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Human factor in software requirements engineering: Preliminary review of qualitative empirical studies

Zeljko Stojanov, University of Novi Sad, Technical faculty “Mihajlo Pupin” Zrenjanin, zeljko.stojanov@uns.ac.rs
Tamara Zoric, University of Novi Sad, Technical faculty “Mihajlo Pupin” Zrenjanin, tamara.zoric@tfzr.rs
Ilija Hristoski, “St. Kliment Ohridski” University - Bitola, Faculty of Economics Prilep, Macedonia, ilija.hristoski@uklo.edu.mk

Abstract— **Inženjerstvo softverskih zahteva je oblast softverskog inženjerstva koja veoma zavisi od ljudskog faktora s obzirom da obuhvata znanja i veštine iz domena softverskog inženjerstva, domena problema u kojem će se softver koristiti, ali i iz domena organizacionih i društvenih nauka. Zbog toga je istraživanje ljudskog faktora veoma bitno za razumevanje industrijske prakse i identifikovanje pravaca njenog unapređenja. Dublje razumevanje uticaja ljudskog faktora na praksu inženjerstva softverskih zahteva podrazumeva upotrebu kvalitativnih metoda istraživanja. U ovom radu je prezentovana studija koja prikazuje preliminarni pregled literature koja primenom kvalitativnih metoda istraživanja proučava uticaj ljudskog faktora u oblasti inženjerstva softverskih zahteva. Studija prikazana u ovom radu predstavlja doprinos ovoj oblasti istraživanja kroz jasno definisan process preliminarnog pregleda odgovarajuće literature, a kao pilot studija predstavlja osnovu za planiranje detaljnog i sistematskog pregleda literature.**

Ključne reči – ***Inženjering softverskih zahteva; Ljudski faktor; Kvalitativna istraživanja; Pregled literature***

Abstract – Software requirements engineering is a field in software engineering that highly depends on human factor since it includes knowledge and skills from domain of software engineering and from the domain of problem where software will be used, but also from both organizational and social sciences aspects. Therefore, researching human factor is very important for understanding industrial practice and identifying improvement directions. Deeper understanding of human factor influence on software requirements engineering practice assumes the use of qualitative research methods. This paper presents a preliminary review of literature that investigates human factor in software requirements engineering by using qualitative research methods. The presented study contributes to the research field by presenting a clearly defined process of preliminary literature review, and as a pilot study, it will be used for planning detailed and systematic literature review.

Keywords **– Software requirements engineering; Human factor; Qualitative research; Literature review**

I. INTRODUCTION

Software requirements engineering is the field in software engineering aimed at managing software requirements throughout the whole software life cycle [1]. Activities related to software requirements start in the early stage of software life cycle, in which software requirements are collected from software users and specified in the formal form suitable for software development activities. According to Sommerville [2], the term ‘software requirements’ is not consistently used in software industry, which depends on the viewpoints of stakeholders in software projects. For software users, software requirements are high-level descriptions of services that software should provide, while for software developers they are detailed formal specifications of software functions. Software requirements are classified in two groups: (1) *functional requirements* that define what software should provide to users, and (2) *non-functional requirements* that define constraints on software (e.g. time, reliability or security issues) or on development process (e.g. use of specific technologies).

Activities in software requirements engineering are [3]: elicitation/discovery, analysis and reconciliation, representation and modelling, validation and management. The success of software requirements activities depends on understanding the needs of different stakeholders (users, customers) and understanding the problem context (e.g. business environment or industrial processes) for which software will be developed. The main challenges in software requirements research originate from problem space, which means that problems for software are usually described by using terminology from the domain of the problem. The main difficulties in requirements engineering are [4]:

- Analysis of requirements starts with incomplete, conflict or poorly stated ideas of what software should do.
- The limitations of the domain of the problem are weaker than the limitations of the software development process, which requires adjusting ideas and determining the real requirements. One possible option is to put some constraints in the domain of the problem.
- Understanding the domain includes an identification of possible threats and problematic issues that may affect software functioning.
- Final requirements specifications should be understandable for all stakeholders, nevertheless of their role in software development project and their specific knowledge.

Processes and activities in requirements engineering are highly interdisciplinary, requiring software engineers with a variety of different skills and knowledge not only related to software engineering topics [1]. Software engineers performing software requirements activities must possess skills and knowledge from problem domain and software engineering domain, but also several additional social and technical skills are essential for successful software requirements practice. Stakeholders in software requirements practice are [1]: *users* – people that use software for solving their problems, *customers* – people that commissioned software, *market analysts* - people that work on investigating market for software that do not have commissioned customers, *regulators* – authorities that arrange different domains in which software is used, and *software engineers* – people that develop software and have interest in it. According to Laplante [3], software engineers play different roles in requirements activities, such as software system engineer, subject matter expert, software architect, and business process expert. These different roles suggest that a software engineer should have different skills and knowledge to efficiently work on requirements activities. According to Joseph et al. [5], technical skills are insufficient for success in information technology, which means that software engineers should acquire several non-technical or soft skills. Recent researches revealed that soft skills are of the primary importance, while technical skills (e.g. programming, database management, configuring hardware and servers) can be developed through adequate trainings [6].

Human factor, or people issues, has gained attention in software engineering literature [7][8]. However, due to its importance for the industrial practice, there is a need for more studies dealing with human factor in software engineering and especially in the field of requirements engineering [9], which is the most critical for the success of software projects [10] and future maintenance of software systems [11]. In addition, understanding human factor issues, or soft skills, by software engineers is essential for improving software requirements industrial practice [12]. Due to the complexity of software engineering, including technical, organizational and human issues, it is difficult to study practice by using only quantitative approaches (dominate in software engineering scientific literature), which indicates that deeper understanding of human performed practice requires qualitative approaches [13]. Qualitative studies can offer richer explanations of studied phenomena, more detailed findings and well-grounded hypotheses that would lead further researches. Qualitative research methods are well suited for addressing software engineering practice as a set of social activities performed by humans, enabling insight into daily work practice [14]. In addition, it is common in empirical software engineering that qualitative findings complement results obtained by using quantitative methods [15].

Based on the justified importance of software requirements for success in software engineering practice, and significance of human factor in software requirements engineering, it is evident that there is a need to systematize knowledge base about human factor in software requirements engineering. This paper aims at presenting a preliminary literature review of qualitative studies that investigate human factor in software requirements engineering. The rest of the paper is structured as follows. The next section presents related work on systematic literature reviews in software requirements engineering and justifies the need for this study. The third section presents a preliminary literature review study, while the fourth section presents a discussion of study constraints and validity, as well as discussion of benefits and implications of the presented study. The last section presents concluding remarks and outlines future research directions.

II. RELATED WORK

Systematic literature reviews (SLRs) have been recognized as an important segment of research aimed at evaluating and synthesizing relevant empirical studies in a consistent manner [16]. SLRs are conducted in several disciplines, such as medicine, social science, education and information systems. Recently, these types of literature reviews have gained attention in the software engineering research community, which resulted with studies covering different segments of software engineering practice and with the proposed guidelines for conducting SLRs [16][17] or systematic mapping reviews [18][19]. Although the study presented in this paper is declared as a preliminary literature review, it is conducted as a pilot study of an SLR study which is in a planning phase, and this justifies dedicating this related work section to SLRs in the domain of software requirements engineering.

SLRs are secondary studies aimed at identifying primary empirical studies in a selected field of the practice [16]. SLRs assume defining a review protocol during the planning phase, whose objective is to minimize bias through clearly defined details of a systematic review. In addition to aggregating existing evidence on the proposed research question, SLRs are intended to support the development of evidence-based (grounded in existing empirical evidence about practice) guidelines for practitioners [20]. In their study with SLR of SLRs in software engineering domain, Kitchenham et al. [20] concluded that: (1) although there exist guidelines for conducting SLRs, many researchers prefer to conduct informal literature reviews, and (2) many areas of software engineering still need SLRs about many specific topics.

Review of leading software engineering journals (journals with impact factor larger than 1 in several consecutive years) revealed that in last few years the number of systematic literature reviews related to software requirements engineering practice is increasing. Issues investigated in these literature reviews are challenges and practice in agile requirements [21], stakeholders in agile requirements [22], prioritization techniques in requirements engineering [23], quality criteria in agile requirements practice [24], requirements engineering of safety-critical systems [25], ontologies in requirements engineering [26] or Bayesian networks for enhancement of requirements engineering [27]. Detailed insight into the findings of these literature reviews revealed that human factor is partially investigated only in review studies [21][22]. Further, a brief insight into other literature review studies revealed that investigation of human factor, especially by using qualitative research methods, is under-researched, which clearly indicate the need for studies that are focused on human factor in software requirements engineering.

III. REVIEW STUDY

This study presents a preliminary review of empirical qualitative studies that investigate human factor in software requirements engineering. This study is a pilot study that will be used as a preparation for conducting more detailed and systematic literature review in the selected field of research. Therefore, the study will not follow guidelines for conducting systematic literature reviews [16][17] or systematic mapping reviews [18][19] that present more detailed results about the select field of research.

A. Procedure

This study uses a simplified version of systematic literature review, with the following steps: (1) defining the study objective, (2) defining sources for searching literature, (3) defining search criteria (search strings), (4) defining study selection criteria, (5) conducting search, (6) evaluating identified studies based on the selection criteria, and (7) synthesizing findings based on proposed study objective.

B. Study objective

The objective of this study is to identify qualitative studies on human factor in software requirements engineering that are published in the period from 2012 to 2017. For the identified studies the following research questions (RQ) will be addressed:

RQ1: Which segments of requirements engineering practice are addressed in studies?

RQ2: Which qualitative methods are used in studies?

C. Sources

Study search has been completed by using search engine Google Scholar, which is a freely accessible Web search engine that indexes the full text or metadata of scholarly literature. Only studies that can be freely downloaded will be included in the review (without subscribing to digital libraries).

D. Search criteria

Search criteria are commonly presented as search strings containing relevant keywords. Selection of keywords is based on proposed study objective or research questions and can be grouped in three categories related to three dimensions of search: (1) software requirements engineering, (2) human factor, and (3) qualitative research. Search string contains the selected keywords and it is presented in the following form:

“software requirements” AND “human factor” AND
“qualitative research”

One of the constraints of this pilot literature review is the selection of keywords used for searching literature. It is common practice to detect similar keywords or synonyms and to construct more detailed search strings in SLRs [16][17].

E. Study selection criteria

Selection of studies to be included in data analysis is based on the proposed study objectives and guided by research questions, which means that study must relate to human factor issues in software requirements engineering and must contain empirical study based on qualitative research methods [28][29]. The inclusion of the potential qualitative studies is based on assessing the identified literature sources in the following two steps: (1) checking the title abstract and keywords, and (2) if it is not possible to decide based on the title, abstract and keywords, a literature source is thoroughly investigated.

Since qualitative research methods can be used within studies with mixed methods [30][31], the study can be included for detailed analysis if it reports usage of only qualitative methods or if it is mixed method study.

In addition, unpublished work (papers, articles or theses) available at the Internet are excluded from further data analysis, which means that only reviewed literature sources are acceptable for inclusion in data analysis. And finally, only literature sources in English language will be included in data analysis.

F. Searching for studies

The search was performed on Google Scholar search engine by using the constructed search string, which is discussed in the section *Search criteria*. An example search is presented in Fig. 1. The search was conducted at Google Scholar with the constructed search string, in the selected period from 2012 to 2017. All types of literature sources are included in the search (conference papers, journal articles, chapters in books, theses) except patents.

G. Evaluation of identified studies

For the preliminary review, the first 50 literature sources listed at Google Scholar were considered. The decision to stop with analyzing 50 literature sources is grounded in the fact that after the 30th listed literature source, majority of them do not relate to the proposed research objective of this study. In this literature search, after the 30th source, only three of them (33, 39 and 43) are included in the detailed data analysis since they fulfill the proposed inclusion criteria.

The first literature sources excluded from further analysis were those that presented unpublished work or work without review, which included 2 sources. One literature source was in Portuguese language, and it was also removed. Totally 24 sources did not relate to software requirements, human factor and do not use qualitative research methods, while some studies do not match one or two of these inclusion criteria. After inclusion/exclusion evaluation of the literature sources, only 11 sources were included in further detailed data analysis. These sources are referred to as primary studies and they are presented in Table I.

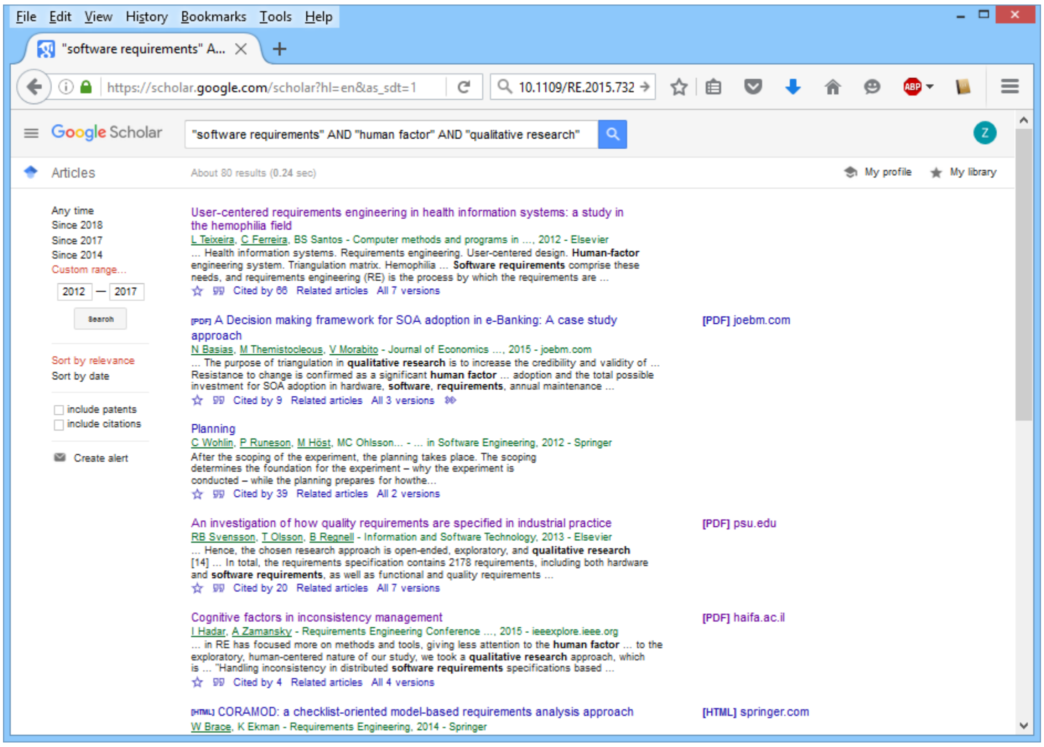
Among selected primary studies 5 of them are published in international journals, 1 in the proceedings of the international conference, 4 as Ph.D. theses and 1 as a master thesis. This revealed that selected topic of this preliminary literature review is interesting for scientific research and gained attention at universities as a subject for working on thesis among master and Ph.D. students.

H. Synthesis of the findings

The findings of this literature review are organized around proposed research questions: (RQ1) identification of software requirements engineering practice explored in the study, and (RQ2) identification of used qualitative research methods.

Insight into details of empirical studies identified as primary studies for this literature review indicates that different aspects of software requirements practice are investigated by using qualitative research methods, which is presented in Table II. Practice aspects such as teamwork, user-centered design, interaction, and misalignment are typical issues that occur in human intensive practice such as requirements engineering.

Insight into the methodological part of explored primary studies revealed that Grounded theory [32] is the most popular qualitative methodology used for researching human factor issues in software requirements engineering. Table III presents the distribution of primary studies per identified qualitative research methodologies.



"software requirements" AND "human factor" AND "qualitative research"

About 80 results (0.24 sec)

User-centered requirements engineering in health information systems: a study in the hemophilia field
L Teixeira, C Ferreira, BS Santos - Computer methods and programs in ..., 2012 - Elsevier
... Health information systems. Requirements engineering. User-centered design. **Human-factor** engineering system. Triangulation matrix. Hemophilia ... **Software requirements** comprise these needs, and requirements engineering (RE) is the process by which the requirements are ...
☆ 99 Cited by 66 Related articles All 7 versions

[PDF] A Decision making framework for SOA adoption in e-Banking: A case study approach — [PDF] joebm.com
N Basias, M Themistocleous, V Morabito - Journal of Economics ..., 2015 - joebm.com
... The purpose of triangulation in **qualitative research** is to increase the credibility and validity of ... Resistance to change is confirmed as a significant **human factor** ... adoption and the total possible investment for SOA adoption in hardware, **software**, **requirements**, annual maintenance ...
☆ 99 Cited by 9 Related articles All 3 versions

Planning
C Wohlin, P Runeson, M Höst, MC Ohlsson... - ... in Software Engineering, 2012 - Springer
After the scoping of the experiment, the planning takes place. The scoping determines the foundation for the experiment – why the experiment is conducted – while the planning prepares for howthe...
☆ 99 Cited by 39 Related articles All 2 versions

An investigation of how quality requirements are specified in industrial practice — [PDF] psu.edu
RB Svensson, T Olsson, B Regnell - Information and Software Technology, 2013 - Elsevier
... Hence, the chosen research approach is open-ended, exploratory, and **qualitative research** [14] ... In total, the requirements specification contains 2178 requirements, including both hardware and **software requirements**, as well as functional and quality requirements ...
☆ 99 Cited by 20 Related articles All 7 versions

Cognitive factors in inconsistency management — [PDF] haifa.ac.il
I Hadar, A Zamansky - Requirements Engineering Conference ..., 2015 - ieeexplore.ieee.org
... in RE has focused more on methods and tools, giving less attention to the **human factor** ... to the exploratory, human-centered nature of our study, we took a **qualitative research** approach, which is ... "Handling inconsistency in distributed **software requirements** specifications based ...
☆ 99 Cited by 4 Related articles All 4 versions

[HTML] CORAMOD: a checklist-oriented model-based requirements analysis approach — [HTML] springer.com
W Brace, K Ekman - Requirements Engineering, 2014 - Springer

Fig 1. An example of a search at Google Scholar with the constructed search string

TABLE I. PRIMARY STUDIES INCLUDED IN THE ANALYSIS

No	Study
S1	Teixeira, L., Ferreira, C., & Santos, B. S. (2012). User-centered requirements engineering in health information systems: a study in the hemophilia field. Computer methods and programs in biomedicine, 106(3), 160-174.
S4	Svensson, R. B., Olsson, T., & Regnell, B. (2013). An investigation of how quality requirements are specified in industrial practice. Information and Software Technology, 55(7), 1224-1236.
S5	Hadar, I., & Zamansky, A. (2015, August). Cognitive factors in inconsistency management. In Requirements Engineering Conference (RE), 2015 IEEE 23rd International (pp. 226-229). IEEE.
S7	Collins, N., Chou, Y. M., Warner, M., & Rowley, C. (2017). Human factors in East Asian virtual teamwork: a comparative study of Indonesia, Taiwan and Vietnam. The International Journal of Human Resource Management, 28(10), 1475-1498.
S9	Seth, F. P., Mustonen-Ollila, E., Taipale, O., & Smolander, K. (2015). Software quality construction in 11 companies: an empirical study using the grounded theory. Software Quality Journal, 23(4), 627-660.
S18	Seth, F. P. (2015). Empirical studies on software quality construction: Exploring human factors and organizational influences. Acta Universitatis Lappeenrantaensis. Ph.D. Thesis.
S20	Pascucci, G. (2017). A Qualitative Case Study on Successful Software Requirements Engineering (Doctoral dissertation, University of Phoenix).
S27	Janits, M. (2013). Practical Insights into Recurring Issues of Requirements Elicitation: The potential of systems analysis in addressing these issues. Master Thesis
S33	Aktunc, O., Erol, B. A., & Garcia, J. D. (2012). Redesign of a seismic monitor using contextual design. International Journal of Software Engineering & Applications, 3(6), 1.
S39	Machiridza, M. (2016). Misalignment - the core challenge in integrating security and privacy requirements into mobile banking application development (Doctoral dissertation, University of Cape Town).
S43	Graziotin, D. (2016). Towards a Theory of Affect and Software Developers' Performance. Ph.D. thesis. The Free University of Bozen-Bolzano. Italy.

TABLE II. DISTRIBUTION OF PRIMARY STUDIES PER IDENTIFIED SOFTWARE REQUIREMENTS ENGINEERING PRACTICE

Software requirements engineering practice	**Primary studies**
User-centered requirements engineering	S1, S33
Quality requirements	S4
Requirements inconsistency	S5
Teamwork in virtual teams	S7
Software quality	S9, S18
Stakeholders interaction	S20
Recurring issues in requirements elicitation	S27
Misalignment in integrating security and privacy requirements	S39
Affects and software development performance	S43

TABLE III. DISTRIBUTION OF PRIMARY STUDIES PER IDENTIFIED QUALITATIVE RESEARCH METHODOLOGIES

Qualitative research methodologies	**Primary studies**	**Number of studies**
Grounded theory	S1, S5, S9, S18, S39	5
Case study	S4, S7, S20	3
General inductive method	S27	1
Ethnographic contextual inquiry	S33	1
Interpretive phenomenology	S43	1

Based on data presented in Table III it is evident that different qualitative research methodologies are used for exploring human factor issues in software requirements engineering, which depends on specific research objectives and topics to be explored. However, use of these methods in technical disciplines such as software engineering requires extensive investigation of literature dedicated to qualitative methods and forming multidisciplinary research teams (e.g. by including sociologists, economists, psychologists, etc.) that are capable to conduct complex and very demanding qualitative data analysis.

IV. DISCUSSION

In this section, limitations and contributions of this study, which are necessary for increasing its reliability and pointing out potential benefits, are discussed.

A. Limitations and validity

Several limitations of this study arise from its quite simplified design, which is reflected in the study findings. The first limitation relates to the selection of the keywords and forming the string for searching literature sources. Only three keywords are selected and used for creating only one search string, although guidelines for literature search [16][17] suggest using multiple keywords and finding potential synonyms, which enables the creation of more complex and comprehensive search strings, resulting with a more reliable search of literature sources and more comprehensive findings. The second limitation relates to the selection of literature sources to be searched. For this preliminary search, Google Scholar Web search engine is selected, while common digital libraries with software engineering literature (e.g. IEEE, ACM, Springer, Wiley, Scopus) are omitted, which resulted with the inclusion of only 11 primary studies from investigated 50 literature sources. In addition, there is a lack of studies published in leading software engineering journals with high impact factor, which are the most influential literature sources in the software engineering community. Since this study presents a preliminary review, these limitations will be addressed in detail, leading to a more comprehensive literature review as a future research direction.

The validity of the presented study is judged in terms of internal and external validity, which are commonly used in empirical software engineering [33]. Internal validity relates to a sound and well-described research process, leading to reliable findings, which is ensured with relaxed but strictly defined and followed research process. External validity relates to implementing research process or findings in other settings, which can be accomplished by following research process described in this study and selecting appropriate keywords for search and inclusion/exclusion criteria for a specific field of research (practice).

B. Contributions and implications

Despite the stated limitations, this study has its own contributions. The first contribution is a detailed description of the process for conducting a preliminary literature review, which is commonly used as a preparation phase for conducting a comprehensive and systematic literature review in the selected field. The next contribution is a short summary of qualitative research methods used in the presented study, which can be used as a guideline for considering the use of qualitative methods for investigating practice in technical disciplines such as software engineering. In addition, experts and managers from software industry can find a summary of qualitative methods that can be used for assessing their everyday practice and identifying potential improvements.

V. CONCLUSION

Due to the recognized importance of human factor for software requirements engineering practice it is necessary to organize different types of literature reviews aimed at systematizing knowledge and identifying perspective directions for further research, The study presented in this paper is a small contribution in that direction, while lessons learned during the study implementation will be used in future for organizing a comprehensive and systematic literature review.

Future research direction relates to preparing a more detailed systematic literature review, which will be used for identifying current research trends and proposing attractive directions for further research in highly interesting and complex aspects of software requirements engineering practice related to human factor.

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