Usability of Requirements Techniques

A Systematic Literature Review

Denise Bombonatti
IBM Brazil, Rua Tutóia, 1157
04007-900 – São Paulo, Brazil
dlazzeri@br.ibm.com

Catarina Gralha
NOVA LINCS, DI, FCT
Universidade NOVA de Lisboa
acg.almeida@campus.fct.unl.pt

Ana Moreira
NOVA LINCS, DI, FCT
Universidade NOVA de Lisboa
amm@fct.unl.pt

João Araújo
NOVA LINCS, DI, FCT
Universidade NOVA de Lisboa
joao.araujo@fct.unl.pt

Miguel Goulão
NOVA LINCS, DI, FCT
Universidade NOVA de Lisboa
mgoul@fct.unl.pt

ABSTRACT

The usability of requirements engineering (RE) techniques has been recognised as a key factor for their successful adoption by industry. RE techniques must be accessible to stakeholders with different backgrounds, so they can be empowered to effectively and efficiently contribute to building successful systems. When selecting an appropriate requirements engineering technique for a given context, one should consider the usability supported by each of the candidate techniques. The first step towards achieving this goal is to gather the best evidence available on the usability of RE approaches by performing a systematic literature review, to answer one research question: *How is the usability of requirements engineering techniques and tools addressed?* We systematically review articles published in the Requirements Engineering Journal, one of the main sources for mature work in RE, to motivate a research roadmap to make RE approaches more accessible to stakeholders with different backgrounds.

CCS Concepts

•**Software and its engineering** → **Requirements analysis;** *Software usability;* •**General and reference** → Surveys and overviews; Empirical studies;

Keywords

systematic literature review; requirements engineering approaches; usability

1. INTRODUCTION

SAC 2016, April 04-08, 2016, Pisa, Italy

DOI: http://dx.doi.org/10.1145/2851613.2851758

In spite of the vitality of the Requirements Engineering community to develop new techniques, approaches and tools, the adoption of those proposals by industry remains challenging. We have observed difficulties at different levels, including: *(i)* improving the stakeholders *perception* on the usefulness of investing in requirements approaches; *(ii)* reducing communication problems with the stakeholders; *(iii)* validating requirements models; *(iv)* resolving requirements conflicts; *(v)* leveraging those approaches by supporting automatic transformations from requirements specifications to artifacts produced in later stages of the development process; and *(vi)* managing requirements traceability.

There are several causes for these challenges, including lack of information on the potential of the different requirements approaches in industry (and of success stories on their adoption), difficulties in adapting some requirements approaches to the increasingly popular agile methodologies, and the usability of requirements approaches. The notion of *usability* includes characteristics such as *learnability*, *understandability*, *readability*, *writability*, *flexibility*, *expressiveness*, and *cognitive effectiveness*. A difficult to learn requirements approach hinders the ability of stakeholders with no requirements engineering training to contribute pro-actively in the requirements specification and validation processes. Even requirements engineers may lack proper training to be able to read and write requirements with a particular approach, discouraging its adoption. When they invest in such an approach (or in a combination of different approaches) there is still a communication barrier with other stakeholders to overcome, if an informed agreement on the requirements is to be reached. Clear concepts for a community may be opaque to another one [32]. Another issue is the extent to which requirements specified with a given technique are transformed into traceable artifacts in later stages of the development process, can be conveniently validated, and potential conflicts resolved. In all these cases, the usability of the approach impacts the performance of the requirements engineers.

Realising that usability is one of the key factors for requirements engineering approaches adoption in industry, in this paper we gather evidence by performing a systematic literature review (SLR) on papers published in one of the main requirements engineering forums, the Requirements Engineer-

ing Journal (REJ), concerning the usability of requirements approaches. Our research question is: *How is the usability of requirements engineering techniques and tools addressed?*

To the best of our knowledge, this is the first SLR conducted on the specific topic of the usability of requirements engineering approaches. With this work, we aim to centralise information concerning existing assessments of the usability of requirements engineering approaches, as reported in the Requirements Engineering Journal. The goal is to provide an overview on how some of the highest profile RE approaches address the challenge of their usability. The availability of a condensed report on this subject is useful both for practitioners and researchers. The former take away an overview on the current usability of RE approaches, while the latter may use this report to help identifying research opportunities to advance the existing RE body of knowledge.

This paper is organised as follows: section 2 provides background on usability of requirements techniques, and on the methodological approach we followed to collect evidence concerning the usability of these techniques. Section 3 describes the SLR protocol defined for conducting this SLR and section 4 presents the main results found. Section 5 discusses the main findings of this study, their implications to industry and academia, and the validity threats. Section 6 discusses related work. Finally, section 7 concludes the paper.

2. BACKGROUND

A systematic literature review is *"a form of secondary study that uses a well-defined methodology to identify, analyse and interpret all available evidence related to a specific research question in a way that is unbiased and (to a degree) repeatable"* [21]. The typical SLR process is composed of three main phases with the objectives to plan the SLR, conduct the search, and report the results. Planning the SLR aims at identifying the need of the review, commission the review, specifying research questions and reviewing the protocol. Searching studies aims at collecting the studies, selecting primary studies, applying a quality assessment, and extracting and synthesising data. Finally, analysing studies aims at formatting and communicating the results.

In this paper we are concerned about the usability (the capability to be understood, learned, used and attractive to the user when used under specified conditions [ISO/IEC 25000]) of requirements engineering approaches. In this study, we consider usability characteristics such as *learnability*, *understandability*, *readability*, *writability*, and *expressiveness*.

3. RESEARCH METHOD

This review was conducted in three main activities, in line with Kitchenham and Charter's guidelines [21].

3.1 Planning the Review

This activity has the role of defining the research questions, search sources, search queries, inclusion and exclusion criteria, data extraction strategy, and quality assessment.

This SLR answers the research question: *How is the usability of requirements engineering techniques and tools addressed?*

The *search source* for this SLR was the Requirements Engineering Journal, which is a top journal for disseminating new results on the elicitation, representation and validation of requirements of software intensive systems. The journal's online description[1] explicitly calls for papers addressing the practical consequences of the ideas presented in its articles, as well as how these ideas should be evaluated by a reflective practitioner. The Springer Link site[2] search feature was used for searching for relevant papers for this SLR.

Our *search string* includes three mandatory elements: expressions to convey the notion of requirements engineering approaches; the term usability; and several keywords originated from the quality attributes that compose usability in the context of this study. "Cognitive requirement" and "cognitive model" are included here as surrogates for understandability, as we found this expression used in some candidate primary studies. In an initial search string, the terms "requirements technique" and "requirements approach" were also used. However, the presence of those terms did not affect the search results. In that sense, and for the sake of brevity, they were excluded from the final search string. The complete search query was as follows:

```
((("requirements engineering" OR "requirements
  specification" OR "requirements model*" OR
"requirements tool" OR "requirements process" OR
  "requirements analysis") AND usability AND
    (learnability OR understandability OR
 expressiveness OR readability OR writability OR
  "cognitive requirement" OR "cognitive model"))
```

The *inclusion criteria (IC)* used were: papers published in the RE Journal (IC1) that answer the research question (IC2). As *exclusion criteria (EC)*, we discarded secondary (e.g. SLRs and mapping studies) or tertiary studies (i.e. reviews on secondary studies) (EC1), papers that did not apply to research question (EC2), and papers with the same contents in different paper versions (EC3).

The *data extraction strategy* comprises demographic data, usability approaches studied, and usability evaluation.

Demographic data includes: authors, paper conference or journal, year, number of Google Scholar citations, digital library, approach, baseline, publication date, primary study goal, study type (experience, research, qualitative, quantitative, or expert opinion), and whether the paper authors have some vested interest in the results of the study (e.g. the study evaluates a proposal created by the authors).

The usability approaches studied include: usability attributes (as described in the background section, presented in section 2), main results of the usability evaluation, impact on the efficiency, and impact on the effectiveness of the approach.

Usability evaluation includes: evaluation method (evaluated method name, whether the paper reports a detailed process, whether a control group was used in the evaluation, what type of analysis was performed, which validity threats are explicitly discussed in the primary study), and collected data

[1]http://link.springer.com/journal/766
[2]http://link.springer.com

(whether the objects under evaluation have an academic, industrial or both origins, the involved participants number and background, which data was collected during the evaluation and whether the evaluation raw data is available).

Regarding the *quality assessment* of the primary studies, several of the above mentioned attributes extracted from the paper contribute to our assessment (e.g. whether there is a vested interest of the authors, the nature of the objects used in the evaluation, the profile of the participants, the validity threats of those studies, among others).

3.2 Searching Studies

The previously defined search string was used to select the candidate primary studies. The search results were collected and imported to a spreadsheet. Papers were then divided evenly among us (one reviewer per paper) for screening of the title and abstract for *analysing search results*. After a sample of those papers were screened, we discussed the inclusion and exclusion criteria to harmonise its understanding. When in doubt, we kept the primary studies for the next phase. The selected papers were downloaded and assessed by a different reviewer from the one making the initial screening; this time the full paper was read.

As of March 2015, the Requirements Engineering Journal has published 427 articles from 1996 to 2015. Using the search string defined earlier, we identified 62 candidates. From these, and after analysing their titles and abstracts, we selected 35 papers for further inspection.

3.3 Analysing Studies

This activity includes applying the data extraction strategy to the selected primary studies, and consolidating results.

Applying data extraction strategy started with the preparation of a common spreadsheet for data extraction, covering the demographic data, usability approaches and usability evaluation, as described in subsection 3.1.

The content of the 35 papers obtained in the previous step was fully analysed, resulting in the selection of 19 papers. The spreadsheet was then populated with data collected from the primary studies. A sample of these papers was reviewed by more than one of the authors, so that, again, a common understanding of the data collection protocol was reached.

Finally, the results were *consolidated*, preparing them for the next phases of the process, where the major tendencies and issues were identified.

4. DATA SYNTHESIS AND RESULTS

4.1 Demographic Data

Although usability captured a lot of interest since the late 80's and REJ exists since the mid 90's, all papers found were published in the 21st century. There is a wide coverage of RE approaches: Artificial Intelligence (AI), Analysis of Web Application Requirements (AWARE); Entity-Relationship (ER), Human, Social and Organisational (HSO) factors, *i**-based, Non-Functional Requirements (NFR), Object-Oriented Data Flow Diagrams (OO-DFD), Provotype, Simple and Casual Temporal Logic - Model of Unspecified States (SCTL-MUS), Software Product Line (SPL) based, Specification Pattern System (SPS), text, use cases, web specifications (WebSpec), and Z. Table 1 summarises the distribution of the papers concerning their demographic data.

There is a surprisingly low number of studies involving UML, considering it is a *de facto* standard in industry, although use cases and scenarios share their quota of attention. Only 7 out of 19 articles compare the usability of their main approach with some other baseline approach. In 14 out of 19 articles the authors are involved in the approach under evaluation, which constitutes a vested interest on the outcome of that evaluation. This result is to be expected, as the vast majority of the papers in REJ propose new approaches or extensions to existing ones, and, naturally, perform some kind of assessment on their proposals.

Table 1: Papers by approach, study type and vested interest.

Approach	Study type					Vested interest
	Exp.	Quali. assess.	Quant. assess.	Expert Opinion	Research Paper	
AI		[9]	[9]		[9]	[9]
AWARE		[7]			[7]	[7]
ER	[6]	[30]	[30]			[30]
HSO		[4]			[4]	[4]
i*-based		[26]			[18]	[18]
NFR				[17]	[17]	[17]
OO-DFD	[12]	[12]				
Provotype				[10]	[10]	[10]
SCTL-MUS		[16]			[16]	[16]
SPL-based			[1]		[5]	[1, 5]
SPS			[28]		[28]	[28]
Text	[15]	[22]	[15]		[22]	[22]
Use cases	[12]	[12]			[29]	[29]
WebSpec		[24]			[24]	[24]
Z		[20]			[20]	

4.2 Usability Approaches Studied

This section addresses the usability attributes studied, the main results and their impact on requirements engineers efficiency and effectiveness while performing their tasks. We note a predominance of more generic usability concepts under scrutiny, namely understandability (10 out 19) and usability itself (8 out of 19). Studies addressing more specific attributes, such as readability (3 out of 19) or writability (2 out of 19) are still in minority. Most of the evaluations are not conclusive with respect to the influence the approaches have on the efficiency and effectiveness of the requirements engineers tasks, while using the approaches (in many cases, this is not the focus of the work). The main results are often about some of the key advantages, but also pending research challenges, brought by the proposed approaches. Table 2 summarises the distribution of the papers concerning their evaluation approach and covered usability attributes. The references are annotated with an $\uparrow$, when the approach in the paper helps improving the corresponding quality attribute; with an $\downarrow$, when the approach in the paper hurts the corresponding quality attribute; with an $\updownarrow$, when the results in the paper depend on the context in which the quality attribute is evaluated; and ?, when the results are inconclusive.

In some cases, the results are context-dependent. In [1] there are four different SPL approaches under evaluation (PLUSS [14], MT [11], MSVCM [8], and VML4RE [2]), each with a different impact on expressiveness. The results indicate that MT [11] and MSVCM [8] offer constructs that help expressiveness. In [15] the presence of an architecture favours

the identification of technical requirements while hurting the identification of human-centred requirements. In [6], the approach leads to a higher readability effectiveness, but also to a lower readability efficiency. In terms of notation design, formal specification depends on embedding the notation into a proper method and having careful consideration of the usability issues of the specification notation [20].

Table 2: Papers by approach and usability attributes

Approach	Usability attributes					
	Usab.	Understand.	Learn.	Read.	Writ.	Express.
AI	[9] ↑					
AWARE						[7] ↑
ER		[30] ?	[6] ↑	[6] ↕		
HSO	[4] ?					
i*-based	[18] ↑	[26] ↑				
NFR	[17] ↑	[17] ↑				
OO-DFD		[12] ↓				
Provotype	[10] ↓	[10] ↓		[10] ↓	[10] ↓	
SCTL-MUS	[16] ↑	[16] ↑				[16] ↑
SPL-based	[5] ↑					[1]* ↕
SPS		[28] ↑				[28] ↑
Text		[15] ↕ [22] ↑			[22] ↑	[15] ↕ [22] ↑
Use cases		[29] ↑	[29] ↑			[29] ↑
WebSpec				[24] ↑		
Z	[20] ↕		[20] ↕			

4.3 Usability Evaluation

10 out of 19 papers provide a detailed description of the evaluation process. Only 7 out of 19 papers use a control group to compare the approach with.

8 of the papers perform an informal analysis while the remaining papers use some form of statistics, from descriptive statistics to statistics tests (e.g. t-tests). Evaluations using academic examples are frequent (14 out of 19), although 7 of the papers use industry examples in their evaluations.

6 papers make the raw data of their evaluations available, promoting independent scrutiny. This is increasingly encouraged by most top events and journals. Regarding the profile of participants involved in the evaluations, these range from the authors themselves (2 out of 19), students (7 out of 19), practitioners (6 out of 19), researchers other than the authors (2 out of 19), and, in one case, the profile of the participants is not disclosed. Evaluations using students are slightly more frequent, although the involvement of practitioners follows closely. Naturally, the number of participants varies a lot, and evaluations involving students usually have a much higher number of participants.

5. DISCUSSION

5.1 Main Findings

A first observation is that there are relatively few studies in the REJ concerning the usability of Requirements Approaches. From over 400 studies, only 19 were selected for data extraction and evaluation. There is no clear tendency concerning the dates of publication of these studies, but 2014 is among the years with more publications in this review (4 out of 19). Given the increasing pressure to include systematic evaluations in research papers, we expect this kind of studies to become more abundant in a near future.

A second observation concerns the type of evaluated approaches. Excepting use cases and scenarios, no other UML techniques were found in this review. This may be because UML notations have specific forums for publication, such as SoSyM[3] or MODELS[4].

A third observation, related to the usability of the approaches, is concerned with dominance of more generic usability attributes, namely understandability and usability in general. A minor number of studies address more specific usability attributes, such as readability or writability. Also, most of the evaluated approaches are inconclusive with respect to their influence on the efficiency and effectiveness of the requirements engineers activities. Indeed, the main results are typically about the key advantages of the approach and open research challenges.

A fourth observation respects the evaluation method and collected data. Although most papers provide a detailed description of the evaluation process, only a minority use a control group to compare the approach with some baseline. Also, there is a positive tendency to make available the raw data of the analysis for independent scrutiny of those evaluations. Finally, there is a wide variety of participant profiles involved in the evaluation, ranging from the authors, to students, practitioners, and other researchers. Although students are used more frequently, the involvement of practitioners follows closely.

5.2 Research Road Map

14 out of the 19 selected papers were written by authors with a vested interest on at least one of the requirements engineering techniques under scrutiny. The production of truly independent evaluations of RE approaches would enhance the perception of the maturity of those approaches, potentially increasing their acceptance by practitioners.

We propose to create a usability evaluation framework for RE approaches, and challenge researchers and practitioners to use it to evaluate their favourite approaches. Similar efforts have been pursued by the Evidence-Based Software Engineering (EBSE) community, through their portal[5], and by the MODELS community, through the *Comparison of Modeling Approaches* workshop series[6]. In both cases, these communities share resources (e.g. guidelines, case studies, data sets, and papers) and results, fostering the independent evaluation of RE approaches.

5.3 Validity Threats

Internal validity threats. Some papers may have a different view of usability and its sub-attributes that contribute positively to it, thus using different keywords. Due to the diversity of terms used, relevant studies may have been lost in the search process, if they were using alternative keywords. The papers are very heterogeneous, presenting a variety of approaches, study types and usability attributes. This may introduce a selection bias, in the sense that we may have not included the right papers. An interpretation bias may also occur, in the sense that we may have not correctly interpreted what the author wrote. Furthermore, inter-rater agreement

[3]http://www.sosym.org/
[4]http://www.modelsconference.org/
[5]http://community.dur.ac.uk/ebse/
[6]http://cserg0.site.uottawa.ca/cma2013models/

may also occur. We have mitigated these threats by having a second reviewer cross-checking a sample of the papers.

External validity threats. This SLR considers papers published in the REJ. There are other venues where relevant work could be found (e.g. the Requirements Engineering conference proceedings, or the Empirical Software Engineering Journal, where empirical evaluations of usability of RE approaches fit well). However, REJ papers are typically written by RE experts, and are good representatives of RE mature work. Indeed, several attempts to aggregate the best evidence in the literature concerning a particular aspect of RE (e.g. [19]) used REJ as their only source.

6. RELATED WORK

Zowghi and Coulin surveyed requirements elicitation techniques, approaches and tools, to help practitioners and researchers to determine which of the available approaches (or combinations of them) would best fit their context [32]. Their scope is broader than ours with respect to which characteristics of the techniques, approaches and tools are scrutinised. On the other hand, their scope is narrower in terms of the target techniques, approaches and tools, which in our paper are not limited to requirements elicitation. A different perspective on this was taken in an SLR concerning the effectiveness of requirements elicitation techniques [13]: gathering data from different experimental evaluations, structured interviews were identified as the most effective method, among other insights. While their work was not directly on the usability of the different approaches, we argue usability plays an important role in the effectiveness of the RE process, with the inherent impact to the software development process.

Recognising that one of the key approaches to prevent defects in software is to identify the errors originating those defects, Walia and Carver performed an SLR on the identification and classification of software requirements errors [31]. We regard our SLR as complementary to [31], in the sense that one of the key aspects of usability is to help preventing those errors and, when they occur, recovering from them. Alves *et al.* performed an SLR on how RE is conducted in the context of Software Product Line Engineering (SPLE) [3]. Their work emphasised a call for more empirical studies comparing alternative RE methods in the context of SPL, as well as the need to further develop tool support and researching how to combine different SPLE approaches. Loniewski *et al.* performed an SLR on how RE techniques are used in the context of MDD [23], highlighting that most MDD approaches use only partially defined requirement models, or even natural language, as well as the need for further improving requirements traceability and tool support. This is in line with our requirements usability concern, where requirements traceability is fundamental for their understandability, and enhanced tool support is expected to increase the overall usability of requirements approaches. Nicolás and Toval performed an SLR on the generation of textual requirements specifications from requirements models [27]. They argue for the importance of increasing the readability of software engineering models, making them more accessible to a wider spectrum of stakeholders. They emphasise the importance of providing different stakeholders with special views so they can have a better grasp on how requirements are realised, in practice. Similarly to [23], they also identify the need for improved requirements traceability and tool support, not only in the generation of requirements from models, but also in the synchronisation among textual requirements and models. They add to this the ability to make the requirements specifications more editable, as requirements are likely to change during the project life cycle. Mellado et al. performed an SLR on how requirements engineering approaches support security requirements [25], concluding very few of these approaches describe complex case studies to illustrate them in practice.

7. CONCLUSIONS AND FUTURE WORK

In this paper, we conducted an SLR on the usability of Requirements Engineering approaches, focusing on publications in the Requirements Engineering Journal. The search on this journal database resulted in over 400 papers, of which over 60 were selected in a first iteration of the process (based on automatic search). From those, 35 remained for extraction, after screening the titles and abstracts. Of these, 19 were selected for data extraction and further analysis.

We answered the research question: *How is the usability of requirements engineering techniques and tools addressed?*

We observed that there is relatively little evidence concerning the usability of the requirements engineering approaches, denoting this has not been a top priority concern in the past. That said, we found a large variety of approaches submitted to some form of usability assessment, so it is fair to say the RE community is increasingly concerned about the problem of making its approaches usable not only for requirements engineers, but also to stakeholders, with their diverse backgrounds and needs. We expect to find an increasing number of studies concerned with usability in the near future, consistently with what we are observing in other software engineering communities.

Although validations with students and academic examples are still the most frequent kind of evaluations reported, the RE community is pushing for evaluations with professional practitioners, in industrial settings, to increase the results validity and its applicability to real work environments.

We plan to create a usability evaluation framework for RE approaches, and challenge researchers and practitioners to use this framework to evaluate their favourite approaches. Ultimately, we aim to build up an open access repository where this community can share resources and results, fostering the independent evaluation of RE approaches.

Acknowledgments

The authors would like to thank NOVA LINCS UID/CEC/04516/2013, Programa Ciência sem Fronteiras, and FCT-MCTES research grant SFRH/BD/108492/2015, for the financial support of this work.

8. REFERENCES

[1] M. Alférez, R. Bonifácio, L. Teixeira, P. Accioly, U. Kulesza, A. Moreira, J. Araújo, and P. Borba. Evaluating scenario-based SPL requirements approaches:

the case for modularity, stability and expressiveness. *Requirements Engineering*, 19(4):355–376, 2014.

[2] M. Alférez, J. Santos, A. Moreira, A. Garcia, U. Kulesza, J. Araújo, and V. Amaral. Multi-view composition language for software product line requirements. In *2nd International Conference on Software Language Engineering*, SLE'09, pages 103–122, 2009.

[3] V. Alves, N. Niu, C. Alves, and G. Valença. Requirements engineering for software product lines: A systematic literature review. *Information and Software Technology*, 52(8):806–820, 2010.

[4] A. S. Andreou. Promoting software quality through a human, social and organisational requirements elicitation process. *Requirements Engineering*, 8(2):85–101, 2003.

[5] E. Bagheri and F. Ensan. Dynamic decision models for staged software product line configuration. *Requirements Engineering*, 19(2):187–212, 2014.

[6] A. Bajaj. The effect of the number of concepts on the readability of schemas: an empirical study with data models. *Requirements Engineering*, 9(4):261–270, 2004.

[7] D. Bolchini and P. Paolini. Goal-driven requirements analysis for hypermedia-intensive web applications. *Requirements Engineering*, 9(2):85–103, 2004.

[8] R. Bonifácio and P. Borba. Modeling scenario variability as crosscutting mechanisms. In *Proceedings of the 8th ACM International Conference on Aspect-oriented Software Development*, AOSD '09, pages 125–136, 2009.

[9] V. Bryl, P. Giorgini, and J. Mylopoulos. Designing socio-technical systems: from stakeholder goals to social networks. *Requirements Engineering*, 14(1):47–70, 2009.

[10] P. Carlshamre. Release planning in market-driven software product development: Provoking an understanding. *Requirements engineering*, 7(3):139–151.

[11] K. Czarnecki and M. Antkiewicz. Mapping features to models: A template approach based on superimposed variants. In *Proceedings of the 4th International Conference on Generative Programming and Component Engineering*, GPCE'05, pages 422–437, 2005.

[12] M. Dahan, P. Shoval, and A. Sturm. Comparing the impact of the oo-dfd and the use case methods for modeling functional requirements on comprehension and quality of models: a controlled experiment. *Requirements Engineering*, 19(1):27–43, 2014.

[13] A. Davis, O. Dieste, A. Hickey, N. Juristo, and A. M. Moreno. Effectiveness of requirements elicitation techniques: Empirical results derived from a systematic review. In *Requirements Engineering, 14th IEEE International Conference*, pages 179–188. IEEE, 2006.

[14] M. Eriksson, J. Börstler, and K. Borg. The pluss approach: Domain modeling with features, use cases and use case realizations. In *Proceedings of the 9th International Conference on Software Product Lines*, SPLC'05, pages 33–44, 2005.

[15] R. Ferrari, J. A. Miller, and N. H. Madhavji. A controlled experiment to assess the impact of system architectures on new system requirements. *Requirements Engineering*, 15(2):215–233, 2010.

[16] J. García-Duque, M. López-Nores, J. J. Pazos-Arias, A. Fernández-Vilas, R. P. Díaz-Redondo, A. Gil-Solla, M. Ramos-Cabrer, and Y. Blanco-Fernández. Guidelines for the incremental identification of aspects in requirements specifications. *Requirements Engineering*, 11(4):239–263, 2006.

[17] D. Gross and E. Yu. From non-functional requirements to design through patterns. *Requirements Engineering*, 6(1):18–36, 2001.

[18] J. Horkoff and E. Yu. Interactive goal model analysis for early requirements engineering. *Requirements Engineering*, pages 1–33, 2014.

[19] M. Ivarsson and T. Gorschek. Technology transfer decision support in requirements engineering research: a systematic review of rej. *Requirements engineering*, 14(3):155–175, 2009.

[20] B. Khazaei and C. Roast. The influence of formal representation on solution specification. *Requirements Engineering*, 8(1):69–77, 2003.

[21] B. A. Kitchenham and S. Charters. Guidelines for performing Systematic Literature Reviews in Software Engineering, 2007.

[22] S. Lauesen and M. A. Kuhail. Task descriptions versus use cases. *Requirements Engineering*, 17(1):3–18, 2012.

[23] G. Loniewski, E. Insfran, and S. Abrahão. A systematic review of the use of requirements engineering techniques in model-driven development. In *Model driven engineering languages and systems*, pages 213–227. 2010.

[24] E. R. Luna, G. Rossi, and I. Garrigós. Webspec: a visual language for specifying interaction and navigation requirements in web applications. *Requirements Engineering*, 16(4):297–321, 2011.

[25] D. Mellado, C. Blanco, L. E. Sánchez, and E. Fernández-Medina. A systematic review of security requirements engineering. *Computer Standards & Interfaces*, 32(4):153–165, 2010.

[26] D. L. Moody, P. Heymans, and R. Matulevičius. Visual syntax does matter: improving the cognitive effectiveness of the i* visual notation. *Requirements Engineering*, 15(2):141–175, 2010.

[27] J. Nicolás and A. Toval. On the generation of requirements specifications from software engineering models: A systematic literature review. *Information and Software Technology*, 51(9):1291–1307, 2009.

[28] A. Post, I. Menzel, J. Hoenicke, and A. Podelski. Automotive behavioral requirements expressed in a specification pattern system: a case study at bosch. *Requirements Engineering*, 17(1):19–33, 2012.

[29] D. Richards. Merging individual conceptual models of requirements. *Requirements Engineering*, 8(4):195–205, 2003.

[30] P. Shoval, R. Danoch, and M. Balabam. Hierarchical entity-relationship diagrams: the model, method of creation and experimental evaluation. *Requirements Engineering*, 9(4):217–228, 2004.

[31] G. S. Walia and J. C. Carver. A systematic literature review to identify and classify software requirement errors. *Information and Software Technology*, 51(7):1087–1109, 2009.

[32] D. Zowghi and C. Coulin. Requirements elicitation: A survey of techniques, approaches, and tools. In *Engineering and managing software requirements*, pages 19–46. Springer, 2005.