Requirements Engineering Process Improvement Challenges faced by Software SMEs in Uganda

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ABSTRACT
Despite the numerous benefits of Requirements Engineering Process Improvement, many Ugandan software developing companies seem not to properly conduct it. This has implications on the quality of software being produced by these organizations. Moreover, little research has been conducted to establish the challenges being faced by the Small and Medium Enterprises that produce software in Uganda. This study examines the challenges of requirements engineering process improvement in Ugandan SME software companies with an aim of coming up with recommendations for improving the quality of software produced by Ugandan SME software companies.

A qualitative research approach was used where four software producing companies in Uganda were selected to participate as case studies. Descriptive statistics were used to analyze data. The main challenges hindering successful Requirements Engineering Process Improvement were identified as ambiguous requirements from the clients, lack of user's involvement and lack of management support. The study recommends that for successful Requirements Engineering Process Improvement in Ugandan software companies, there should be training, user involvement and establishment of proper change management strategies.

General Terms
Software Development, Software Design, Computer Software, Process Re-engineering

Keywords
Keywords: Requirements Engineering, Process Improvement, Challenges, Software Engineering, SME, Uganda

1. INTRODUCTION
Requirements Reengineering Process Improvement (REPI) is one of developments in the area of Software Engineering (SE) discipline, which is concerned with all aspects of software development from the early stages of requirements engineering, specification to maintenance of the system when it goes into use [1]. According to [2], Requirements Engineering (RE) is the first stage in system development and it is during this process that what to build is decided. It lays a foundation for the later phases of system development.

Requirements are a description of what an application is expected to do [3-4]. They represent what the delivered system will be able to accomplish. [5] Posits that without a well-written requirements specification, developers do not know what to build, users do not know what to expect, and there is no way to validate that the created system actually meets the original needs of the user. In [5], requirements are statements that identify a necessary attribute, capability, characteristic, or quality of a system in order for it to have value and utility to a user. These requirements are mostly constraints on the system design. Good requirements should be complete, correct, unambiguous, consistent and traceable.

In [6], requirements can be differentiated among: *functional requirements*, which specify the behavior, and/or services that the product must provide; and *non-functional requirements* or quality requirements, which express the desirable qualities that the final product must have and, so, they impose certain restrictions on the design or implementation. [6] Proposed five universal truths that system developers should take into consideration about system requirements. These are; teams should always try to get the requirements right, requirements definition is a discovery and invention process, not just a collection process, user involvement is very important to software quality and managing requirements change is very important.

On the other hand, RE is a process-oriented approach to the definition, analysis, model, documentation, and maintenance of requirements throughout the software development life cycle [7]. [8] Defines a *process* as an organized set of activities which transforms inputs to outputs. Documented processes are very important in software projects because they help work to be done successfully and they can be used to repeat the success enjoyed in previous projects. According to [9], RE is "the branch of software engineering concerned with the real-world goals for, functions of, and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behavior, and to their evolution over time and across software families". The RE process varies enormously depending on the type of system being developed as well as the size of the companies involved in the process. For large systems, it is more formal than in small systems [8]. Whether in large or small systems, some activities are fundamental to all RE processes [10] as described below;

- *Requirements elicitation* - deals with exploring, acquiring, and rectifying user requirements through discussions with the problem owners, introspection, observation of the existing system and task analysis.
- *Requirements analysis* - requirements are evaluated and analyzed for correctness properties (such as completeness and consistency) and feasibility properties (such as cost and resources needed), as well as understanding the requirements in details.
- *Requirements validation* - once requirements have been defined, they have to be validated through requirements validation, the requirements specification is checked to correspond to the user's needs and the customer's requirements.

Requirements can be validated using techniques like reviews, audits, Traceability matrix and prototyping.

- *Requirements negotiation* - during this phase, the systems analyst and other stakeholders harmonize all the requirements that are not agreeable to both sides. Trade-off points are reached in this phase, as well as incorporating emerging requirements. This produces a consistent set of requirements.
- *Requirements Documentation* - documenting the requirements in a way that all stakeholders and software developers can understand. The outcome of which is a Requirements specification document that forms the contractual basis of the whole process.
- *Requirements Management* - Control the requirements changes that will inevitably arise using a set of procedures that assist in maintaining the evolution of requirements throughout the development process. These include planning, traceability, and impact assessment of changing requirements.

While RE is being recognized in its own right of recent, from the SE perspective, it is the first activity of the software process, and it is meant to establish the services and constraints on the system's operation and development. RE is a very important phase of the software process as errors at this phase inevitably lead to later problems in the system design and implementation [11]. Moreover, RE, being an important process of the software life-cycle can lead to better quality in software and systems development processes [12-13]. RE is also an important component of the systems engineering process; it sets the problem scope and then links all the subsequent development phases to it. It is only with efficient RE that the development process can be controlled and directed in terms of appropriateness and cost-effectiveness of the solution produced [14]. The main aim of a RE process is to come up with a set of necessary, verifiable and attainable requirements, which are acceptable to all the relevant stakeholders [13; 15]. Agreed requirements provide the basis for planning the development of a system and accepting it on completion. They are essential when sensible and informed tradeoffs have to be made and they are also vital when, as inevitably happens, changes are called for during the development process [14]. RE process is widely recognized as the most crucial and difficult part of systems development. As stated by [16], nothing is harder than deciding what to build, hence RE process is a critical success factor in system development.

Despite the above benefits of RE and REPI, many Ugandan software developing companies seem not to properly conduct it. This has implications on the quality of software being produced by these organizations [17]. Moreover, little research has been conducted to establish the challenges being faced by these Small and Medium Enterprises (SMEs). This study examines the challenges of requirements engineering improvement process in Ugandan SME software companies with an aim of coming up with recommendations for improving the quality of software produced by Ugandan SME software companies.

2. THE NEED FOR RE PROCESS IMPROVEMENT IN SMEs

For some time, research in RE has not had such a big impact on the practices, techniques, methods and tools used in the industry. In a bid to narrow the gap between the theory and practice, there are incentives that are derived from improving RE process in software companies and these have been advanced by [18] and [19]. However, it may not be very easy to measure the benefits of RE process improvement because there is a long time lag between the requirements phase and system delivery to pinpoint how specific RE techniques contribute to a system's success or failure [4]. Despite this, there are many benefits that can be derived from RE process improvement:

Early Error Detection; RE helps to discover errors early in system development. Such errors are very easy and cheap to correct than errors detected in the later stages of system development. This can save time as well as human efforts that would have been dedicated to correcting such errors in the later stages of system development. Fixing errors at later stage made at requirements level accounts for 75% of all error removal costs [20].

Early Detection of Differences among Stakeholders; RE is inherently complex because of the various stakeholders that are involved with different backgrounds and intentions. It is very common for such stakeholders to have differences, but with RE in place such differences can be detected and solved early. With a common aim among the stakeholders a precise, unambiguous and agreed upon requirements document can be produced and this clarifies differences among the stakeholders if any remaining among the stakeholders early in the development process [4].

Solid Foundation for Later Phases; RE forms the basis of the later stages of system development, there is always interaction between these stages and RE as stated in [4; 6]. The output from RE is the requirements document that is used in the design of the system. This forms a contract between the developer and the client and is also used in system testing and implementation. Therefore the success of any Information system is measured according to the degree to which it meets the purpose, and RE plays a crucial role in making sure that the system developed meets the purpose for which it was developed [6].

Improved Quality and Productivity; RE is arguably one of the most important processes in system development [4-5] where quality is much emphasized. There is a general agreement that RE can improve both quality and productivity tremendously. This improves chances of the system development to success. Practitioners in the industry can be interested in trying out such methods in order to improve the success of their system development projects.

Improved Management Visibility and Control; RE can help management to have a better control of system development projects and can be able to predict the completion of the project. One of the problems facing system development projects is delivering of the finished product late; therefore management can use RE to estimate when the product will be delivered. This improves the chances of getting another contract from the same client [21].

Given the above benefits that accrue to RE process improvement, SMEs can be able to reduce on software project failures and produce software within budget and time frames agreed upon with the customers. Management of SMEs will have a better control of the development process in terms of resource and schedule monitoring.

3. METHODOLOGY

A qualitative research design and case study research approach was adopted give the nature of the study. A total of

four SMEs that develop software in Uganda were purposively selected to participate in the study. The companies represented different application domains, experiences in software development and company sizes. Based on this selection criteria therefore, our findings give a general overview of different kinds of SMEs, their attitudes towards RE and the challenges they face. The SMEs selected for this research study operated in a wide range of application domains; business information systems, office automation, web based systems, loan performer software and education information systems. Employees of these SMEs who participated as respondents were working as systems analysts, systems administrators, programmers and project managers. Below is a brief description of the selected cases for the study.

Case 1: *Makerere University Business School (Socket works project).* The Socket works project in Makerere University Business School aimed at developing an Education information management system that was to be used by the school. The key areas in this project were among others requirements elicitation, analysis, design and implementation. However, the project did not yield the intended results and one of the problem areas was user requirements. It provided respondents in these specific areas of requirements engineering.

Case 2: *Department of Innovations and Software Development, Makerere University School of Computing and Informatics Technology.* It focuses on the growth of software conception, design and development capacity at the School of computing and Informatics Technology. The department believes in the development of local capacity to build and exploit ICT innovations in the Country. The department's plan centers on Open Source software development model, driven a strong collaboration with the community. Their first software system is a Free & Open Source school management system for primary and secondary schools in Uganda. The department is involved in different external and internal projects ranging from business information systems to web based applications. The department has a core team of full-time employees who have considerable experience in their relevant areas and carry out extensive software development activities in accordance with detailed business designs and plans.

Case 3: *Crystal Clear Software Ltd*. This company is the sole developer of Loan Performer software, the award winning, Software for Microfinance in Uganda since 1998 located on 3rd Floor King Fahd Plaza, P.O.Box 7463, Kampala. Crystal Clear Software's mission is to deliver high quality, user friendly and tailor made business software for her clients. LOAN PERFORMER is a database for recording and evaluating microloans. This program has its roots at the "Uganda Women's Finance Trust" where it was initially developed as the "Trust Information System" in 1995. Crystal Clear software Ltd now has 15,000 clients and has registered over 150,000 savings transactions and 6,000 loans in their database.

Case 4: *Software Factory Ltd*. Software Factory Ltd was used because the respondents in Digital Solutions Ltd couldn't find time to either attend interviews or fill the questionnaires. Software Factory deals in a range of solutions from Business Information Systems to Web Based Systems. RE is one of the areas emphasised in Software Factory in order to develop quality software for their clients. It has been in existence for close to 5 years. Software Factory is located in Ntinda, Nakawa Division Kampala.

3.1 Sampling and data collection

Using purposive sampling technique, 60 employees of the above companies were selected to participate as respondents. Purposive sampling was used mainly to target only those employees that were useful to the study, given their knowledge and skills, work experience and job positions. 20 respondents were picked from Makerere University Business School, 20 from the Department of Innovations and Software Development, 10 from Crystal Clear Software Ltd and 10 from Software Factory Ltd. However, 52 questionnaires were considered for analysis after eliminating inconsistent ones and those that were not fully filled in.

3.2 Validity and Reliability of the Questionnaire

[22] Suggests that validity tests should be done to establish how well a research instrument (questionnaire) used measures to the concept for which it was intended while reliability tests evaluate the consistence and stability of a research instrument. Cronbach Alpha Coefficient was used to test for reliability [23], and Content Validity Index was used to test for validity of the questionnaire [24] results of which are shown under findings.

3.3 Data analysis

Qualitative data was coded, collated and themed before being analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistics, including frequencies, percentages and means were used to extract the challenges being faced by SME software companies in Uganda with regard to RE Process Improvement.

4. FINDINGS

This section presents the study findings.

4.1 Validity and Reliability Test

As earlier mentioned, the research questionnaire was tested for validity and reliability. Table 1 shows the results.

Table 1: Validity and Reliability

Variable	No of Items	CAC	CVI
Challenges to successful RE process improvement in SME	9	0.701	0.762
Recommendations to RE Process Improvement Challenges	7	0.722	0.761

Reliability and validity results in table 1 show that the questionnaire was both reliable and valid since both variables scored a Cronbach Alpha Coefficient and Content Validity Index greater than 0.7 [25].

4.2 Challenges to successful RE process improvement in SMEs

Respondents were asked to provide the challenges that their organizations and themselves face in using RE process improvement. The responses in Table 2 were recorded.

Table 2: Challenges to RE Process Improvement in SME Software companies

Challenges	Freq	Percent
Lack of User's Involvement	9	17.3
Lack of management support	9	17.3
Lack of Skills	3	5.8
Changing Requirements	2	3.8
Resistance to change	2	3.8
Ambiguous Requirements	16	30.8
Lack of proper Documentation	3	5.8
Measurement of RE benefits	3	5.8
Expensive	5	9.6
Total	**52**	**100.0**

From table 2, findings revealed that ambiguous requirements from the clients are the biggest challenge (30.8%) faced by the respondents, followed by lack of users' involvement and lack of management support (17.3%) respectively. Respondents further reported that changing requirements and resistance to change were the least challenges faced (3.8%) respectively.

4.3 Recommendation to RE Process improvement Challenges

Respondents were asked about how RE process improvement challenges can be minimized. Their responses are given in Table 3.

Table 3: Recommendations to REPI Challenges in Ugandan SMEs

Recommendations	Freq	Percent
RE process Documentation	3	5.8
Training and workshops	20	38.5
Management Support	3	5.8
User involvement	9	17.3
Project Management Skills & planning	7	13.5
RE improvement strategy	3	5.8
Management of changing requirement	7	13.5
Total	**52**	**100.0**

As seen in Table 3, majority of the respondents reported that training is the most favored solution to the challenges of RE process improvement in SMEs (38.5%), closely followed by user involvement in the RE process (17.3%). It was also observed that project management skills and planning, and management of changing requirements contributed to minimizing the mentioned challenges by (13.5%) respectively. On the other hand, RE process documentation and management support were considered the least solutions (5.8%).

5. DISCUSSION OF FINDINGS

This section presents the study findings.

5.1 Challenges to REPI in SME Software Companies in Uganda

Findings revealed a set of impediments (see Table 2) to successful RE process improvement in SME software companies. These are discussed as follows:

Lack of user involvement; This affects the acceptability of the new process in the organization. If users are not involved in the process from the beginning it may create a gap between the developers and the users of the new process [26]. In this study it was revealed that users are not fully involved in RE process improvements. Instead systems are just imposed on them. Consequently, users rejected or did not properly use the systems imposed on them. This concurs with [11] who looked at user involvement in process improvement as a very important factor for user acceptance of new processes.

Lack of management support; This challenge affects the availability of the facilities that support any process improvement efforts in the organization [27]. Management support can be in terms of financial and/or any other forms such as provision of a good work environment for process improvement. In this study it was reported that support from management was lacking towards RE process improvement and this was hindering RE process improvements in the SME software companies. This is in line with [28] who argues that sustainable changes across an organization require management commitment and support at all levels.

Lack of skills; Generally, there are low levels of RE process improvement awareness in SMEs. SMEs lack the people with the right skills to carry out proper process improvements that can yield benefits to such organizations and yet they cannot use consultants because of their budget constraints [29]. In this study, it was established that SMEs lacked the necessary skills to start process improvements within their organizations despite their interest to start process improvements. This view is shared by [28] who argues that a process improvement initiative is at risk if the developers, managers, and process leaders do not have adequate skills to carry out process improvement.

Ambiguous requirements; Requirements from users are never clear or complete, so the developers are always occupied with correcting and understanding requirements than starting process improvements in the organization. It is reported in [30] that prior to a RE process improvement initiative; requirements were not clearly defined and not fully understood by developers. This was because clients were ambiguous in stating their requirements. In this study, it was established that clients did not state exactly what they wanted from the new system as they keep on changing their requirements from time to time.

Expensive; Given the tight budgets of SME software companies, it is always difficult to spare some funds for process improvements [29]. It was found out in this study that majority of the case organizations could not carry out RE process improvement because it was very expensive. This is in agreement with [17; 31] who highlighted small budgets as the main obstacles to RE process improvements in SMEs.

Measurement of RE process benefits; measurement of the RE process improvement benefits to the organizations implementing the improvement is a problem to SMEs. [4] Argue that it is very difficult to measure the benefits of RE process improvement because there is a long time lag between the requirements phase and system delivery to pinpoint how specific RE techniques contribute to a system's success or failure.

Resistance to change; this can threaten the success of any new RE process improvements. It is stated in [32] that there is a direct relationship between resistance to change and the total amount of change required of individuals. [28] Points out that people resist change because change initiatives are introduced too quickly and frequently. This problem has also been discussed in [30] as a very important success factor for RE

process improvement where acceptance of new RE practices can be one of the key challenges in RE process improvement.

The challenges highlighted above have impeded successful RE process improvement in Ugandan SMEs. [11] Suggest that managing some of the above challenges can lead to better management of RE process improvement.

6. CONCLUSION

To urge SME software companies to improve their RE process is a challenging undertaking and a complex phenomenon due to budget and time constraints. The success of this endeavor depends on the critical success factors in the organization as well as the approach used in the RE process improvement because the process of RE improvement is gradual and not an event. Many studies have focused on the development of RE process improvement models with little effort to examine the challenges SMEs in Uganda faced.

In this study we looked at the RE process challenges and how these can be improved in order to minimize the number of information system development failures as a result of the RE process. These among others included size and characteristics of SMEs as small budgets, tight deadlines, lack of skills and trained personnel, management reluctance to support the endeavor as well as unclear requirements from users that keep on changing from time to time. The study also established recommendations for improved RE and process improvement. These included support user involvement, use evolutionary improvement strategy, support change management, encourage training and education and encourage management support among others.

7. RECOMMENDATIONS

The study established a set of recommendations in Table 3, where it was established that most respondents thought training would provide the necessary skills that are lacking in most of the cases studied. On the other hand, a few respondents opted for management support and improvement strategies to bring about successful REPI in their organizations. Summarized, the recommendations that SMEs suggested include:

Training: [33] emphasis the need for training in order to improve on RE and process improvement. According to [33] education and training helps to promote the good understanding of the RE process to all the people involved in the improvement process. It is considered to be one of the critical success factors for any RE improvement process. Therefore, there is need to adequately train all people involved in the RE process improvement in order to ensure sustained change. [28] Suggests that training helps the organization's members to have a common vocabulary and understanding of how to assess the need for change and how to interpret specialized concepts of the improvement model being used as well as to achieve a common understanding of the improvement process.

Management support and commitment; For any system process improvement to be successful there should be full support of top management and commitment. Management support to process improvement can be in form of funding, encouragement, allocation of staff and providing a good work environment [11]. Raising the management awareness and support of RE practices would make it easier to start RE process improvement efforts in organizations and thus eventually raise the RE process maturity in companies [15]. [11] Concur that management commitment process is a fundamental requirement for a successful improvement in RE process.

Change management; can help to manage resistance to change by employees during the REPI. This is in line with [30] who suggest change management as a very important success factor for RE process improvement where acceptance of new RE practices can be one of the key challenges in RE process improvement.

User involvement; in the RE process, it is very important to institutionalize system process improvement. Among the stakeholders from whom requirements are elicited should be the potential users of the new system. This helps to come up with a useful system that will meet the needs of the users as well as acceptance of such systems [11]. Several authors have also pointed out that RE process improvement should be a team effort [30; 34].

*Use an evolutionary improvement strategy***;** [13] argue that organizations should not invest huge sums of money in process improvements without examining their viability. It is imperative that a cost-benefit analysis is conducted prior to such investments, otherwise, when they fail on first attempt, the organizations will be discouraged from future investments in process improvement. [28] Aligns with these statements and points out that, instead of aiming at perfection, it is important to develop a few improved procedures and to get started with implementation.

The above recommendations if implemented can help improve RE and process improvement for SME software companies in Uganda.

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