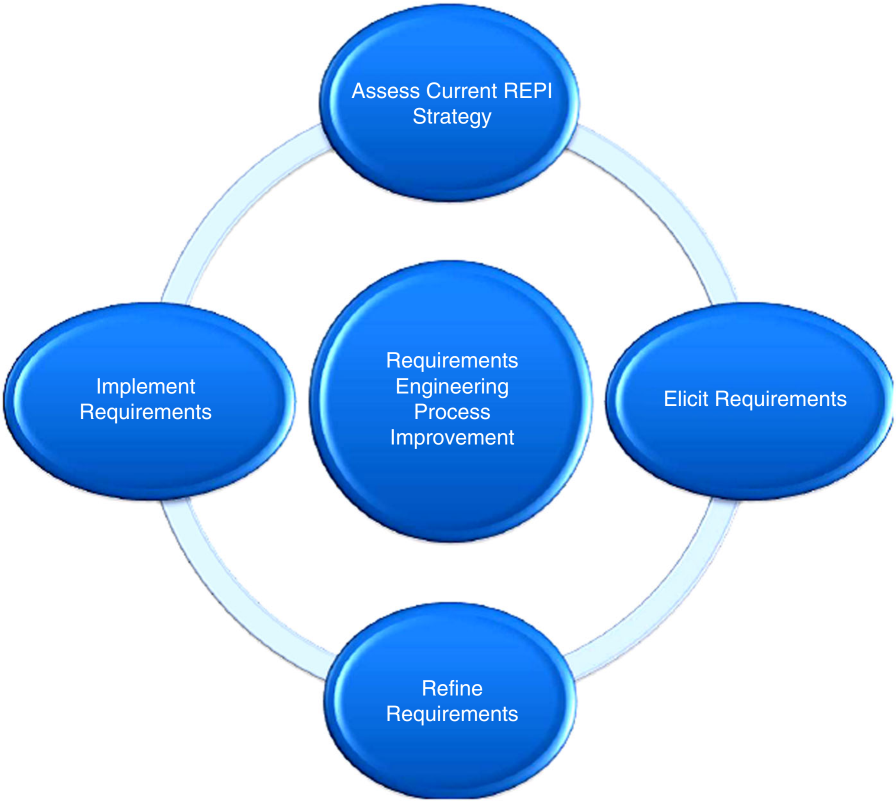

Figure 1.
Framework for requirements engineering and process improvement in SMEs

Support change management. It is important to manage change so as to minimize employee resistance to new and improved RE processes. This can be done by adapting the new RE process, i.e. tailor the improved process to the organization. There is need to set clear, quantifiable and measureable REPI benefits if the process is to succeed (Damian *et al.*, 2004). The benefits of the improved process should be known to all the team members involved in the software development process through a proper change management plan. The new RE process should be adapted to the needs of the organization and be integrated in the daily routines of the organization.

Support training and education. Education and training helps to promote the good understanding of the RE process to all the people involved in the improvement process (Pinheiro, 2003). It is considered to be one of the critical success factors for any RE improvement process. This can be enabled by creating awareness and promoting the new RE process. This involves usage of the new RE process benefits to promote its use in the organization and persuading software product development teams to adopt the new RE process and secure the support of senior management. Communicate these practices through face-to-face discussions, staff meetings and newsletters so that everyone in the organization is informed. Organize training and education about the new RE processes to the employees so as to eliminate any chances of resistance to change to the new RE processes.

Encourage management commitment and support. Management support to PI can be in form of funding, allocation of staff and providing a conducive environment for working (Kauppinen *et al.*, 2004). This can be done by promoting systematic use of the new processes throughout the organization.

8. Framework validation

In this section, we present and discuss the validation of the REPI framework for SME software companies. The framework was exposed to four case SMEs organizations. Validation is a process of ensuring that the framework is sufficiently accurate for the purpose for which it is designed (Beecham *et al.*, 2005). Validation helped us to find out whether the framework is applicable to SME software companies or not. As earlier explained, to validate the framework, a group of experts was chosen from the case organizations. Similar validation processes have been used in Kituyi *et al.* (2012), Beecham *et al.* (2005) and Niazi *et al.* (2003) to validate frameworks. This was done by use of a questionnaire and interviews that were administered to the experts. The questions therein centered mainly on design science value parameters (usability, understandability, simplicity, completeness and applicability) posited by Gonzalez (2009).

A validation criterion was set to find out from the experts how systematic the framework is, in improving RE process in SMEs. Five areas were considered for the framework as follows.

Ease of use: usability is the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use (Niazi *et al.*, 2003). The goal of this criteria was to locate areas of confusion and ambiguity for the users which, when improved increases the efficiency and quality of a users' experience with the framework. The following usability validation factors were used:

- the framework should be simple yet retain meaning;
- the framework should require little or no training to be used;
- the framework should be easy to learn and understand; and
- the framework should bring about user satisfaction in using it.

Niazi *et al.* emphasize usability as a key requirement of any PI framework. Therefore, usability was used to find out how easy the framework is for the users. Ease of use of the framework can lead to its adoption.

Understandable: all users of the framework should develop a shared understanding of the RE process in order to identify where improvement is needed. There should be no ambiguity in interpretation, especially when goals are set for improvement and all terms should be clearly defined. Validation factors for understandability included:

- use of simple language;
- framework steps to follow are well defined;
- clear definition of framework terms; and
- no ambiguity; systematic flow of the framework.

Understanding is a prerequisite for effective PI and management (Beecham *et al.*, 2003a). Therefore it was used to assess how easy to understand the framework and this in turn will facilitate its use in the REPI in SME software companies.

Consistency: having consistent use of terms and processes in the framework. Framework development and adaptation depends on an acceptable level of consistency. Validation of framework consistency was based on the factors below:

- there should be consistent use of terms in the framework;
- there should be consistency in structure between framework components; and
- there should be logical flow of the framework processes.

To fully understand the framework or model, it is important that there is a common and consistent language used in the development. This helps users to easily understand and use the framework or model.

Applicability: this factor assessed the framework's applicability to SME software companies in the Ugandan context. To determine the framework's applicability and suitability, the factors below were used:

- the scope/level of detail should be appropriate;
- the framework should be flexible;
- the framework should be easy to tailor to different SMEs environments; and
- the framework should be simple to adopt.

The framework should be structured so that it can be extended and tailored to different SME software companies in REPI.

8.1 Validity and reliability of the validation questionnaire

To ensure validity and reliability of the validation process, tests were carried out on the validation questionnaire to ensure it measured to design science value parameters (Gonzalez, 2009) and that the questionnaire was consistent and stable. Table VII presents validation and reliability results.

Results in Table VII show a Cronbach's α coefficient and Content Validity Index >0.6. These results indicate that the questionnaire was valid and reliable (Krishnaveni and Ranganath, 2011; Carcary, 2008; Saha, 2008).

8.2 Respondents role in their organizations

We desired to learn about the roles of the respondents in relation to RE process and their responses are represented graphically in Figure 2.

In Figure 2, results show that majority of the respondents were systems analysts (43.3 percent), followed by software developers (33.3 percent). Only (3.3 percent) were systems administrators and IT managers involved in RE process activities. This fits our criteria of choosing the experts basing on their areas of expertise in RE

Variable	No. of items	Anchor	Cronbach's α coefficient	Content Validity Index
Functionality of the framework	5	Agree/disagree	0.882	0.601
Ease of use	4	Agree/disagree	0.878	0.605
Understandability	4	Agree/disagree	0.878	0.605
Framework consistency	3	Agree/disagree	0.879	0.609
Framework applicability and scope	8	Agree/disagree	0.702	0.641

Table VII. Validation questionnaire pre-test results

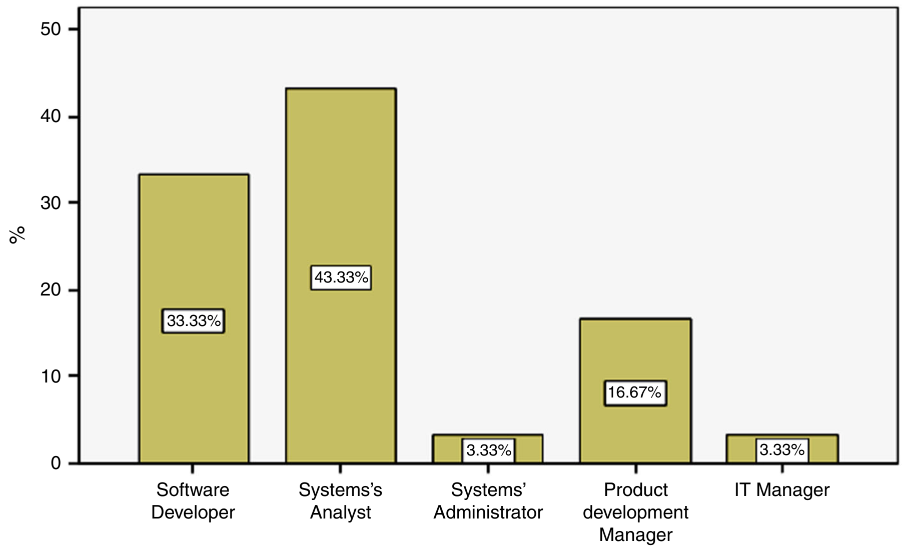

Figure 2. Respondents' roles in the organization

environment and the results show systems analysts as the major people with the responsibility of eliciting requirements.

8.3 Level of experience

To determine the respondents' level of experience, data were collected on how many years each respondent had spent working with RE process and the results were analyzed and interpreted using frequencies and percentages as shown in Table VIII.

Findings from Table VIII indicate that majority of the respondents (47.2 percent) had seven to nine years of experience. This was followed by those respondents with four to six years of experience (41.7 percent). Only four respondents had spent more than nine years working with RE process activities. This was enough experience for respondents to qualify as experts in the validation process.

8.4 Framework usability

From Table IX, results revealed that the framework is easy to use (77 percent) because of its simplicity (85 percent), easy to learn and understand (68 percent) as well as user satisfaction (68 percent). On the other hand only 23 percent did not agree that the framework is easy to use. This may be due to the fact that this was the first framework being used in their organizations.

Years of experience	Frequency	%
1-3	0	0.0
4-6	15	41.7
7-9	17	47.2
Others	4	11.1
Total	36	100.0

Table VIII. Level of experience

Respondents were asked about their understanding of the proposed framework. Table X presents the findings.

From Table X, results reveal that the new framework is easy to understand (80 percent). This was attributed to the use of simple language (80 percent), few steps to follow (84 percent) while using the framework, clear definition of terms (70 percent) and the framework not being ambiguous (86 percent). However, on the other hand only 20 percent of the respondents did not find the framework very easy to understand as well. This was mainly given by those respondents who did not find the framework easy to use. Having established that the framework was easy to use and understand, it was necessary to find out the factors behind the simplicity of the framework. Table XI presents the finding.

Results in Table XI, show that the framework has consistency in terms of the terms used (87 percent), consistency in structure (85 percent) and logical flow of framework processes, only 17.7 percent did not find the framework consistent. Further, we desired to find out how applicable the framework is to SMEs. Table XII shows the results.

From Table XII, the framework is applicable to SMEs in different environments and it contained the appropriate details (80 percent). This is because of the level of details being appropriate in the framework (75 percent); the framework was flexible (85 percent) and simple to adopt (80 percent). It is easy to tailor to different SMEs environments (80 percent). However, a few respondents (20 percent) did not agree that the framework is applicable to SMEs and that it did not contain the appropriate details.

Table IX. Response about ease of use of the framework

The framework is easy to use	Agree (%)	Disagree (%)
Framework is simple to use	85	15
Framework is easy to learn and understand	68	32
It brings about user satisfaction in using it	70	30
It requires little training or no training to use it	85	15
Average percentage	77	23

Table X. Response about understandability of the framework

The framework is easy to understand	Agree (%)	Disagree (%)
Use of simple language	80	20
Few steps to follow	84	16
Clear definition of terms	70	30
No ambiguity	86	14
Average percentage	80.0	20.0

Table XI. Response about framework consistency

The framework is consistent	Agree (%)	Disagree (%)
Consistent use of terms	87	13
Consistency in structure	85	15
Logical flow of the framework processes	75	25
Average percentage	82.3	17.7

8.5 Framework recommendation

Finally, a summary of the above responses was done to find out if respondents would recommend this framework to other SME software companies that are planning REPI. Table XIII shows the results.

From Table XIII, majority of the respondents (80.7 percent) recommended the proposed framework to other organizations in REPI. Only 19.3 percent did not. This calls for more case validation of the framework in different settings to build confidence in more stakeholders in RE area. These statistics can conclusively assert that the framework was found acceptable by the majority (80.7 percent) who comprised the knowledgeable people in RE area of system development compared to 19 percent who disagreed.

9. Conclusion

To operationalize the REPI requirements, we co-opted the REPI four cycled phases which should, if well utilized, lead to effective REPI. This framework is a methodical approach that is learnable and understandable given its simplified and decomposed design. Therefore it is very important to SMEs that are unable to improve their RE processes due to different reasons, and consequently assist them in improving their RE processes systematically.

From the validation results it was established that the framework can be beneficial for REPI in SME software companies. It was observed that the framework was easy to use in terms of being simple to learn and understand, requires little time or no training to be used; understandable in terms of using simple language, steps to follow and systematic flow of the phases; consistent in terms of using consistent terms and logical flow of the approach processes; applicable and systematic in terms of its flexibility to different environments.

Therefore, given the feedback from our cases and validation results, we conclude that the proposed REPI can indeed assist SME software companies specifically in developing countries like Uganda to improve their RE processes. The framework is

The framework applicability and scope	Agree (%)	Disagree (%)
Level of details is appropriate	75	25
The framework is flexible	85	15
The framework is easy to tailor	80	20
The framework is simple to adopt	80	20
Average percentage	80.0	20.0

Table XII. Response about framework applicability and scope

Framework recommendation	Agree (%)	Disagree (%)
Framework functionality	82.4	17.6
Easy to use	78.8	21.3
Easy to understand	80	20
Consistency	82.3	17.7
Applicability and scope	80	20
Average percentage	80.7	19.3

Table XIII. Framework recommendation suitable and applicable to SME software companies in different environments that could be in need of REPI.

9.1 Limitations

The low levels of RE processes in SME software companies, where some SMEs did even not see the need to engage in a process that did not yield immediate results was a limiting factor. We also observed that requirements skills were still lacking in SMEs and this impacted negatively on the RE process.

During the exploratory study we noted that most of the cases visited had little or no defined RE process, though some SMEs were using customized ways of requirements development. It was hard to assess such cases using the more common known RE improvement and assessment models.

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