25 years of Requirements Engineering in Brazil: a systematic mapping

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Abstract. The celebration of 25th anniversary of the Brazilian Symposium of Software Engineering (SBES) as well as the forthcoming Requirements Engineering Conference to be held in Brazil for the first time, has led us to have a closer look at the local Requirements Engineering (RE) Community. A systematic mapping was performed in order to find out the main Brazilian research groups, authors as well as their topics of interest and publications with greatest impact. This information may be useful for those that do not know well the local requirements engineering community, such as local newcomers or foreign researchers. It may also help to identify potential groups for collaboration. Similarly, it may provide valuable information to assist local agencies when granting research funds.

Keywords: requirements engineering; systematic mapping

1 Introduction

The activities related to software requirements are some of the most important steps in software development, since the requirements describe what will be provided in a software system in order to fulfill the stakeholders' needs. The process of eliciting, analyzing, specifying, validating and maintaining requirements is known as Requirement Engineering (RE).

The RE research community is constantly investigating methods and techniques to tackle and overcome open issues and challenges that may compromise the quality of RE activities [1–3]. The ACM taxonomy has often been used to classify the types of RE work performed [4].

The Brazilian Software Engineering community has recently celebrated its 25th anniversary. It includes several RE groups that have national and international participation in events such as Brazilian Symposium on Software Engineering- SBES, Workshop on Requirements Engineering - WER, IEEE International Requirements Engineering Conference (RE), etc. As an evidence of its growing importance, it was successful in bidding to host the flagship IEEE International Requirements Engineering

Conference which will be held in Rio de Janeiro in 2013. Hence, we felt that it timely to perform an investigation about the contributions made by the Brazilian Requirements Engineering research community to the RE area and their impacts. Thus, this work presents a systematic mapping of the literature related the RE scientific works carried out and published by the Brazilian community during the last 25 years [5]. The purpose of this mapping study is to identify the main research groups, authors and their publications as well as the topics of interest and the scientific works with greatest impact. With the results obtained from this study, a newcomer will be able to identify main groups, key researchers and the work already developed as well as topics that have not deserved much attention by the local community. This kind of information will also be useful for setting up possible collaborative network as well to identify priorities for the allocation of further research funds.

It is worth noting that we started our systematic review examining the main local event of the Brazilian Software Engineering community (i.e. SBES) together with the regional specialized Requirements Engineering event (i.e. WER). The research reported is primarily a statistical analysis of search results for Brazilian papers published in SBES and WER. These events served as the basis for the initial identification of the most productive RE groups. Then, we widened our search using specialized search engines (such as ACM Digital Library, IEEE digital Library, Scopus, Elsevieer) to identify their relevant publications in the RE field, which enabled us to identify the most popular research topics as well as the publications with the greatest impact.

This paper is structured as follows. Section 2 describes our research protocol, including the search strategy and studies selection. In Section 3, we describe the results of our mapping. Section 4 includes the analysis and discussion of the mapping results. Section 5 addresses the threats to the validity of this research' results. Lastly, the paper is concluded in Section 6.

2 Research Protocol

To achieve the purpose of this paper, we performed a systematic mapping of the literature, which provides an overview of the RE research area to assess the amount of existing evidence on a topic of interest and trends to guide future studies [6]. In the sequel we define the research scope; the research planning of the search process; the inclusion and exclusion criteria of the data gathering and its analysis.

The Systematic Mapping protocol has been designed and executed by three pair of researchers and three additional researchers that revised this protocol, conducted the inclusion and exclusion of papers, and discussed the results of the review.

2.1 Scope

The scope of this research is the analysis of the major Brazilian research groups and their published papers in Requirements Engineering area. In order to identify them we examined both regional and international events. First, we examined the proceedings

of the 25 editions of SBES (the most prestigious Brazilian venue for publication of works in Software Engineering) as well as 14 editions of WER (the regional specialized forum on Requirements Engineering). In doing so we will be able to identify the groups that have published most papers at SBES and WER. Later, we will use some search engines (ACM, IEEE, SCOPUS and Elsevier) to investigate publications written in English in other international forums that are indexed by them. Unfortunately, given the complexity of our query the Springer search engine could not be used.

2.2 Research questions

The definition of the research questions is the most important part of a systematic review [6]. Therefore, the research questions that we intend to answer in this Systematic Mapping are the following:

RQ1. *What are the main Brazilian RE research groups, authors and publications published at SBES and WER?*

RQ2. *What are the main research topics published by the Brazilian RE community?*

RQ3. *What are the publications of the Brazilian RE community with the greatest impact?*

2.3 Search process

We performed our systematic mapping in two cycles. In the first cycle we examined the SBES and WER events to find out the requirements engineering contributions of the Brazilian community. Since not all SBES Editions were available in a digital library we had to manually search the proceedings of all 25 editions. We also considered the 14 editions of WER. As a result we identified 07 major Brazilian research groups.

In the second cycle we widened our search using automatic engines to check the publication of these 07 groups in international forums. The following scientific search engines were used: ACM (Advanced Search); IEEE (Advanced Search); Scopus; Elsevier (Science Direct Search). In order to identify and select the studies, we created a search string that was defined in three parts: first, the keywords related to the different RE areas and their variants; second, the term Requirement Engineering, in order to associate the keywords to our area of interest; last, the affiliations related to the major Requirements Engineering research groups in Brazil (according to the results of the first cycle). The string was structured as follows:

(("Analysis" OR "Analyzing" OR "Model" OR "Modeling" OR "Modelling") OR ("Elicitation" OR "Elicit" OR "Eliciting") OR ("Language" OR "Notation") OR ("Management" OR "Evolving" OR "Traceability" OR "Maintaining") OR ("Methodology" OR "Method") OR ("Process") OR ("Specification" OR "Specifying" OR "Communication" OR "Communicating") OR ("Tool") OR ("Validation" OR "Validating" OR "Agreeing" OR "Verification" OR "Verifying")) AND ("Requirements Engineering") AND (Affiliation:"*major Brazilian groups in SBES and WER*")

The specific syntax of this specialized search string was adapted to each digital library previously mentioned. In order to provide more thorough results, we searched each affiliation using its abbreviation, its full name in Portuguese and its full name in English.

In the second cycle, we also manually searched the Springer Requirement Engineering journal (*REJ*) to find works with Brazilian affiliations. This is the most important international journal on Requirements Engineering. Thus it is imperative to consider it when analyzing the impact of researches in this field. The other important international conferences are indexed in the digital libraries used.

2.4 Inclusion and exclusion criteria

As it is usual in systematic mappings, we defined inclusion and exclusion criteria in both cycles in order to guide the selection of the papers that would be considered in our analysis. The inclusion criteria used for the selection of papers in this systematic review were the following:

- The selected papers should be related to Requirements Engineering and contain at least one Brazilian affiliate on its authors list;
- The papers must be available on-line or made available by the author.

On the other hand, the defined exclusion criteria were:

- Documents that are not full papers (e.g., PowerPoint presentations and Short papers);
- Informal research (e.g., Wikis, Blog posts, etc);
- Papers that do not mention Requirements Engineering;
- Duplicated papers.

Three pairs of researchers read the title and abstract and skimmed the paper in order to determine the inclusion or exclusion of the papers listed by the search engines. When there was some divergence, a third researcher would be assigned to make the inclusion/exclusion decision.

2.5 Quality assessment

The assessment of the quality of a research is a quite debatable matter because it is a subjective task, i.e. different reviewers may value different aspects. As systematic reviews and systematic mappings are key tools for enabling evidence-based practice, we have decided assess if each publication had followed basic principles suggested by the Empirical Software Engineering Community [17]. Based on [7] we proposed the following questions to assess the quality of the individual primary studies as well as the overall strength of the body of evidence used:

- Is the study objective clearly mentioned? (Yes = 1 / No = 0);

- Are the measures used in this study completely defined? (Yes = 1 / Measures are cited, but are not defined = 0,5 / No = 0);
- Are the methods to collect data well described? (Yes = 1 / Methods are cited, but its application is not described = 0,5 / No = 0);
- Are the study results reported in a clear and unambiguous way? (Yes = 1 / No = 0);
- Are the results reported based on evidence? (Yes = 1/ Yes, but not in the paper = 0.5 / No = 0);
- Are the threats to the study validity discussed? (Yes = 1 / Possible threats are cited, but its effects are not discussed = 0,5 / No = 0);

The sum of the answers to each question will provide an indicator (ranging from 0 to 6) of the quality of empirical study. Of course, some other well-known indicators could have been used to assess the quality of the primary study (eg. citation impact that was analyzed separately).

2.6 Data extraction

After the search and the selection processes, we performed a data extraction process by reading each one of the selected papers. In order to guide this data extraction, we adapted a data collection form from Biolchini *et al*. [8], containing the following fields:

- Paper Information: Source; Year; Source Type (Journal or Conference); Brazilian affiliations; Authors list; Title
- Citation (according to the source); Impact Google Scholar; Impact Scopus
- ACM Classification
- Requirements Structure (Models [Standard and Non-Standard]; Natural Language, Textual or Graphical Representation)
- Initial Model (Goal-Oriented Models; Business Models; Stories, Scenarios and Use Case Template; Use Case Diagram; UML; User Interface [Prototype]; Not Specific)
- Method (KAOS; RESCUE; GGBRAM; Any UML-based Method; RUP; CREWS-SAVRE; Not Specific)
- Empirical Study Type (Controlled experiments; Quasi-experiments; Case Study; Survey; Ethnography; Action Research; Illustration; Empty[1])
- Empirical Study Classification
- Context (Industry and Academia)
- Use any tool? (Yes; No)
- Subjective results extraction

[1] We just classified the papers as empirical studies but did not restrict it to this (eg. Surveys do not have empirical validation).

2.7 Data synthesis

In order to facilitate the analysis of the research questions the data collected were tabulated to show:

- The identifier assigned to the study, its authors, affiliations, source and year of publication;
- The amount of publications of each author (concerning RQ1);
- The classification of the study following the taxonomy proposed (concerning RQ2);
- The citations numbers and the quality score of each published work (concerning RQ3).

3 Results

This section presents the results of this systematic mapping in which each criterion is commented.

3.1 Search results

The first part of this research was the mapping of all Brazilian studies published since the first edition of SBES (1987) and WER (1998). After a careful analysis of all papers from these events, the number of works selected in this process was 63 papers at SBES and 154 at WER.

As a result we obtained the top five Brazilian institutions with more RE papers published at each event (see Table 1). Merging the results from both events, we found the major RE Brazilian groups in terms of number of publications are the following: Universidade Federal da Paraíba (UFPE), Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio), Universidade Metodista de Piracicaba (UNIMEP), Univesidade Estadual do Rio de Janeiro (UERJ), Universidade Federal de São Carlos (UFSCar), Universidade Federal do Rio Grande do Sul (UFRGS), Universidade Federal do Rio de Janeiro (UFRJ).

Table 1. The top Brazilian affiliations at SBES and WER by number of publications.

SBES		WER	
Affiliation	Publications	Affiliation	Publications
UFPE	22	UFPE	45
PUC-Rio	11	PUC-Rio	33
UFRGS	6	UNIMEP	11
UFSCar	5	UERJ	9
UFRJ	4	UFSCar	8
Total	48	Total	106

In the second part of our research, we used the digital libraries engines to broaden the search for RE publications of those 7 Brazilian institutions. We also conducted a manual search of Requirements Engineering journal (published by Springer) to identify papers of authored by researchers of those Brazilian institutions.

The number of papers found on each scientific search engine, plus the Requirements Engineering journal is summarized in Table 2.It also presents the number of papers marked as candidates and those ultimately selected according to the inclusion and exclusion criteria.

Table 2. Number of studies found, candidate and selected studies, by source.

Source	Studies found	Candidate studies	Selected studies
ACM	49	22	19
IEEE	125	13	13
SCOPUS	7	3	3
Science Direct	13	6	6
REJ	9	9	9
Total	203	53	50

3.2 Synthesis of the findings

The findings of this mapping were separated in two main groups: first we discuss the SBES and WER studies, related to RQ1; then, the proposals published in other venues, found in automatic and manual search, that answer RQ2 and RQ3.

3.2.1 What are the main Brazilian RE research groups, authors and publications published at SBES and WER? (Answer to RQ1)

The distribution of papers per year can be seen in Fig. 1. Considering the Brazilian RE studies representation, we identified that at SBES and WER these studies had an average participation rate of 12% and 60%. Note that in 1998 the WER (Workshop on Requirements Engineering) was established with the specific goal to become a forum for the Ibero-American Requirements Engineering community.

In Table 1, we presented the top five Brazilian RE research groups at each event. They represent approximately 77% of the total of Brazilian RE papers published at SBES and 70% at WER. This result suggests that a substantial amount of RE Brazilian papers comes from these institutions. Of these total, UFPE and PUC-Rio are the most important groups and together are responsible for around 70% of the Brazilian RE papers at SBES and 73% at WER.

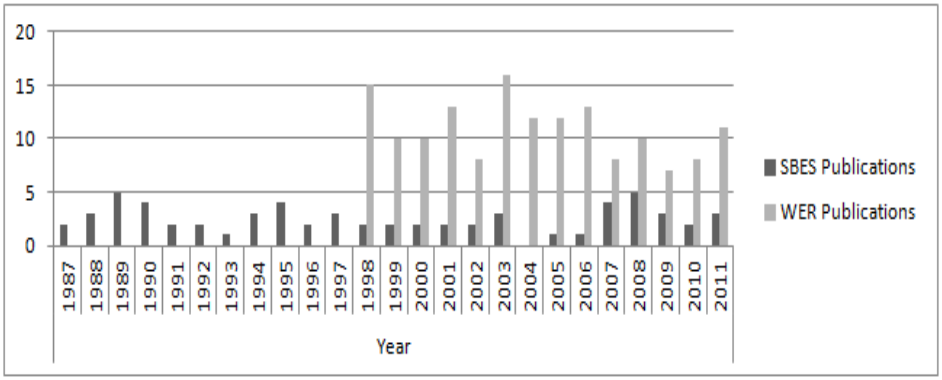

Fig. 1. Number of SBES and WER publications per years

In Table 3 we present the top five authors by number of RE publications at SBES and WER. These researchers are recognized as leaders in the RE community with a history of project management and supervision that explains their participation in several papers.

Table 3 Top RE Brazilian Authors by number of publications at SBES and WER

SBES			WER		
Author	Organization	Number of publications	Author	Organization	Number of publications
Jaelson Castro	UFPE	11	Jaelson Castro	UFPE	38
Julio Leite	PUC-Rio	9	Julio Leite	PUC-Rio	31
Silvio Meira	UFPE	7	Fernanda Alencar	UFPE	13
Fernanda Alencar	UFPE	4	Luiz Martins	UNIMEP	9
Paulo Cunha	UFPE	3	Carla Silva	UFPE/UFPB	8
Rosângela Penteado	UFSCar	3	Vera Werneck	UERJ	8

There are two RE publications at SBES that have more than 20 citations [9] [10]. The paper titled “CRE: A Systematic Method for COTS Components Selection” [9] has more than 90 citations and is the second most cited SBES paper considering all SBES editions. Regarding WER, there are four publications with more than 20 citations [11] [12] [13] [14]. The study “From Early Requirements Modeled by the i* Technique to Later Requirements Modeled in Precise UML” [11], with 35 citation, is the second most cited WER paper considering all WER editions.

3.2.2 What are the main research topics published by Brazilian RE community? (Answer to RQ2)

After the mapping of the RE area published at SBES and WER, we searched the digital libraries and the Requirements Engineering journal to obtain the internationals venues that have had Brazilian RE publications. These selected papers are listed in [18], which presents the identification and ACM Classification of each selected study. The studies were assessed in order to catalog the main research topics in an international scenario. The result is summarized in Table 4.

The results for the ACM Classification suggest that the majority of works (38%) is focused on Methodologies, followed by Specification with 14%. Together, they account for 52% of the total. The other topics correspond at most to 10% of the selected papers. We analyzed these topics by combining them as follows: (i) Methodologies and Specification (52 %); Elicitations methods, management and process (30%); and Analysis, tools, assessment, frameworks software architectures and validation (18%). In the following subsections we will discuss the results on these topics.

Table 4. Number of studies by ACM Classification

ACM Classification	Number of publications	Percentage
Methodologies	19	38%
Specification	7	14%
Elicitation methods	5	10%
Management	5	10%
Process	5	10%
Analysis	3	6%
Tools	2	4%
Assessment	1	2%
Frameworks	1	2%
Software Architectures	1	2%
Validation	1	2%

Methodologies and specification

The majority of the Brazilian RE groups have been working mainly in areas related to Methodologies (19 publications) and Specification (7 publications), corresponding to 26 of all selected studies. Analyzing Methodologies area, we observed some interesting points. According to the Requirements Structure criterion, 63% of the studies are associated to Models and 37% to Natural Languages. Considering the type of models, the most used Initial Models in these methodologies are Goal-Oriented Models with 42% of the total. As Empirical Study Types, Illustrations and Case Studies are the most used. The Validation Context of these studies is mainly Academics (89%). With

respect to the use of tools, we realized that 63% of the papers in Methodologies area were not supported by tools, i.e. only 37% indicated the availability of some tool.

Some important works rely on Goal-Oriented Models and more specifically i* (iStar) approaches. In one of them, the authors present a methodology for information systems development based on i* modeling language. The authors of another work argued that the Use Cases development can be improved by using i* organizational models. Another study describes a set of guidelines for the integration of early and late requirements specifications. They proposed the GOOD tool (Goals into Object Oriented Development) that consists of an extension of the Rational Rose tool which integrates with Organization Modeling Environment (OME), an i* supporting tool. There are also three more works related to i*. One important publication related to models proposes a systematic approach to assure that conceptual models will reflect the elicited NFRs. The authors use OORNF tool and work on a UML based approach.

There are 7 studies in Specification area. One study is a survey and as such fell outside the Requirements Structure criteria, the others are considered either as Models (43%) or Natural Languages (43%). Considering these 6 studies, the most used Initial Models are Stories, Scenarios and Use Case Template while 1 study is based on Business Models. Regarding Study Types, the majority of the works rely on Illustrations and Case studies (72%) with few (28%) using other types. On the other hand, the Validation Context of these studies is Academic. With respect to the use of tools, none of the Specification studies benefited from tool support.

In the Specification area, one important paper describes a method to improve requirements specification using scenario and the LEL. Another study presents a way for eliciting and describing business rules and states and how they are related to requirements. A third study describes an approach to support use case scenario variability management, enabling separation of concerns between languages used to manage variability and languages used to specify use case scenarios. All of them are related to Stories, Scenarios and Use Case Template unlike the Methodologies area that strongly uses Goal-Oriented Models

Elicitations methods, management and process

Observing the studies in Elicitation methods area, we identified that 60% of them rely on modeling techniques for requirements specification; the other studies (40%) use natural language or textual/graphical representation in their elicitation methods. With regard to modeling techniques we can highlight two studies that use traditional models in elicitation: one paper uses business models and the other applies scenarios in its requirements elicitation. Another study uses a non-traditional modeling technique applied to some kind of formalization in its elicitation method. Within the studies that use natural language or textual or graphical representation, we highlight the use of the viewpoint concept in one study and the use of studies of the future methods in order to anticipate requirements elicitation in other paper.

It is also important to note that 60% of the studies in Elicitation Methods area are validated through illustrative examples. Besides that, we found one paper with empirical evaluation based on a case study and other paper that performed a controlled experi-

ment. Another relevant aspect of the studies identified is that 100% of the studies were conducted in an academic context. With respect to the use of tools, we identified that 60% of the studies in requirements elicitation area propose some tool support.

Considering the management area, we identified 5 publications, which represent 10% of the total number of selected studies. Analyzing these studies we can highlight some interesting points. The use of modeling techniques constitute 40% of the studies in this area, 20% of the studies rely on natural language or textual/graphical representation and 40% of the studies do not use any kind of requirements structure. Both studies that use models apply Goal Oriented techniques. Moreover, the studies that do not use requirements structure have different characteristics, one study is a survey and the other is a position paper that indicates some challenges in mobile game requirements management.

The distribution of empirical studies types in the requirements management area is: 2 papers with case studies, 1 survey, 1 lab demo and 1 illustrative example. Another interesting result observed in this area is their distribution in academic or industrial context. The academic studies constitute 80% of the publications while only 20% of the studies are performed in industrial context. With respect to automation, we identified two studies that provide some kind of tool support to their studies; the first tool extends a traditional goal-oriented tool (OpenOME) and the second presents the Scenario Evolution Tool (SET) to support the framework proposed in the study.

Regarding the studies of the requirements process area, the use of modeling techniques appears in 60% of the studies while the use of natural language and textual/graphic representation appears in 40% of the studies. Note that all papers that present some kind of modeling technique in their requirements process proposal use goal-oriented models, in particular the i* framework. With respect to the studies that include natural language or textual/graphic representation, one study proposes a scenario construction process and the other one uses natural language.

Concerning the classification of the empirical studies, we noticed that case studies are used in 60% of the papers in the requirements process area. In the remaining 40%, one paper is an Action Research and the other paper uses an illustrative example. Among the studies of this area, we can highlight that 80% of them were conducted in an academic context. The only one that was performed in an industry setting presents an experience during a technology transfer project to improve the requirements engineering process in market-driven companies. Finally, there is no tool support for the studies of this area.

Analysis, tools, assessment, frameworks software architectures and validation

There are 9 studies in this group, corresponding to 18% of the total. Analyzing the requirements structure, 5 of them use textual requirements (with natural or controlled language), while 3 use models; the last one consists of a test-bed, so this aspect can-not be evaluated. Considering the initial type of model used 33% relied on goal-oriented models, 11% depended on scenarios and the rest of them did not use a specific model.

From the 9 studies in this group only one was conducted in the industry scope, the other 8 were under an academic scope. As for the empirical study type, case studies

are used by 3 studies, while 1 work used survey and another used action research. However, 2 studies preferred to use only an illustrative example and 2 other presented their proposals without corroborating their findings with any empirical evidence or illustrating them with an example.

As for the tool support, three studies of this group provide it: one study was classified as framework, other one was classified as validation and the last one was classified as tools. The other study under tools classification is actually a systematic review about tools, so it does not provide tool support for any approach; it analyzes the existing tools instead.

3.2.3 What are the publications of the Brazilian RE community with the greatest impact? (Answer to RQ3)

In the second part of our systematic mapping, we performed automated search on the main scientific search engines, considering the following Brazilian universities: UFPE, PUC-Rio, UNIMEP, UERJ, UFSCar, UFRGS, UFRJ. We also performed a manual search for papers that appeared at the Requirements Engineering journal published by Springer. This search resulted in a total of 203 papers. After applying the inclusion and exclusion criteria (see Table 2), we selected 50 papers for analysis. The results comprise 16 years of research publications, from 1996 to 2011. The distribution of these papers throughout the years is presented in Fig. 2. This distribution shows a slight increase of the number of publications in the last years.

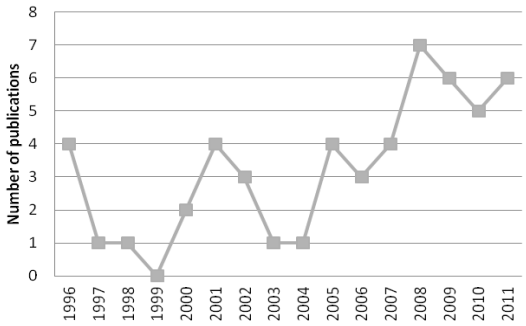

Fig. 2. Papers published by year

Table 5 shows the most cited papers found on our survey, based on the Google Scholar citation count. These papers represent the Requirements Engineering papers from the Brazilian community that had the greatest research impact, considering citation count. The citations of these ten papers amount to 74,77% of the total number of citations from the 50 selected papers.

Table 5. Most cited papers

Year	Title	# Citations
2002	Towards requirements-driven information systems engineering: the Tropos project	540
1997	Enhancing a requirements baseline with scenarios	186
2000	A Scenario Construction Process	134
2002	Requirements Engineering and Technology Transfer: Obstacles, Incentives and Improvement Agenda	90
2002	Deriving use cases from organizational modeling	84
2001	A Framework for Integrating Non-Functional Requirements into Conceptual Models	83
1998	Business Rules as Organizational Policies	47
2001	Using UML to reflect non-functional requirements	46
2008	Configuring features with stakeholder goals	36
2001	A framework for building non-functional software architectures	34

Regarding the publication venues of the 50 selected papers, we find the following distribution: 43,4% on international conferences; 35,85% on international journals; and 20,75% on international workshops or Brazilian symposiums. Regarding conference papers, 34,78% of them were published on the Requirements Engineering Conference. From the journal papers, 47,37% of them were published in the Requirements Engineering journal. These numbers suggest that the Brazilian papers have a small but already reasonable impact on the Requirements Engineering research.

Our quality assessment (Section 2.5), resulted in an average score of 2,55 out of 6,0. Given that in this paper we equated the quality to the use of sound Software Engineering Principles, we reach a conclusion that the Brazilian RE community, may be neglecting some Empirical Software Engineering principles. Nonetheless, we found no correlation between the quality score and the impact factor of these papers.

4 Discussion

As expected, there is a clear relationship between the organizations found in Table 1 and the authors found in Table 3. The leadership of these authors certainly reflects the consolidation of local groups of research and thus put their organizations in a prominent position. Some authors have presented pertinent contribution for both SBES and WER events showing their importance for the Brazilian RE community. For both conferences, the most cited publications were authored by the author with more publications selected in the respective conferences. This revels that the authors with highest number of publications also contributes with the more relevant ones.

The two major research topics identified in the selected studies were Methodologies and Specification. It reveals the preference of Brazilian researchers for these topics. In addition, the two more cited publications were grouped in these two topics. The first more cited publication and second one refer to Methodologies and Specification, respectively. This does not mean that remaining topics are not researched; in fact

all the topics cited in Table 4 have been represented at least by one publication. Hence, there is a wide thematic covered by the Brazilian RE research groups.

In general, there is no significant difference in the use of models or natural language to structure requirements. The publications point for both types of structure has the same level of relevance. On the other hand, when considering the use of CASE tools to support RE activities, no such balance is observed. About 68% of the studies are not supported by tools. When considering tools as the main topic of a paper, the difference is even higher with only a small percentage of the total papers (see Table 5). Since the use of tools has become essential to deal with complex cases, the development of CASE tools could be better addressed by this community.

Majority of the works are illustrative examples and are focused in the academic context. This tendency can be explained by several reasons. For instance, the innovative contribution for the state of art could be not mature enough to be applied in industrial environments. The descriptive nature of the studies also could be a reason to the small presence of controlled experiments. Nonetheless, it could be justified by the fact that the Brazilian RE community has recently started to adopt principles of Empirical Software Engineering.

Regarding the impact of Brazilian research on the Requirements Engineering field, it is important to note that this is not an extensive systematic mapping and, therefore, it does not represent the whole set of contributions generated by this community. We only considered the five top publishing Brazilian universities at SBES and WER, which resulted in a total of seven distinct universities: UFPE, PUC-Rio, UNIMEP, UERJ, UFSCar, UFRGS, UFRJ. Moreover, it is possible that some RE papers published by these universities have not been considered. This is the case because the 'search by affiliation' feature on the search engines is not completely accurate. In particular, we can observe that the list of results only starts at 1996, even though we are aware of works published on international venues at least as far as 1989. This kind of limitation is expected on systematic mappings that make use of automatic search mechanisms, as it is our case.

Nonetheless, we can draw some comments considering the sample we obtained, as follows. The chart on Fig. 2 shows a slight increasing trend on the number of RE papers that are published. This is a positive indicator, showing that the RE community in Brazil is growing stronger. Moreover, there is a reasonable amount of publications at the most important Requirements Engineering venues (the Requirements Engineering journal and the Requirements Engineering Conference). Thus, we may say that the research produced by the Brazilian community is not confined to Brazil, i.e., it has a worldwide reach.

From the total of 50 papers analyzed in cycle two, the top 10 cited papers amount for 74,77% of the total number of citations. This shows an uneven distribution of the impact of these papers. i.e., some papers have a very strong impact, while several papers have a weak impact. Moreover, all the top four most cited papers, which amount to 55,49% of the total number of citations, were published on journals. This indicates that papers published on this kind of venue are more likely to have a strong impact. Thus, publishing more papers on high quality journals may be a good way of increasing the impact of the Brazilian RE community.

The findings also indicate (see section 3.2.3) that Empirical Software Engineering principles are not fully used by the RE Brazilian community.

5 Threats to Validity

We have validated our review protocol to ensure that the research was as correct, complete, and objective as possible. We identified possible limitations of this study in two moments of the review process: in the publication selection and in data extraction.

The search for publications was performed in two cycle but in three major steps: (i) manual search of the studies in the proceedings of SBES and WER; (ii) automatic search considering the major Brazilian research groups in four digital libraries (ACM, IEEEXplore, Scopus and Science Direct); and (iii) manual search in the Requirement Engineering journal to find works with Brazilian affiliations. In the first step, we did not have problems to find the papers of all editions of SBES and WER. The main limitations regarding the publication selection occurs in steps (ii) and (iii).

In step (ii), the search string associates the different RE areas (and synonyms) to the term "Requirements Engineering", which may constitute a limitation because studies that only refer to specific techniques in RE are not considered in the mapping. In addition to that, the synonyms of RE areas may be insufficient to capture all studies in each area. With regard to the automatic search in the digital libraries, there is a limitation in the review because we could not use our search string in Springerlink library, which possibly leads to a reduction in the considered studies. However, we used SCOPUS that is a large database that includes springer papers.

In the step (iii), we identified a limitation concerning the journal papers included in the mapping. We only performed the manual search in the Requirements Engineering Journal (published by Springer). We took for granted that the other RE studies published in other journals would have been captured through the automatic search performed in the previous step. However, given the acknowledged limitations of the search engines we cannot guarantee that all RE Brazilian papers published in other Software Engineering journals are included in the systematic mapping. Besides that, we did not consider grey literature (e.g. industrial papers, PhD thesis and books) or unpublished results.

With regard to the data extraction, the data collection spreadsheet was based on two papers [15] [16]. However, we could have explored a broader set of data in order to investigate other aspects of the papers included in the review. Moreover, it is possible that some kind of inaccuracy or misclassification may have occurred in the data extraction performed in this systematic mapping.

6 Conclusion

We have conducted a systematic mapping to find out (i) the most productive RE Brazilian research groups at SBES and WER, (ii) the main research topics published by these groups, and (iii) the publications of the Brazilian community of Requirements Engineering with the greatest impact in the international community, according to their number of citation.

The information provided in this paper may be useful in different contexts. For example, a newcomer (eg. new research student) will be able to identify main groups, key researchers and the work already developed. Moreover, topics that have not deserved much attention by the local community may be identified and become the subject of new research projects. This kind of information will also be useful for setting up possible collaborative networks as well to identify priorities for the allocation of further research funds. The local industrial community may also benefit as they may be able to identify experts and groups that could help them if a specific RE need arises.

The systematic mapping was divided in two cycles: the first consisted of a manual search of the SBES and WER proceedings; the second cycle included an automatic search of four major digital libraries and a manual search on editions of the Requirements Engineering journal. The main goal of the first cycle was to answer the research question RQ1 and to answer RQ2 partially. The second cycle was used to answer RQ2 and RQ3. As a result, 177 papers were selected and assessed from an initial set of 367. Our findings allowed us to answer the three proposed research questions.

With the data extracted from the select studies, we were able to discover the Brazilian researchers that have extensively published at SBES and WER and relate them to the leadership of RE research groups in Brazil. With regard to the research topics, about 38% of the examined studies were about methodologies, either presenting new ones or improvements of existing ones. Moreover our findings reveal the better empirical validation maybe required.

This work is primarily a statistical analysis of search results identified in our SMS. It would be interesting in the future also to discuss the type of research conducted by the Brazilian research groups. We also plan to address some the weakness found as well as the topics that deserve further studies. Likewise we would like to examine the extend that the Brazilian institutions have contributed to the RE progress.

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