Qualitative and Quantitative study for Requirement Change Management Model

Muhammad Akram[1], M. Hamid Fayaz[2], M. Imran Shafi[3], M. Usman Shafique[4], & Imran Ali[5]

[1]*Abdul Razak Institute of Modern Languages & Computer Sciences, Mirpur AK Pakistan*
[2,4,5]*Blekinge Institute of Technology (BTH) Ronneby, Sweden*
[3]*Nackademin YRKESHÖGSKOLA Stockhlom, Sweden*

akram.moghal@gmail.com, mhfa0student.bth.se, cancerbyname@hotmail.com, muse06@student.bth.se, syim06@student.bth.se

ABSTRACT: Requirements change management is a crucial activity for requirement engineers in industry during development of product in market driven context. Study shows that this implementation of requirements change is still problematic for requirement engineers. In this paper we presents a research design that includes both qualitative and quantitative study analysis to find out different factors that can affect the performance of proposed model for requirement change management process. Experiments are used for quantitative study and three case studies are conducted in industries for qualitative analysis. It is concluded that our proposed model will be helpful to manage change in requirements during development life cycle of product in market driven environment. We also expect that data collected analyzing the experiment will be helpful for researcher to remove deficiencies in proposed model and increase its performance. This model will also be used to increase the performance of industry in market. These experiments will increase the knowledge of subject about quantitative research and change management in Software Requirement Specification.

1. INTRODUCTION

Development of software in Market Driven Requirement Engineering (MDRE) is a dynamic process and requirements come from different sources during development of a product. Change occurs in requirements because of evolving needs of customers, business and development team [3, 4]. Change occurs in requirements due to different reasons like changes in government policies, business goals, market demands and work environment. In MDRE, these changes in requirements occur frequently and requirement engineers face difficulties to manage it [3]. It is necessary for requirement engineers to get knowledge about those requirements changes which have more significant impact and which have minor impact on product before managing it [4]. Manage changes in requirements as more accurately and quickly during development of product in market driven environment is still a problem for requirement engineers.

Change in requirements for a product during its development can be of three types, in first type requirement could be add in Software Requirements Specification (SRS), secondly existing requirement could change and in third case requirement could be deleted [3]. There are certain issues that should be keep in mind while changing in requirements like traceability, dependency among requirements, prioritization of requirements and decision making to implement that change [4]. There are certain models proposed in literature [3, 5, and 6] for requirements change management but each model has its own limitation.

After studying different models regarding change management in SRS, we have proposed a model which can handles requirements change management process in industry. In this model, we try to remove limitations of previous models in literature.

We will use two approaches of study to check the validity of our proposed model, one is the qualitative study where we will use three case studies in industry and other is quantitative study where we will use experiment in software house to check performance of proposed model.

2. BACK GROUND AND RELATED WORK

Some empirical studies have been conducted in literature [7, 8, 9, 10, and 11] for requirement change management. These studies help us for further research about proposed model. In our report we will conduct empirical study for our proposed model to check its performance in industry by using qualitative and quantitative approaches. We choose qualitative research method for model validation because it has advantage to involve people from different organization. In Requirement engineering more understanding is developed by qualitative methods like case studies. In qualitative study, we will conduct three case studies in different industries which use techniques of requirement engineering to handle requirements for their product. Through these case studies, we will evaluate the performance of model. Cress well [2] says that case study is in depth process of one or more activity to explore.

Through quantitative study, we will measure the different factors of requirement change management through proposed model. In quantitative study, we will conduct an experiment at software house in Sweden. This experiment will be performed by requirement engineers of software house which have no more than six month experience to handle requirements management. There are also some quantitative studies in literature in the form of experiment about requirements management which help us to conduct the experiment.

3. QUALITATIVE STUDY

3.1 Purpose
Purpose of qualitative study for requirement change management is to find out different factors related with proposed model during its practical implementation in industry. Also its purpose is to remove those issues about the model which will create by different participants of qualitative studies, so that performance of proposed model in industry could be increased.

3.2 Research Questions
This qualitative research will provide answers to the following research questions after completion of three case studies in different industries. Those research questions are as follows.
1. Find the different factors of change management process and how these factors involve during formation of model.
2. Does the propose model help to decrease the limitation of other models used in literature?
3. Is it possible to validate proposed model/process in certain organizations?

3.3 Procedure

Our research is based on three case studies about requirement change management in which proposed model will be implemented in three different companies. Selection of companies will be based on criteria in which companies must produce market driven products by using different techniques of MDRE. These companies' products should be for whole market and not for specific customer. Purpose of these case studies is to get knowledge about different factors that

can influence the requirement change management process by proposed model. We will also check this model if it overcome the limitations of other models already in literature for change management. Proposed model will be analyzed according to different perspective like managing change in SRS for code, or design, according to business, customer or development point of view for certain product in organization.

3.4 Qualitative Research Strategy

Our research strategy will be based on case study; the reason is that we can give better answer to our research questions by this study. Cress well said that case study is a good approach if purpose of researcher is to investigate the process [2]. It could also be helpful because researcher has no control on requirements that are coming and could change from real resources of market [12]. We will conduct three case studies to check the validity of proposed model for requirements change management. Researchers get three kinds of observations from these case studies because each company have different product for market and requirements comes from different sources of market during development of product.

We will hold a training session before start in each company so that people get awareness about the proposed model. In this session we will describe about different activities of model and how this model can be used to manage change in requirements.

Companies, where case study will be held, must be handled requirement change management process in market driven environment. Complexities in this environment increases due to requirements coming from different sources at the same time so change management in requirements could be a problem. It is not necessary in the process selection of company, whether that company used any tool for requirement management or not but company should follow requirement engineering techniques for requirements.

For each case study, we will use different requirements perspective such as business, development and customer. In business perspective, requirements can change for product if business strategies of company change. Development perspective is related with development process of product i.e. changes can occurs in SRS for code or design. Customer perspective is related with change occurs in customer requirements. In market driven environment, customer is count as market for the product [4].

3.5 Data Collection Procedure

An interview will be conducted with project managers of each company to know about company products and requirement change management process in company. Some predefined set of questions will be already prepared for this interview but open questions can also be asked. After some investigation about company and after getting permission for analysis of proposed model, then we will implement proposed model in a company for testing purpose. Now requirement engineers of company will implement changes by following proposed model in SRS while requirements comes from development, business and customer perspectives for its company product. Before implementing this model, we will first get initial knowledge about the project for which this model can be used. To implement changes in requirements like how much time require to complete project, what is the purpose of product, what kind of changes could be occurs in it.

Now with the collaboration of requirement engineers, we will use this model to implement changes, coming from different sources for the purpose of data collection from its different perspectives of product.

We will observe different change management activities like changes in requirement prioritization, impact of requirements on other requirements by change, decision about to implement the change and problems faced by requirement engineers by proposed model during change management in requirements. We will also observe how this model can provides more facilities to requirement engineers for handling change management process. It is also necessary to keep in mind the research questions before observing sessions of case studies in companies so that we can provide answers of these questions more accurately and it will also helpful us to further research. It may require long time to get the complete observation of model during case study, may be this process takes more than one month and it depends on project how long it is and how much changes can occurs in it. For data collection, we will also help requirement engineers to handle change in requirements in such ways which can help us in further research about our proposed model. All things should be in mind which could be helpful to improve model performance before observing it.

We will collect data about case studies by two ways, in written form and in video recorded form. Video recorded data is very helpful for us to analyze our model because lot of important type of data could be missing if data saved in written form, that missing data can get easily from video recorded form. Video form also has advantage for saving such kind of data which could be difficult to understand like discussion of some issues with requirement engineers and other participants of this case study.

3.6 Data Analysis Procedure

After collection of data from three case studies in different industries, now we will analyze this data to check about performance of model. Data of each case study will be divided with respect to its perspective in which the change occurs in requirements. During analysis of data, we will also describe important aspects of change, like rational of change, implementation of change, is that change successful or not? Data from same perspective of one case study will be analyzed by comparing it with same data from other case study. By comparison, one can see the difference between factors of success of change implementation by same model in different companies. During analysis, we will see the different and common points, or strong and week points of three case studies so that we can decide what should we do for further improvement of model.

We will analyze those issues which will be discussed during case studies by different participants with the help of video recording. Data gathered in these case studies for change management will be analyzed by during research according to different point of views like researchers, participants, and company point of view.

3.7 Validity of Study

There may be certain threats for validity of study of requirement change management by proposed model. One of the threats is, if requirement engineers from different companies use their experience to manage change in requirements, so that they can use model not seriously and in that case purpose of model is not fulfilled. To overcome this situation, first we will describe

the importance of change management in SRS with model to participants of case study and will provide some training that how to use the model.

Also one threat is that, participants may have different opinions about same issue like requirement prioritization and impact of change on other requirements. This threat can overcome if we have lot of knowledge about different issues of requirement change management process, so that we can convince the participants of case study which have not much knowledge.

We can also have different opinions about same issues created by participants during case studies. This threat can remove by practical implementation of model for that issue until the participants satisfy about that issue. Final report about all case studies will also be discussed with participants so that they mention their point of view about the authenticity of model.

3.8 Expected Outcomes

After three case studies about requirement change management process by proposed model, its different factors, change management according to different perspective and after getting point of view of researchers and participants about the proposed model. It is expected that we will able to proposed such model which will be helpful for requirement engineers to manage change in requirements during product development life cycle in market driven environment more efficiently and accurately. It is also expected that participants and researchers will get much knowledge about change management process, its different issues and will know about its importance for the success of product in market. Some common and different points also occur in three case studies that will be used for further investigation. Issues in requirement change management will also remove after this qualitative study. Limitations of other model will be discarded in our proposed model for requirement change management.

4. QUANTITATIVE STUDY

4.1 Definition

Motivation of this experiment is that there is always a need of such mechanism or process that will be helpful for requirement engineers to manage change more accurately and quickly in SRS during development of product. To check the validity of our proposed model for requirements change management, it is necessary to use it in industry by requirement engineers and analyze those differences that come during experiment about performance of model. The research question for this purpose is as follows;

What are the differences in performance if a change implements in SRS with proposed model and without it by two groups of participants?

4.1.1 Objects
There are two objects which will be used for this experiment. First is the SRS and second is the proposed model which will be used to implement change in SRS during development of product.

4.1.2 Purpose
Purpose of this experiment is to evaluate the proposed model to measure its performance for manage change in requirements specification during development of product in market driven environment.

4.1.3 Quality of focus
Quality of focus is the effectiveness and efficiency of model to implement change in requirements for software product. Main focus in this experiment will be on the time taken to understand and implement change by requirement engineers and accuracy to implement change at correct place.

4.1.4 Perspective
It is more helpful to the researchers and project managers to get knowledge if there is a difference in performance for requirements engineers to implement a require change in SRS by following proposed model or without it. We will also get knowledge about different perspective like development, business and customer of change management from participants of experiment by using model. That knowledge can be helpful in making a future strategy for requirements change management in different companies.

4.1.5 Context
This experiment will be run in software house in Sweden by using fresh requirements engineers or internees which handles requirements management process of that company. These requirements engineers must have studied requirement engineering subjects and know well about different artifacts of the experiment. They should also have skill to implement change in SRS from different perspective. Their experience should not be more than 6 months in software house.

4.1.6 Definition Summary
Analyze the software requirement specification, proposed model for the purpose of evaluation with respect to the effectiveness and efficiency from the point of view of project managers and researchers in the context of fresh requirements engineers in the software company to implement changes in SRS by following proposed model.

4.2 Planning
4.2.1 Context Selection
In planning context, our purpose will be to check the performance of proposed model for change management by requirement engineers of Software Company. Some characteristics of this experiment will be as follows

Offline- experiment will be implemented on already done project and not connected with any real project.

Subjects- subjects here will be fresh requirement engineers having background with requirement engineering.

Real- experiment results will also help full for project managers and requirement engineers in decision making to use that model for online and real projects.

Instruments- as this project is already done so instruments will be used through which given change will be handled by proposed model during experiment. Previous data of already done project about change management will helpful for us to get result about the performance of proposed model.

Performance measurement- performance can be measured by counting number of defects in change management of requirements in SRS, time to implement change, accuracy of change by using model.

4.2.2 Hypothesis and Formulation
Two kinds of hypothesis can be used in this experiment, one is Null hypothesis and other is Alternative hypothesis.
Null Hypothesis (H0): there is no difference in performance of requirement engineers while they used proposed model with comparison if they not used proposed model for requirement change management.
Alternative Hypothesis (H1): there is a positive difference in performance (performance increases) of requirements engineers while they used proposed model with comparison if they not used proposed model for requirement change management.

4.2.3 Variables
There are two kinds of variables; independent and dependent. SRS is independent variable.
Required change to implement is another independent variable. Performance of model to implement change in SRS is dependent variable and depends on users who use it and developers who develop it.

4.2.4 Subjects
Fresh requirement engineers who have skill to implement change are the subjects of this experiment. They must have skill to using tools for requirement change management and should studied course of requirement engineering.

4.3 Design of Experiment

4.3.1 Randomization
Objects will be given to the two teams of requirement engineers in Software Company. Each team includes eight people. But the members of team chosen will be randomly selected.

4.3.2 Blocking
This experiment needs requirement engineers or internees having experience no more than six months in a software company. Project manager can helpful in choosing required persons to perform the experiment.

4.3.3 Balancing
Experiment has balanced by issuing two teams of equal size which has to do same kind of tasks. One team implements required change in SRS with the help of model and other team done this task without any help of model.

4.3.4 Design Type
Design is one factor with two treatments, factor in this experiment will be the proposed model and treatments will be proposed model, SRS. Change in requirements which will implement in SRS by proposed model and without it.

4.3.5 Instrumentation
Objects used in this experiment are as follows.
All requirement engineers will have access to computers on which proposed model installed and that model will be used to implement changes in SRS.

A copy of previous record of changes in form of software requirements document of already done project will be provided to requirement engineers.

Document or form will be provided during experiment to requirement engineers that can be used to save record about model performance measurement.

4.4 Validity Evaluation

Any experiment can face some threats to validity of its results. According to wholin [1] there are four types of threats, described as follows;

4.4.1 Conclusion Validity

This type of validity threats relates with such problems which can affect the outcomes of experiment [1]. One of the threats is reliability of measures. But it is not taken as threat for this experiment because each requirement engineer will provide answer to the question like time to implement a change, how many changes etc.

Low statistical power is also other threat which could not be removed because attendees are not too much for this experiment. To remove the threat, this experiment should perform in more software houses and companies for better result.

4.4.2 Internal Validity

Internal validity relates with issues concerning the independent variable without researcher knowledge [1].

One threat is mortality, which exists if some subject has no knowledge about requirement engineering but in this experiment all have requirement engineers and handling requirements in software house so this threat is not valid for this experiment.

Each subject has applied same number of changes by following a model and without it so threat related with maturation is also not valid for this experiment.

Instrumentation in the experiment could be a major threat if forms and other material used in experiment are not designed correctly.

Statistical regression is a threat which could be valid for this experiment because data used here is borrowed by previously done project.

Selection is a threat which is not valid because experiment performed by employees of software house and is necessary for them to attend this experiment during their job by project manager.

4.4.3 External Validity

External validity relates experiment results with industrial practice [1]. As this experiment is performed by fresh requirement engineers in Software Company and also they have not much experience to handling change in requirements so the threat about using fresh graduates is valid here.

Result of this experiment can also be used for further research in requirement change management. Another threat is size of subjects as only sixteen subjects used for this experiment and have divided into two teams, it has done because of resource constraints in software house. In the pre-experiment session there must be training provides to requirement engineers about using model so that this threat could be minimized.

4.4.4 Construct Validity

In construct validity, one of the threats is the hypothesis guessing in which subjects try to find out the purpose of experiment, in this case, subjects can give answers according to expectation of

the examiner. As a result, invalid conclusion could be created about the experiment. As subjects are requirement engineers and having some experience in handling requirements so it is difficult to overcome this threat because purpose of experiment will be known by subjects.

Some people dislike to take part in this experiment for model evaluation, but it is responsibility of project manager in software house that all requirement engineers must take part in this experiment, other wise required result could be difficult to get. Time of experiment could also be the threat because many subjects do not want to attend the experiment due to much time of experiment. This threat could be overcome by dividing experiment into sessions with two hours each and total time of experiment will be four hours.

4.5 Experiment Operation

4.5.1 Preparation
Preparation of the experiment will be mandatory before executing it by requirement engineers for the purpose of handling change in the requirements. In this preparation, we will introduce the topic of experiment and tasks to requirement engineers which they will do in experiment. Time require for preparation for experiment will be one hour. In preparation session we will describe to subjects of experiment about the proposed model for requirement change management, and will tells them that how it can be used for handling change. During this session, we will also discuss about data or observations which will be used in this experiment. We will tell second group of participants that how changes could be implemented without model and what are necessary things in mind before implement change in SRS.

There will be allocated two rooms for this experiment with eight computers in each room for eight subjects. Proposed model also install on one room computers. Two teams will be selected randomly with all fresh graduates and each having experience no more than six months in software house as a requirement engineers. One team implementing change in requirements without the help of model and other team implement change with help of proposed model in SRS. One form for saving records about experiment will be given to each candidate before execution of experiment. This form contains some type of questions like record time to implement change, requirement numbers in which change implements and some more. Each student will take online SRS about specific project; data (new requirements or changes in requirements) which will be implemented in SRS, and form provided to them for records for the experiment. Online model will be available only for one team of requirement engineers.

4.5.2 Execution
Experiment executes in such environment where communication among subjects are not allowed. Duration of experiment will be five hours long in which hour will be training session. We will remain in rooms for the help of requirement engineers during execution of experiment. All record about experiment will be saved for further research. Time of execution of experiment will be four hours.

4.5.3 Data Validation
At the end of experiment, forms collected from requirement engineers. These forms will be used for further investigation or research to improve week points about the model after comparing data from two teams and data among team members which will use proposed model.

4.6 Experiment Analysis

Analysis of experiment is a three step process as descriptive statistics, data set reduction, hypothesis testing.

Descriptive statistics is used for graphical presentation of data set and its numerical processing. Goal of descriptive statistics is to get understanding about how data set will be distributing for analysis purpose. In descriptive statistics, we check about the distribution whether it is normal distribution or non-normal distribution. Statistical methods are used for this purpose.

For normal distribution first use scale to measure central tendency. Mean and median are the scales in which mean, shows the average value of data set and median, shows the central value of data set after ordering data in ascending or descending. If mean and median are equal then distribution will be normal for data set. It is also necessary to check dispersion of data set, which is the variation of data from its central tendency. Dispersion can be measured by standard deviation.

Graphical visualization is done by scatter plot, which is used to plotting for pair wise samples in two dimension graph. In this experiment we will plot data of experiment which shows the data comparison of two teams and shows which one can implement change in SRS more efficiently. It is helpful to check the dependency between variables and tendency of linear relation.

Next step for analysis is data set reduction in which outliers discarded from data set. Outliers are actually the points of data set which are significantly different from other data points in data set. The best way to identify outliers is by drawing scatter plot of data set. If outliers are identified then they will be discarded from data set so that data set will be reduced. In our experiment, outliers could be subjects that are not interested in experiment and left room of experiment early.

Now final step of analysis is hypothesis testing, in this step data will be analyzed for the purpose of rejecting NULL hypothesis. In this experiment our result should be alternative hypothesis after analysis of data so that there is positive difference if change management occurs by using proposed model and without using it. Now select the level of significance, in this case level of significance will be 5%. Design of our experiment will be one factor with two treatments for its design types, for this case wohiln et al [1] suggest that two types of test, one will be t-test which is a parametric test and other will be Mann-Whitney test which is a non parametric test can be used. We will use above mentioned test because we want two compare two results for each change from two different teams.

5. CONCLUSION

This report presents two approaches to analyze data, one is qualitative and other is quantitative approach. We have used these approaches for validation of our proposed model. Main purpose of this model is to help requirement engineers to manage change in SRS. Experiments are based on data analysis. Expected conclusion for the experiment is that in which null hypothesis will be rejected after performing experiment. Our proposed model will be more helpful to manage change in requirements during development life cycle of product in market driven environment. We also expect that data collect after analyzing the experiment will also be helpful for researcher to remove deficiencies in proposed model and increase its performance. This experiment will increase knowledge of subjects about quantitative research and change management in SRS. There are certain threats through which performance of experiment could be decreased. Requirement engineers should have some experience to handling requirements so that these threats could be decreased and performance of experiment can increases.

At last this study will help the researchers to investigate important aspects of requirement change management in industry. It describes the different aspects of case study and experiment which can help researchers to implement both qualitative and quantitative study in industry.

6. REFERENCES

[1] Wohlin C, Runeson P, Host M, Ohlsson M C, Regnell B, Wesslen A. *Experimentation in Software Engineering: An Introduction*, Kluwer Academic Publishers, 2000.

[2] Creswell J. *Research Design: Qualitative, Quantitative and Mixed Method Approaches*. Sage Publications Ltd, 2003.

[3] Didar Zowghi. *Analysis of requirements volatility during software development life cycle*, IEEE, 2004.

[4] GORSCHEK T. *Requirements Engineering Supporting Technical Product Management.* Ph.D. Thesis, Blekinge Institute Of Technology, Ronneby**,** 2006.

[5] Björn Regnell; Ola Eklundh. *A Market-driven Requirements Engineering Process results from an Industrial Process Improvement Programme*, Requirements Engineering Journal, 1998.

[6] Höst M, Regnell B, Natt och Dag J, Nedstam J, Nyberg C. Exploring Bottlenecks in Market Driven Requirements management Processes with Discrete Event Simulation. *In Proceedings of PROSIM*, London 2000.

[7] Anderson S., and Felici M. Requirements Changes Risk/ Cost Analyses: an Avionic Case Study, *in Foresight and Precaution, Proceedings of ESREL 2000, SARS and SRA-Europe Annual Conference*, Edinburgh, Scotland, UK, 2000.

[8] Lavazza L., and Valletto G., Enhancing Requirements and Change Management through Process Modelling and Measurement, *in Proceeding of ICRE 2000 - Fourth International Conference on Requirements Engineering*, Schaumburg, Illinois, 19-23 June 2000.

[9] Lavazza L., and Valletto G. *Requirements-Based Estimations of Change Costs*, in Empirical Software Engineering – An International Journal, Kluwer, 5(3), November 2000.

[10] Loconsole A., Measuring the Requirements Management Key Process Area, *Proceedings of ESCOM - European Software Control and Metrics Conference*, London, UK, April 2001.

[11] Loconsole A. and Börstler J., A Comparison of two Academic Case Studies on Cost Estimation of Changes to Requirements - Preliminary Results, *in Proceeding of SMEF – Software Measurement European Forum*, Rome, Italy, 28-30 January 2004.

[12] Robert K Yin, Donald T Campbell. *Case Study Research: Design and Methods*, Sage Publications Inc, 2003.