Analyzing the Use of an Enterprise Model as a Stakeholder Requirements Model: An Experiment

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Abstract. There are several possible representations for stakeholder requirements, such as goal models, scenarios, and natural language. This paper analyzes the use of an enterprise model as a stakeholder requirements model. We conducted a quasi-experiment with 29 graduate students who received either a textual problem statement or an enterprise model, representing the stakeholder requirements, and refined it into use cases, representing the software requirements. The subjects were evaluated considering the use case quality and the time spent, for two different scopes. The results indicate that the mean quality of the use cases created using an enterprise model was equal to or greater than the mean quality of the use cases created by the other groups. In addition, the mean time spent to create a use case using an enterprise model was equal to or less than the mean time needed for the other groups.

Keywords: stakeholder requirements, enterprise model, use case, experiment.

1 Introduction

ISO 29418 [6] differentiate three levels of requirements: stakeholder requirements, system requirements, and software requirements. Stakeholder intentions (needs, goals, and objectives) are refined into stakeholder requirements that describe "the intended interaction the system will have with its operational environment" [6, p.19]. These requirements are transformed by a requirements engineer into system requirements, based on the organization, the environment, and other constraints (this process is called refinement by Jackson and Zave [13]). System requirements represent a technical specification for the system. Therefore, they must be measurable, but they must avoid describing implementation details. Some system requirements may be allocated into a software element of the system, resulting in software requirements.

There are several possible representations for stakeholder requirements. For instance, stakeholder requirements can be represented using goal models, scenarios, or natural language. Another possible representation of stakeholder requirements is an enterprise model, describing the environment as the stakeholders would like it to be [11]. This possibility seems to be even more appropriate given the content of the stakeholder requirements specification (StRS) defined in ISO 29148 [6]. Even though

an enterprise model may not contain all the StRS information, it could be used as a partial description of the stakeholder requirements.

In order to analyze the use of an enterprise model as a stakeholder requirements model, this paper presents a quasi-experiment – i.e., an experiment in which the participants are not randomly assigned to the treatments. It considers software-intensive systems, in which software requirements are almost all the system requirements. The experiment investigates the impacts of using this model during stakeholder requirements refinement, analyzing the quality of the resultant software requirements and the time spent to create it. Among the possible representations of software requirements we selected use cases due to its popularity. Therefore, the experiment evaluates use case quality and the time spent to generate it in order to analyze the adequacy of using an enterprise model during requirements refinement.

The paper is structured as follows: Section 2 presents the related work. Section 3 presents the experiment planning. Next, in Section 4, it is presented the experiment results and analysis. Finally, in Section 5 we discuss the results and present our conclusions, including proposals for future works.

2 Related Work

Few approaches propose using an enterprise model as a stakeholder requirements model, for instance the approaches proposed by De La Vara, Sanchéz and Pastor [4], and by Molina et al. [7]. These approaches propose methods to manually refine enterprise models into use cases, considered as a software requirements model. However, they do not analyze experimentally their method.

There are some experiments that evaluate the use case quality, in general to investigate the use of guidelines in use case authoring [1, 2, 3, 9]. Consequently, these studies analyze the approach used to generate the use cases – and not the model used as input, as described here. A similar experiment that evaluates the input model is presented by Yue, Briand, and Labiche [12]. It evaluates the quality of the analysis model created from use cases in order to analyze an approach for use case authoring. However, it analyses a different task in the software development process.

3 Experiment Planning

The experiment's goal is to analyze if the use of an enterprise model as a stakeholder requirements model affects the quality of the resultant use case model, used as software requirements, and the time spent to create it. Based on this goal, we formulated the following hypotheses:

H1. The quality of a use case obtained by refining an enterprise model is equal to or greater than the quality of the use case obtained considering a textual stakeholder requirements model.

H2. The time spent to create a use case model by refining an enterprise model is equal to or less than the time spent considering a textual stakeholder requirements model.

Therefore, if both hypotheses are true, then it can be concluded that there are no negative impacts in using an enterprise model as a stakeholder requirements model.

3.1 Context

The experiment was conducted with graduate students of the Software Technology course at the Continued Education Program in Engineering (PECE) of the Polytechnic School of the University of São Paulo (USP). The subjects were 29 students at the last period of the course. They had already concluded a Requirements Engineering discipline, which covered use case modeling. The students also had an overview of business process modeling during another discipline. The experiment was conducted during a discipline, but the results were not used to grade the subjects.

3.2 Experiment Design and Operation

Table 1 presents the experiment design considering the stakeholder requirements model used and the project scope, which were chosen as factors. The factor "stakeholder requirements model" was divided into three groups: *Textual* (using a textual problem statement); *Enterprise Model* (using an enterprise model created by another subject); and *Both* (creating first an enterprise model and then the use cases, thus using both stakeholder models). The other factor, the project scope ("Project"), considered two alternatives: a *Bank Teller* (*ATM*) and a *Video Rental Store* (*Video Store*). When possible, the values and the overall experiment were based on similar experiments [1, 2, 3, 9, 12], thus allowing future comparisons.

Table 1. The experiment design and the number of subjects for each treatment.

		Stakeholder Requirements Model		
		Textual	Enterprise Model	Both
Project	ATM	5	5	4
	Video Store	5	5	4

First, all subjects watched a 10 minutes presentation about business process modeling. Then, they answered an initial questionnaire covering the independent variables regarding the knowledge and the experience of the subjects.

The subjects were divided into 2 groups. The Group 1 corresponds to the subjects for *Textual* and *Enterprise Model*, and the Group 2 corresponds to subjects who created the enterprise model. As there was no time available to evaluate the subjects' responses to the initial questionnaire, they were assigned to these groups considering their seating arrangement in the classroom. The subjects for the Group 1 received a problem statement presenting textually the stakeholder requirements. They were requested to create a use case in one hour. The subjects for the Group 2 received the same problem statement as the other group and a description of the environment as-is (which is domain knowledge). They were requested to create the enterprise model as-is and to-be in one hour.

In a different day, the subjects from the Group 1 received an enterprise model created by another subject and considering a different project scope from the previous activity. They were requested to create a use case in one hour. Part of Group 2 received the enterprise model he/she created, and the original problem statement. They were requested to create a use case in one hour.

The models (use case and enterprise) were created manually by the subjects. The enterprise model was created considering a simplified version of the metamodel described in [11], while the use cases were described using a template based on the meta-model proposed in [10]. As some subjects needed to use the enterprise model created by another subject, the experimenter used a tool [11] to represent all the enterprise models created, in order to avoid influences or misunderstandings.

Based on the experimental hypotheses, the results of the experiment are evaluated by two dependent variables: the quality of the use case created, and the time spent to create the use case. To evaluate the use case quality, this work uses the seven quality factors to help use case communication, proposed by Phalp, Vincent, and Cox [8]. In order to use a more objective evaluation, we defined criteria for each quality factor and sub-factor. Each sub-factor is graded from 0 to 5, and the maximum grade is 65, as there are 13 sub-factors.

4 Experiment Results and Analysis

On average, the subjects needed 46 minutes to create the use cases in the *ATM* scope, obtaining a score of 60.47. On the *Video Store* scope, the average time spent was 42 minutes and the average score 61.49. Analyzing the data, it was found two outliers, which were discarded from the analysis.

Each hypothesis will be analyzed separately for each scope and control group (*Textual* and *Both*). As a result, eight experimental hypotheses were formulated. They will be tested using a Wilcoxon test [5], with a 0.05 significance level (α).

Table 2 presents the summary of the Wilcoxon test results for the four experimental hypotheses regarding the use case quality (H1). All the alternative experimental hypotheses compare if the mean quality of the group *Enterprise Model* (μ_{QE}) is less than the quality of the groups *Textual* or *Both* (μ_{QT} and μ_{QB}, respectively). Considering the format of the Wilcoxon test presented in [5], the null hypothesis of HE1 and HE2 can be rejected if the rank sum is less than or equal to the rejection value. On the other hand, the null hypothesis of HE3 and HE4 can be rejected if the rank sum is greater than or equal to the rejection value.

Table 2. Results of Wilcoxon test for hypothesis H1.

Experimental Hypothesis	Project Scope	Null Hypothesis	Alternative Hypothesis	Rank Sum	Rejection Value	Reject Null hypothesis
HE1	ATM	$\mu_{QE} = \mu_{QT}$	$\mu_{QE} < \mu_{QT}$	27	13	No
HE2		$\mu_{QE} = \mu_{QB}$	$\mu_{QE} < \mu_{QB}$	17	12	No
HE3	Video Store	$\mu_{QT} = \mu_{QE}$	$\mu_{QT} > \mu_{QE}$	21	27	No
HE4		$\mu_{QB} = \mu_{QE}$	$\mu_{QB} > \mu_{QE}$	22	27	No

It is not possible to reject the null hypothesis for all experimental hypotheses. Therefore, the hypothesis H1 cannot be rejected. In other words, it indicates that the use of an enterprise model as a stakeholder requirements model did not resulted to lower quality use cases.

Table 3 presents the summary of the Wilcoxon test results for the four experimental hypotheses regarding the time spent. The alternative hypotheses consider that it is faster (demands less time) to create use cases for *Textual* and *Both*. For the group *Both*, only the time spent creating the use case was considered. The null hypothesis of HE5 and HE6 can be rejected if the rank sum is greater than or equal to the rejection value. On the other hand, the null hypothesis of HE7 and HE8 can be rejected if the rank sum is less than or equal to the rejection value.

Table 3. Results of Wilcoxon test for hypothesis H2.

Experimental Hypothesis	Project Scope	Null Hypothesis	Alternative Hypothesis	Rank Sum	Rejection Value	Reject Null hypothesis
HE5	ATM	$\mu_{TE} = \mu_{TT}$	$\mu_{TE} > \mu_{TT}$	10	27	No
HE6		$\mu_{TE} = \mu_{TB}$	$\mu_{TE} > \mu_{TB}$	11	24	No
HE7	Video Store	$\mu_{TT} = \mu_{TE}$	$\mu_{TT} < \mu_{TE}$	19	13	No
HE8		$\mu_{TB} = \mu_{TE}$	$\mu_{TB} < \mu_{TE}$	24	13	No

None of the four null hypotheses could be rejected. It indicates that the use of an enterprise model as a stakeholder requirements model did not demanded more time to create the use cases. That is, hypothesis H2 cannot be rejected.

5 Discussion and Conclusion

This study presented an experiment to analyze the use of an enterprise model as a stakeholder requirements model. The analysis considered the quality and the time spent to refine an enterprise model into software requirements, which were represented with use cases. The results obtained by subjects who created the use cases based only on an enterprise model (group *Enterprise Model*) were compared with the results obtained by two groups: subjects who received a textual problem statement (group *Textual*), and subjects who received both a textual problem statement and an enterprise model they created earlier (group *Both*). Additionally, experiment had two scopes, *ATM* and *Video Store*.

The results indicate no negative effect in the use case quality when using an enterprise model. For both scopes the mean quality of the use cases was equal to or greater than the mean quality of the use cases created by the other groups. The results also indicate no negative effect in the time spent when using an enterprise model as a stakeholder requirements model. For both scopes the mean time spent to create a use case using an enterprise model was equal to or less than the mean time needed considering a textual problem statement. Nevertheless, there are threats to the validity of this experiment. The most important threats are the small statistical power and some limitations of the experiment setting (time constraint, the scopes, the use of students, and the generation of only one use case). Another important threat is that the

subjects for the treatment *Textual* did not receive information about the environment as-is, as it was not considered useful for their activity.

Other analysis must be done before recommending the use of an enterprise model as a stakeholder requirements model in real projects. Other experiments must analyze if these results are true when generating more than one use case (a complete use case model) and real scopes. In addition, a case study or an experiment analyzing an industrial setting must be executed. Anyhow, the results obtained in this experiment motivate further analysis.

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