Information Sciences 181 (2011) 3356–3378

Contents lists available at ScienceDirect

Information Sciences

journal homepage: www.elsevier.com/locate/ins

Evaluating requirements modeling methods based on user perceptions: A family of experiments

Silvia Abrahão [a,*], Emilio Insfran [a,1], José Angel Carsí [a,1], Marcela Genero [b,2]

[a] ISSI Research Group, Department of Information Systems and Computation, Universitat Politècnica de València, Camino de Vera, s/n, 46022 Valencia, Spain
[b] ALARCOS Research Group, Department of Technologies and Information Systems, University of Castilla-La-Mancha, Paseo de la Universidad, No. 4, 13071 Ciudad Real, Spain

ARTICLE INFO

Article history:
Received 4 August 2009
Received in revised form 24 January 2011
Accepted 2 April 2011
Available online 8 April 2011

Keywords:
Requirements modeling
Method evaluation
RUP
Theoretical models
Controlled experiment

ABSTRACT

Numerous methods and techniques have been proposed for requirements modeling, although very few have had widespread use in practice. One drawback of requirements modeling methods is that they lack proper empirical evaluations. This means that there is a need for evaluation methods that consider both the theoretical and practical aspects of this type of methods and techniques. In this paper, we present a method for evaluating the quality of requirements modeling methods based on user perceptions. The evaluation method consists of a theoretical model that explains the relevant dimensions of quality for requirements modeling methods, along with a practical instrument with which to measure these quality dimensions. Basically, it allows us to predict the acceptance of a particular requirements modeling method in practice, based on the effort of applying the method, the quality of the requirements artifacts produced, and the user perceptions with regard to the quality of the method. The paper also presents an empirical test of the proposed method for evaluating a Rational Unified Process (RUP) extension for requirements modeling. That test was carried out through a family of experiments conducted with students and practitioners and provides evidence of the usefulness of the evaluation method proposed.

1. Introduction

The requirements engineering (RE) process is recognized as being the most critical process in software development. Errors made during this process may have negative effects on subsequent development steps, as well as on the quality of the resulting software. Research into the requirements engineering process has produced an extensive body of knowledge, along with different types of methods, notations, and automated tools.

Despite the existence of numerous methods for requirements modeling, very few of these have had widespread use in practice. One drawback of requirements modeling methods is that they lack proper empirical evaluations. As pointed out by Cheng and Atlee [9], the ultimate impact of requirements engineering research depends on how relevant the results are to industry. However, if practitioners are to consider adopting a given requirements modeling method, they must know how effective it is, as well as how it compares with other similar methods.

Despite the efforts already made to define approaches for evaluating requirements modeling methods, we believe that an evaluation method that considers both theoretical and practical aspects of this type of methods has yet to be developed. We

* Corresponding author. Tel.: +34 96 387 7000x83510; fax: +34 96 387 7359.
E-mail addresses: sabrahao@dsic.upv.es (S. Abrahão), einsfran@dsic.upv.es (E. Insfran), pcarsi@dsic.upv.es (J.A. Carsí), Marcela.Genero@uclm.es (M. Genero).
[1] Tel.: +34 96 387 7000x83510; fax: +34 96 387 7359.
[2] Tel.: +34 926 295300x3747; fax: +34 926 295354.

0020-0255/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.ins.2011.04.005

attempt to address this issue by proposing a method with which to evaluate the quality of requirements modeling methods based on user perceptions. This method consists of a theoretical model which explains the relevant dimensions of quality for requirements modeling methods, together with a practical instrument to measure these quality dimensions.

We use existing theories and models to determine the appropriate dimensions (and their relationships) for evaluating requirements modeling methods from the user point of view. To be more specific, we adapt the Method Evaluation Model (MEM) [28], which is a theoretical model for evaluating Information Systems (IS) design methods. The MEM incorporates both aspects of method "success": actual performance and likelihood of acceptance in practice. It combines Rescher's Theory of Pragmatic Justification [31], a theory for validating methodological knowledge, with Davis's Technology Acceptance Model (TAM) [13]. Our evaluation model allows us to predict the likelihood of a particular method being accepted in practice, based on the effort of applying the method, the quality of the produced requirements artifacts, and the user perceptions of the quality of the method.

To test the usefulness of the proposed evaluation method (i.e., the adapted MEM) empirically, we performed a family of four controlled experiments with students and practitioners, in order to evaluate a Rational Unified Process (RUP) extension for requirements modeling [19,20]. A family of experiments contains multiple similar empirical studies that pursue the same goal. As Basili et al. [5] observe, and as we have corroborated in previous research [11,32], a family of experiments builds the knowledge that is needed to extract significant conclusions that can be applied in practice. That being so, the primary goal of the family was to test the usefulness of the adapted MEM in the evaluation of requirements modeling methods. To attain this goal, we pursued another objective, which was to evaluate the likelihood of acceptance in practice of a specific requirements modeling method, i.e., the Rational Unified Process (RUP) extension.

This paper is organized as follows: Section 2 discusses existing methods and models for evaluating requirements modeling methods. In Section 3 the MEM is described, along with its adaptation for use with requirements modeling methods. Section 4 introduces the RUP extension for modeling requirements which is used to test our proposed evaluation method. An overview of the family of experiments conducted to empirically test the proposed evaluation method is set out in Section 5, and this is followed by a description of the design of the individual experiments in Section 6. Section 7 presents the individual data analysis and Section 8 gives a summary of the results of the experiments. It also discusses the limitations of the evaluation method proposed, along with the limitations of the empirical tests conducted to validate the proposed evaluation method. Finally, Section 9 summarizes the conclusions, as well as the lessons learned for future work.

2. Related work

As a young, multi-disciplinary field, requirements engineering (RE) still lacks a broad consensus on appropriate research methodologies and evaluation criteria. One of the first attempts to identify and measure the quality of software requirements was presented by Davis et al. [12]. Most of the evaluation criteria, however, were presented in the form of unsystematic lists of the properties that were desired. As far as the quality evaluation of the requirements modeling methods is concerned, several approaches have been proposed here. For example, Al-Subaie and Maibaum [3] evaluated a goal-oriented requirements engineering method (KAOS) and its support tool (Objectiver) with respect to a number of general RE issues such as traceability, validity, and completeness. The purpose of this study was to investigate the range of success of the KAOS method in dealing with these RE difficulties when it was applied to solve a target problem. This experience was used to evaluate the strengths and weakness of KAOS, as well as to explain why the KAOS method and the Objectiver tool are/are not appropriate for helping to solve the difficulties of RE.

In a similar study, Geisser et al. [15] presented an evaluation method for requirements engineering approaches in distributed software development projects. They developed an adaptable and cost-effective evaluation method for distributed RE methods, in addition to the corresponding tool for conducting evaluation projects, both in terms of RE process efficiency and effectiveness (i.e., quality of specification).

Nikula and Sajanie [29] put forward an evaluation framework that is applied to evaluate a new domain-specific method which has been designed to ease the adoption of basic requirements engineering practices in small organizations. This framework, which is based on discovering studies dealing with the adoption of technological innovations, uses contextual factors and method-specific factors to guide the evaluation efforts made to detect causalities.

Although several frameworks for evaluating requirements modeling methods have been proposed, very few have had widespread use in practice. One drawback of these approaches is that they lack theoretical foundations [7]. This deficiency has in turn brought about the appearance of several theories and models whose aim is to evaluate the quality of Information Systems design methods and conceptual models. Most of these theories have their roots in theoretical models defined in the field of Social Sciences.

Such theoretical models incorporate constructs with which to measure the user's psychological reactions and organizational factors systematically. Of all the models that have been proposed for user technology acceptance, the TAM proposed by Davis [13] has been one of the most influential. This model allows us to predict the likelihood of a new technology being accepted and/or adopted within a group or an organization.

In the field of Software Engineering, some theoretical models have been used to explain the acceptance of methodologies and tools on the part of the software developer. For instance, Riemenschneider et al. [33] examined five theoretical models of individual intentions to accept tools in the context of software methodologies. In another study, Ali Babar et al. [4] extended