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Enhancing the Process Specification for Systematic Literature Reviews

Guido Tebes, Denis Peppino, Pablo Becker and Luis Olsina
GIDIS_Web, Facultad de Ingeniería, UNLPam, General Pico, LP, Argentina
{guido.tebes92, denispeppino92}@gmail.com;{beckerp, olsinal}@ing.unlpam.edu.ar

Abstract. SLR (*Systematic Literature Review*) is a research methodology intended to obtain evidence from scientific articles stored in digital repositories. It must be systematic, repeatable and auditable to formulate research questions about a thematic area or phenomenon of interest and to search, select, analyze and communicate all basic or applied research relevant findings in order to answer those questions. SLR can be carried out on primary or secondary studies. In both cases, well-established processes and methods are required. Although there are guides to the SLR process in Software Engineering, which indicate the steps to be followed in the three phases of the process proposed by Kitchenham, we considered that would be a contribution for the research community the strengthening of its current process specification. For this goal, we document the SLR process specification using mainly the SPEM (*Software & Systems Process Engineering Metamodel*) language and process modeling perspectives. As long as we develop the present work, we exemplify process aspects using a pilot SLR on software testing ontologies already performed.

Keywords: SLR; Process Modeling Perspectives; Functional, Informational and Behavioral Perspective; SPEM.

1 Introduction

Since Kitchenham issued in 2004 a technical report [12] about systematic literature reviews –based on previous research applied to the medicine domain-, the use of SLR in different scientific communities of Software Engineering (SE) has become more and more frequent for gathering evidence mainly from primary studies and, to a lesser extent, from secondary studies. The output document yieled when applying the SLR process on primary studies is called *secondary study*, while on secondary studies is called *tertiary study*.

To quote just a few examples, authors in [22, 23, 24] document secondary studies on diverse topics in SE, while the authors in [6, 11] report tertiary studies. Very often researchers have reused the procedures and guidelines proposed by Kitchenham in 2004 [12], which first were reviewed by Biolchini *et al.* [3] in 2005, and later updated by Kitchenham and her colleagues in 2007 [4, 10]. More recently, in 2013, by conducting a SLR, Kitchenham *et al.* [8] evaluated and synthesized studies published by SE researchers (including different types of studies, not only primary ones) that discuss about their experiences in conducting SLR and their proposals to improve the SLR process.

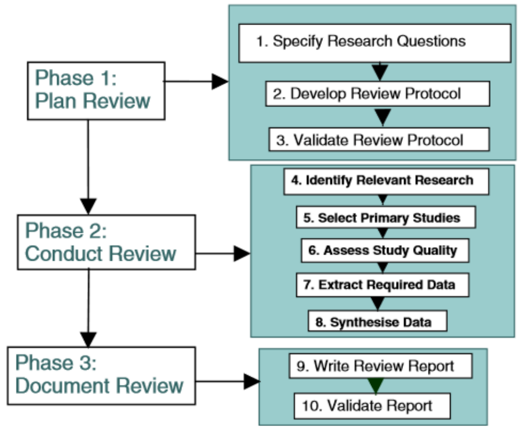

Fig. 1. SLR process proposed by Brereton and Kitchenham *et al.* [4].

Fig. 1 depicts the process specification made by Brereton and Kitchenham *et al.*, which was totally adopted or slightly adapted by the rest of the SE community up to the present time. Basically, the proposed SLR process [4] describes 'what' to do through its phases and steps (or in other words [2], through its processes, activities and tasks) rather than 'how' to realize each activity or task by means of methods. It is worth mentioning that a well-established strategy, either for evaluation [13], testing, or SLR, should integrate three capabilities, namely: a domain conceptual framework, process perspective specifications, and methods specifications. Focusing only on the process aspect (and not in method specifications), we have observed that the process perspective specified in Fig. 1 can be improved if we take into account the principles of process modeling proposed by Curtis *et al.* [5], and used for instance in [1].

Curtis *et al*. describe four perspectives (views) for modeling a process: *functional*, which describes what activities should be carried out and what flow of artifacts (e.g., documents) is necessary to perform the activities and tasks; *behavioral*, which specifies when activities should be executed, including therefore the identification of sequences, parallelisms, iterations, etc.; *informational*, which focuses on the structure of artifacts produced or consumed by activities, on their interrelations, etc.; and *organizational*, which aims at showing where and who are the agents (in compliance with roles) involved in carrying out the activities. In addition to these four views, a *methodological* perspective is defined in [14], which specifies particularly what constructors (i.e., methods) are assigned to the activity descriptions.

Some benefits of using process modeling to strengthen the process specifications in general, and to strengthen the SLR process in particular, are: to *facilitate the understanding and the communication*, which it implies that the process model (with the richness that graphic representations provide) should be understandable for the target community; to *give support to the process improvement*, since all the fundamental perspectives of the process model are identified, which benefits the reutilization and the evaluation of impacts in front of potential changes in the process; to *give support to process management*, that is, to the planning, scheduling, and monitoring and control ones; to *allow the process automation*, which can help to provide supporting tools and to improve the performance; to *favor the verification and validation of the process*, fostering thus the consistency, repeatability and auditability in projects.

Hence, the main contribution of this work is to strengthen the SLR process currently used by scientific communities, considering with higher rigor the principles and benefits of process modeling such those described above. To this aim, we will use the *functional*, *informational* and *behavioral* perspectives. We considered only three modeling perspectives due to space constraints. Additionally, we will illustrate aspects of the SLR process using a pilot study on software testing ontologies recently performed [18].

The rest of the article is organized as follows. Section 2 specifies the SLR process and discusses aspects of the modeling perspectives. Section 3 illustrates a practical case applied to software testing ontologies. In Section 4 related work is discussed. Finally, Section 5 summarizes conclusions and outlines future work.

2 The SLR Process Model Specification

Considering that there is no generalized consensus yet in the terminology used in the process domain, we introduce the meaning of some terms used in this work and then we focus on the SLR process specification. It is important to remark that the terms considered below (highlighted in italic) are taken from the process ontology in [2].

In this work, a *process* is composed by activities and an *activity* is formed by a set of *tasks*, being the latter an atomic element (i.e., it cannot be decomposed). Taking into account that an activity can be in turn decomposed into activities of lower level of granularity that cannot be considered tasks, the *sub-activity* concept has been included [2]. Besides, process, activity and task are considered *work definitions*, which indicate 'what' to do. Every work definition (process/activity/task) consumes and modifies and/or produces *work products*. A particular work product type is *artifact* (e.g., diagrams, documents, among others). Lastly, *methods* are *resources* that indicate 'how' to carry out the *description* of a work definition.

Regarding the core aim of this section, Fig. 2 illustrates the proposed SLR process from the behavioral perspective using SPEM [16]. There are several process modeling languages viz BPMN [15], SPEM and UML Activity Diagram [17], which are the most popular in the academy and industry. Their notations are very similar considering different desirable features such as expressiveness (i.e., amount of supported workflow patterns), understandability, among others [20, 21, 25]. But SPEM is more robust since allows to use both BPMN Business Process Diagram and UML Activity Diagram, among other diagrams such as UML Class Diagram to specify all process perspectives.

As seen in Fig. 2, our process, like the original process [4], has three main activities: (A1) Design Review, (A2) Implement Review and (A3) Analyze and Document Review. In turn, these activities group sub-activities and tasks.

For instance, note that for the Design Search Protocol sub-activity, the included tasks are shown, while not for the rest of the A1 sub-activities. It is done so intentionally to communicate that sub-activities have tasks, but at the same time for not giving all the details in order to preserve the diagram legibility. In the following sub-sections, the three main activities are described. In addition, to enrich the process specification, the functional and informational perspectives are used in some cases as well.

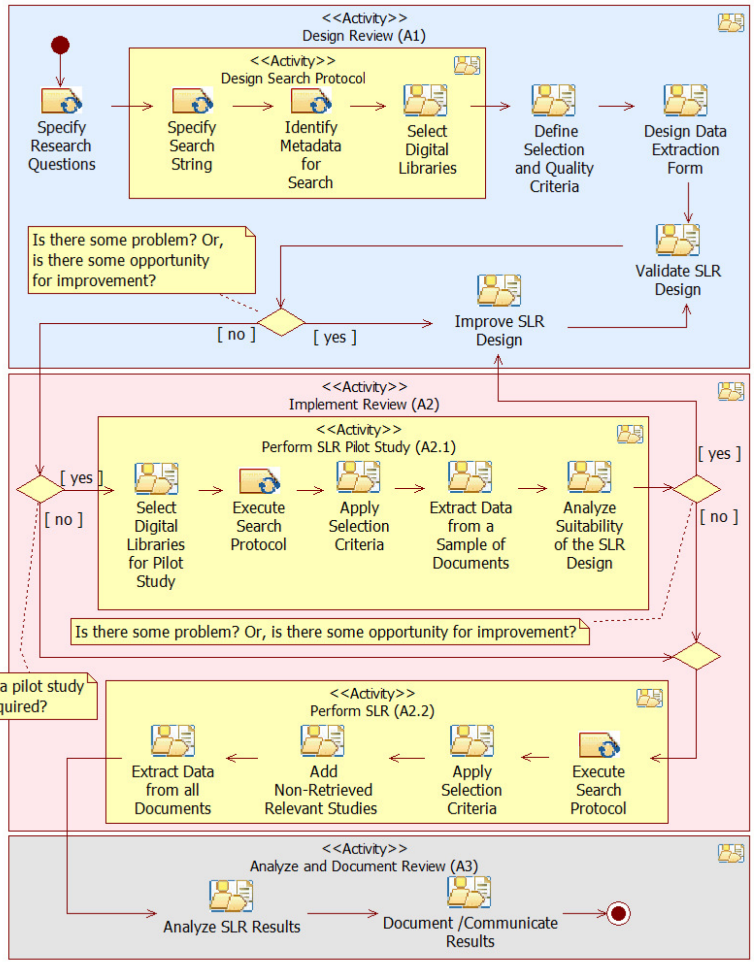

Fig. 2. Behavioral perspective of the proposed SLR process

2.1 Design Review (A1)

The A1's main objective is to design the SLR protocol. To achieve this, the tasks and activities of Fig. 3 should be performed following the represented flow and the input and output artifacts. As shown in it, the first task is Specify Research Questions, which consumes the "SLR Information Need Goal Specification" artifact. It contains the statement established by researchers, which guides the review design. Then, from the "Research Questions", the Design Search Protocol activity is carried out, which includes the Specify Search String and Identify Metadata for Search tasks, and the Select Digital Libraries sub-activity (see Fig. 2). As a result, the "Search Protocol" is obtained, which includes a search string consisting of terms and logical operators, the metadata on which the search will be applied (e.g., title and abstract) and, the selected digital libraries.

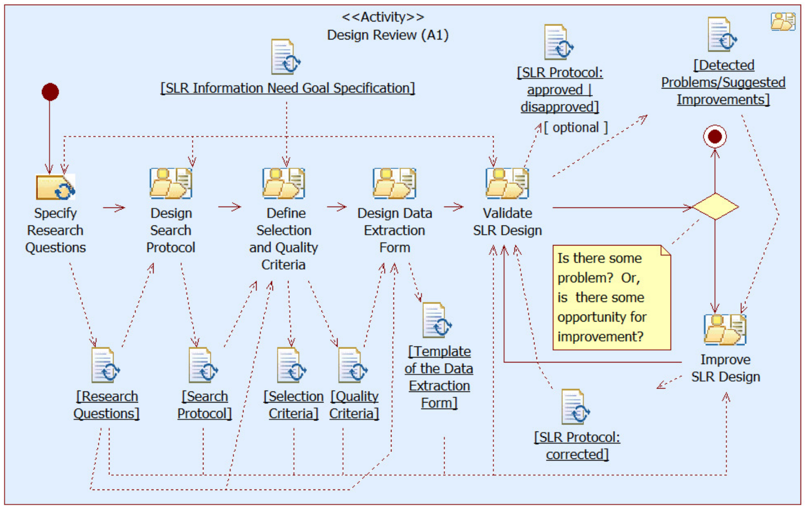

Fig. 3. Functional and behavioral perspectives for the Design Review (A1) activity

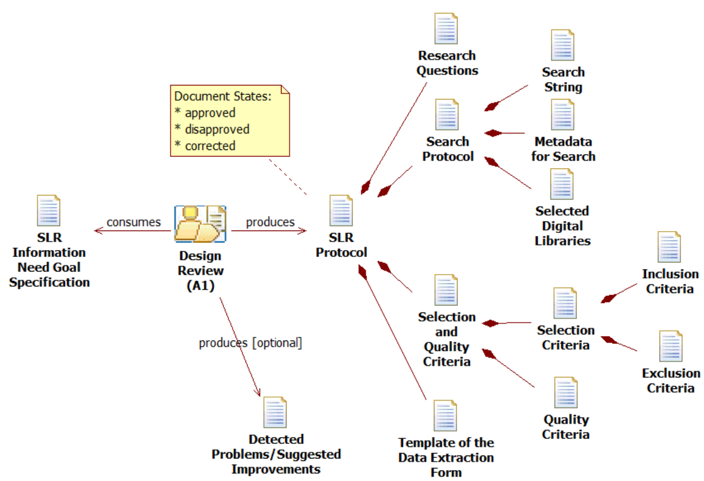

Fig. 4. Informational perspective for the Design Review (A1) activity

From the "Search Protocol", it is possible to execute the Define Selection and Quality Criteria activity. This produces the "Selection Criteria" and "Quality Criteria" artifacts. The former, documents the set of inclusion and exclusion criteria, i.e., the guidelines that determine whether an article will be considered in the review or not. The latter, documents features that allow us to evaluate to some extent in A2 the quality of retrieved studies as well as to identify relevant or desirable aspects for the researchers.

As shown in Fig. 3, the next activity is Design Data Extraction Form. As output, the "Template of the Data Extraction Form" is yielded, whose fields are defined from the "Research Questions" and "Quality Criteria". This will be used in A2 to collect information about each selected article. Then, all the artifacts produced until that moment should be validated. To validate the SLR Design implies reviewing such documents in order to detect problems or opportunities for improvement. Usually, researchers with expertise in conducting SLRs perform this activity. As outcome, the "SLR Protocol" document is obtained, which contains all the artifacts previously produced, such as observed through the informational perspective in Fig. 4.

It is worth mentioning that the "SLR Protocol" document may be in an *approved* or *disapproved* state. In the latter case, a list of "Detected Problems/Suggested Improvements" must also be produced. This artifact will serve as input to the Improve SLR Design activity, which deals with a set of tasks to introduce changes, that is, to correct the "SLR Protocol". Once the protocol has been corrected, Validate SLR Design activity is performed again with the intention of checking that the new protocol complies with the "SLR Information Need Goal Specification". Ultimately, A1 activity ends when the "SLR Protocol" is approved.

2.2 Implement Review (A2)

The A2 main objective is to perform the SLR. Fig. 5 shows the different sub-activities and tasks of A2 together with its input and output artifacts. Note that for first-time cases where a study is not a repeated or replicated one, performing first a pilot test is recommended, which is aimed at fitting the "SLR Protocol" produced in the A1 activity.

When it is considered necessary to perform a SLR pilot study (A2.1), the first sub-activity to be realized is Select Digital Libraries for Pilot Study. This consists of choosing a library subset (usually one or two) from the "Selected Digital Libraries" artifact in A1. Then, the Execute Search Protocol task on selected libraries considering the "Search String" and the "Metadata for Search" is enacted. As outcome, a list of "Pilot Study Retrieved Documents" is produced. From this list, in Apply Selection Criteria activity, the articles are downloaded and filtered considering the "Inclusion Criteria" and "Exclusion Criteria". This results in the "Pilot Study Selected Documents". From this subset of documents, the Extract Data from a Sample of Documents is done. As tasks of this activity are the selection of sample documents, which can be done randomly [12], and the extraction of data using the "Template of the Data Extraction Form" (tasks not shown in Fig. 5). Note that data is extracted from only one sample since the aim of the pilot test is just to analyze how suitable the protocol that is being followed is. If more than one researcher will use the forms in the final review, then it is recommended that more than one researcher participate in the pilot study data extraction. To test the forms by different researchers can be useful to find inconsistencies.

Finally, considering all the parts that integrate the "SLR Protocol" artifact (Fig. 4) and the "Forms with Pilot Extracted Data", the Analyze Suitability of the SLR Design activity is performed. This analysis permits to adjust the data extraction form as well as other protocol aspects such as the research questions, search string and/or selection criteria. When no problem is detected in the protocol, the Perform SLR activity (A2.2) is carried out. However, if a problem is detected or there is an opportunity for improvement, the Improve SLR Design and Validate SLR Design activities should be carried out again, as shown in Fig. 5. Once all the changes have been made and the SLR Protocol has been approved, the A2.2 activity should be executed. Notice in Fig. 5 that, a new cycle of the pilot study could be performed, if were necessary.

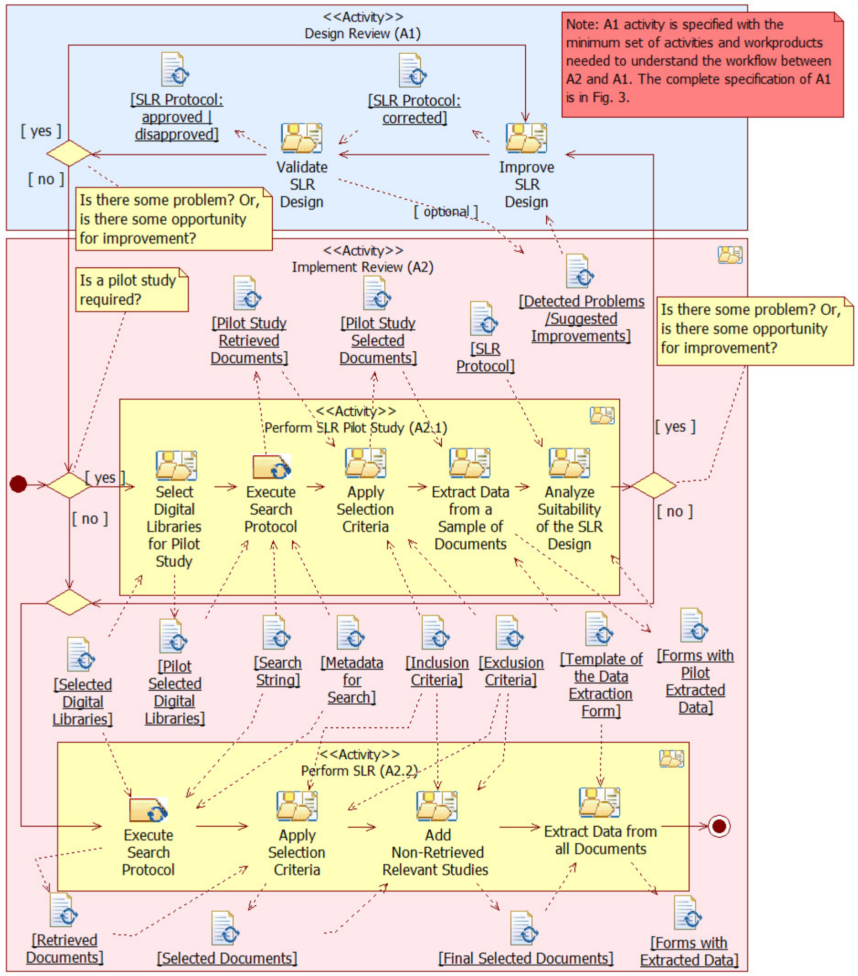

Fig. 5. Functional and behavioral perspectives for the Implement Review (A2) activity

Then, Perform SLR (A2.2) implies Execute Search Protocol taking now into account all the "Selected Digital Libraries". Researchers Apply Selection Criteria on the "Retrieved Documents" in order to filter out those that do not meet the criteria defined in A1. As artifact, "Selected Documents" is yielded serving as input to the Add Non-Retrieved Relevant Studies activity (in which, for example, the *snowballing* method can be used). At the end, the Extract Data from all Documents activity is done using the "Template of the Data Extraction Form". In cases where the same article is read by several researchers, the extracted data should be compared and disagreements be solved by consensus among them or by an additional researcher. If each document is just reviewed by one researcher due to time or resource constraints, it is important to ensure that some method will be used for verifying consistency. Once A2 is accomplished, the "Forms with Extracted Data" artifact is available for the A3 activity.

2.3 Analyze and Document Review (A3)

The main objective of this activity is to analyze and communicate the SLR results. Furthermore, considering that a SLR should be systematic, reproducible and auditable, the documentation of the followed process, applied methods and produced artifacts is a key issue.

Fig. 2 shows that Analyze SLR Results is the first activity to be performed in A3. Analysis is carried out looking at the "Forms with Extracted Data" artifact. In analysis, diverse categorization, aggregation and visualization methods of data may be used in order to give answer to the established research questions, for instance, to allow the findings of similarities and differences between the different studies, among others. As a result, a "Data Synthesis" artifact is produced. The synthesis is usually descriptive. However, sometimes, it is possible to supplement a descriptive synthesis with quantitative summaries through meta-analysis, using statistical techniques appropriately.

Finally, the Document/Communicate Results activity is carried out. To this end, dissemination mechanisms are first established, for example, technical reports, journal and conference papers, among others. Then, the document that will communicate the results to the interested community are produced. In this way, the SLR process concludes.

2.4 Highlighting Aspects of the Proposed SLR Process

The process proposed by Kitchenham *et al.*, which was so far adopted or slightly adapted by other researchers (for example in [22, 23, 24]) is (weakly) represented using only the behavioral perspective from the process modeling standpoint. If we compare Fig. 1 with Fig. 2 –where both are a representation of the behavioral perspective-, we can observe, on one hand, a greater richness of expressiveness in sequences and decision flows in Fig. 2, and, on the other hand, the possibility of representing different levels of granularity in work definitions such as activity, sub-activity and task. (Note that, for the reason of maintaining the simplicity of the diagram in Fig. 2, and being aware of the space limits in the present article, we have not specified other aspects such as iterations and parallelisms –e.g., the parallelism that can be modeled between the Define Quality Criteria and Define Inclusion/Exclusion Criteria tasks, within the Define Selection and Quality Criteria sub-activity in Fig. 2).

Although the behavioral perspective is undoubtedly necessary, it is usually not sufficient since it does not represent inputs and outputs for the different activities and tasks. For this reason, the functional perspective in conjunction with the behavioral perspective enhance the model expressiveness as shown in Fig. 3 and 5. Furthermore, the informational perspective also enriches the SLR process specification and favors the understanding of the process by showing the structure of a given artifact. This is illustrated for the "SLR Protocol" artifact in Fig. 4, which is produced by the A1 activity.

On the other hand, a key aspect to be highlighted in the present proposal is the modeling of the A2.1 sub-activity (Perform SLR Pilot Study), which gives feedback to the A1 activity (Design Review). This pilot activity, in the adapted processes of [4] is very often neglected. Or, if it is mentioned or considered such as in [4, 22], it is poorly specified. For example, in [22], authors include the Selection and Pilot Extraction activity (which is represented simply as a step in the A2 activity -named phase in [22]), but it does not give feedback to the A1 activity (phase). So modeling the feedback loop is important due to it could help to improve aspects of the SLR design, as we propose in Fig. 5, and illustrate its usefulness in Section 3. Additionally, notice that in our proposal we include both the Validate SLR Design sub-activity (which is represented in A1) and the Perform SLR Pilot Study sub-activity (which clearly must be represented in A2 since it contains tasks inherent to the execution of the SLR).

In short, the main contribution of this work is to strengthen the SLR process currently and widely used by the SE scientific communities considering, on one hand, the principles and benefits of process modeling with greater rigor by using in this particular case three perspectives, namely: functional, informational and behavioral. And, on the other hand, the vision of decoupling the 'what' to do aspect, which is modeled by processes, activities, tasks, artifacts and behavioral aspects, from the 'how' to realize the description of work definitions, which is modeled by method specifications (aspect not covered in this article). It can be observed in the cited literature (and in general) a lack of separation of concerns between what to do (processes) and how to do it (methods).

3 Application of the Process to a SLR Study

In [13] a family of evaluation strategies is presented. Any strategy, regardless if it is devoted to evaluation, testing or development purposes, should integrate a well-established conceptual base, process and method specifications. To broaden the family, we are considering to develop testing strategies. Hence, our current aim is to have a testing domain terminology. In this sense, in [18] a SLR about software testing ontologies was designed, i.e., the A1 and A2.1 activities were carried out. Currently, we are concluding the whole study so we started to document it (A3). The result allows us to establish the grounds for developing a top-domain software testing ontology that will be integrated to the conceptual framework already developed for existing evaluation strategies.

To illustrate the proposed process with its perspectives, next we describe aspects of the pilot study ([18]) that allowed to evaluate and refine the SLR design. Fig. 4 shows that to perform A1, the "SLR Information Need Goal Specification" is required. To this, the information need establishes that papers documenting software testing ontologies from digital libraries must be systematically analyzed. As result of A1, the "SLR Protocol" was obtained. Table 1 shows the artifacts that integrate this document, which correspond to those specified in the informational perspective of Fig. 4. It is important to remark that this protocol is the result of having carried out the Improve SLR Design sub-activity after considering the list of "Detected Problems/Suggested Improvements" when validated by external researchers with experience in reviews.

Looking at the activity flow shown in the behavioral perspective of Fig. 2, we conducted a pilot study for analyzing the suitability of the SRL protocol. As part of the A2.1 execution, from the "Selected Digital Libraries" in A1 (see WP1.2.3 in Table 1), Scopus was selected for this pilot test because it contains digital resources from various sources such as Elsevier, IEEE Xplore and ACM Digital Library. As result of carrying out the Execute Search Protocol and Apply Selection Criteria activities, 19 documents were obtained, which were reviewed by three researchers to Extract Data from a Sample of Documents. Once A2.1 was completed, a list of "Detected Problems/Suggested Improvements" was produced and the Improve SLR Design activity was run again (as prescribed in Fig. 5 through the functional and behavioral perspectives).

Table 1. "SLR Protocol" artifact produced in A1 for the software testing ontologies study.

Research Questions (WP 1.1) –Note that WP stands for *Work Product*	
RQ1: What are the existing ontologies for the software testing domain? RQ2: What are the relevant concepts, their relationships, attributes and constraints or axioms needed to describe the software testing domain?	
Search Protocol (WP 1.2)	
Search String (WP 1.2.1)	"Software Testing" AND ("Ontology" OR "Conceptual Base")
Metadata for Search (WP 1.2.2)	Title; Abstract; Keywords
Selected Digital Libraries (WP 1.2.3)	Scopus, IEEE Xplore, ACM Digital Library, Springer Link and Science Direct
Selection and Quality Criteria (WP 1.3)	
Inclusion Criteria (WP 1.3.1)	1) That the work be published in the last 15 years; 2) That the work belongs to the Computer Science area; 3) That the work documents a software testing ontology; 4) That the document is based on research (i.e., it is not simply a "lesson learned" or an expert opinion).
Exclusion Criteria (WP 1.3.2)	1) That the work be a prologue, article summary or review, interview, news, discussion, reader letter, or poster; 2) That the work is not a primary study; 3) That the work is not written in English.
Quality Criteria (WP 1.3.3)	1) Is/Are the research objective/s clearly identified? 2) Is the description of the context in which the research was carried out explicit? 3) Was the proposed ontology developed following a rigorous and/or formal methodology? 4) Was the proposed ontology developed considering also its linking with Functional and Non-Functional Requirements concepts?
Template of the Data Extraction Form (WP 1.4)	
Researcher name; Article title; Author/s of the article; Journal/Congress; Publication year; Digital library; Name of the proposed ontology; Relevant concepts used to describe software testing domain; Methodology used to develop the ontology; Research context; Research objective/s; Does the proposed ontology consider its linking with Functional and Non-Functional Requirements concepts?; Additional notes.	

Table 2 shows the updates (highlighted in blue and underlined) that the "SLR Protocol" underwent after the pilot study. Following some changes are described.

The "relevant" term in the research question RQ2 in Table 1 influenced negatively the number of terms extracted by each researcher. Therefore, the research question was reformulated as observed in the WP1.1 in Table 2. In addition, the "Relevant concepts used [...]" field in the form was changed for "Specified concepts [...]". This change made the extraction more objective and easier to interpret than with the initial design.

Moreover, the full reading of articles during the pilot study allowed us to detect that ontologies of various types were presented, such as foundational ontology, top domain ontology, domain ontology as well as application or instances ontology. Since the final aim after executing the SLR was to adopt, adapt or build a new top-domain ontology, this information turned out relevant. Consequently, a new research question (RQ3 in the WP1.1 in Table 2) and the "Classification of the proposed ontology" field in the template of the data extraction form (see WP1.4 in Table 2) were added.

The search string was modified slightly (compare WP1.2.1 in tables 1 and 2) because not all search engines take into account variations or synonyms of the used words. The inclusion criterion 1 in the WP1.3.1 (Table 1) is not very specific; therefore, it was modified as observed in the WP1.3.1 of Table 2. The full reading of articles also permitted to detect that some of them were different versions (or fragments) of the same ontology. Therefore, exclusion criteria 5 and 7 were added (see WP1.3.2 in Table 2).

Table 2. The new "SLR Protocol" version after the Pilot Study (A2.1) activity was performed. (Note that changes are indicated in blue and underlined w.r.t. that shown in Table 1).

Research Questions (WP 1.1) –Note that WP stands for *Work Product*	
RQ1: What are the conceptualized ontologies for the software-testing domain? RQ2: What are the most frequently included concepts, their relationships, attributes and axioms needed to describe the software-testing domain? RQ3: How are existing software testing ontologies classified?	
Search Protocol (WP 1.2)	
Search String (WP 1.2.1)	("Software Testing" OR "Software Test") AND ("Ontology" OR "Ontologies")
Metadata for Search (WP 1.2.2)	Title; Abstract; Keywords
Selected Digital Libraries (WP 1.2.3)	Scopus, IEEE Xplore, ACM Digital Library, Springer Link and Science Direct
Selection and Quality Criteria (WP 1.3)	
Inclusion Criteria (WP 1.3.1)	1) That the work be published in the last 15 years (from the beginning of 2003 until November 12, 2018); 2) That the work belongs to the Computer Science area or to the Software/System/Information Engineering areas; 3) That the document has the ontological conceptualization of the testing domain (i.e., it is not simply a "lesson learned or expert opinion" or just an implementation).
Exclusion Criteria (WP 1.3.2)	1) That the work be a prologue, article summary or review, interview, news, discussion, reader letter, poster, table of contents or short paper (a short paper is considered to that having up to 4 pages size); 2) That the work is not a primary study; 3) That the work is not written in English; 4) That the work does not document a software testing ontology; 5) That the ontology presented in the document be an earlier version than the most recent and complete one published in another retrieved document; 6) That a same document be the result of more than one bibliographic source (i.e., it is duplicated); 7) That the conceptualized ontology in the current document be a fragment of a conceptualized ontology in another retrieved document.
Quality Criteria (WP 1.3.3)	1) Is/Are the research objective/s clearly identified? 2) Is the description of the context in which the research was carried out explicit? 3) Was the proposed ontology developed following a rigorous and/or formal methodology? 4) Was the proposed ontology developed considering also its linking with Functional and Non-Functional Requirements concepts? 5) What other terminologies of the software testing domain were taken into account to develop the proposed ontology?
Template of the Data Extraction Form (WP 1.4)	
Researcher name; Article title; Author/s of the article; Journal/Congress; Publication year; Digital library; Name of the proposed ontology; Specified concepts used to describe software testing domain; Methodology used to develop the ontology; Terminologies or Vocabularies taken into account to develop the proposed ontology; Classification of the proposed ontology; Research context; Research objective/s related to software testing ontologies; Does the proposed ontology consider its linking with Functional and Non-Functional Requirements concepts?; Additional notes.	

On the other hand, since searches in Scopus retrieve documents that belong to other digital libraries, exclusion criterion 6 of the WP1.3.2 was added to eliminate duplicates.

Finally, we also observed that some ontologies were built taking into account other terminologies, which may add a quality factor to the new proposal. For this reason, quality criterion 5 was added in the WP1.3.3 of Table 2, which implies a new field in the template of the data extraction form (see "Terminologies or Vocabularies taken into account [...]" in WP1.4). This new quality criterion may prove to be useful information in the construction process of any ontology.

4 Related Work and Discussion

One motivation for modeling the SLR process arose from certain difficulties that we faced (all the authors of this paper) when carrying out a SLR pilot study about software testing ontologies [18]. As discussed above, the general objective of this pilot study was to be able to refine and improve aspects of the protocol design such as the research questions, search protocol, selection and quality criteria, and/or data extraction forms. Analyzing several works about SLR, we observe that activities related to the SLR pilot test are not explicitly specified and some aspects in the existing SLR processes are weakly specified from the point of view of the process modeling perspectives (as we analyzed in Section 2). Furthermore, there is often a lack of a clear separation of concerns between what to do (process) and how to do it (methods).

Thus, the first graphic representation of the SLR process proposed by Brereton and Kitchenham *et al.* [4] was outlined in 2007 (taking into account previous works by the same authors [12] and others as [3]). It was adopted or slightly adapted by the rest of the SE community until to the present moment. Most of the works have in common the Plan Review (or Design Review, A1 activity in Fig. 2), Conduct Review (or Implement Review, A2 activity), and Document Review (Analyze and Document Review, A3 activity) phases. While at phase level the same three main activities are generally preserved (for example, in [22, 23, 24], to quote just a few works), at step level (or sub-activities and tasks) they differ to some extent from each other. For example, in [23] three steps are modeled for phase 1: 1) Necessity of SLR; 2) Research questions formation; and 3) Review protocol formation. Note that these steps differ from those shown in Fig. 1 [4]. Moreover, in [22] five steps are presented: 1) Goal and need of SLR; 2) Define research questions; 3) Define search string; 4) Define inclusion and exclusion criteria; and 5) Protocol Validation.

The same lack of consensus in naming and including steps is observed in the above-mentioned works for phase 2. For example, the "Pilot selection and extraction" step is included in [22], which could be similar to the "Potential primary studies Selection" step in [23]. Nevertheless, the selection and pilot extraction step does not iterate into – or feedback to- phase 1, which may help to improve SLR design aspects, as we depicted in Fig. 2.

In [6, 7], we observe another adaptations or variations of the process documented in [4]. In [7] the use of two methods called *backward and forward snowballing* is emphasized, while in [6] the *snowballing* activity is included in the review process.

On the other hand, it is important to remark that while SLRs are focused on gathering and synthesizing evidence of primary or secondary studies, systematic mapping (SM) studies are used to structure (categorize) a research area. In [19], authors conducted a SM study of systematic maps, to identify how the SM process is conducted and to identify improvement potentials in conducting the SM process. Although there are differences in the aim between SLRs and SMs with respect to the research questions, search process, search strategy requirements, quality evaluation and results [9], the process followed in [19] is the same to that used for SLRs. Therefore, we can envision that our proposed process can be used for both SLR and for SM studies. What can differ, it is the use of different methods and techniques for the activities.

In summary, as an underlying hypothesis, the existing gap in the lack of standardization of the SLR and SM processes currently used by the scientific communities can be minimized, if we would consider more rigorously the principles and benefits of process modeling enumerated in the Introduction.

5 Final Remarks

In this work, we have documented the SLR process specification by using process-modeling perspectives and mainly the SPEM language. Additionally, we have highlighted the benefits and strengths of the proposed SLR process model compared with others. Finally, we have illustrated aspects of it by exemplifying a SLR pilot test on software testing ontologies.

The proposed process model for the SLR provides a good baseline for understanding the details and discussing alternatives or customizations to this process. In fact, the rigor provided by process modeling, where several perspectives are combined (e.g., functional, informational and behavioral), but can also be independently detached, provides a greater richness of expressiveness in sequences and decision flows, while representing different levels of granularity in the work definitions, such as activity, sub-activity and task.

It is worth mentioning that the specified process contributes to one pillar of a well-established SLR strategy –knowing beforehand that a strategy should also integrate the method specification capability. Note that, for the same task, different method specifications could be applied. In consequence, the life cycle of a given SLR project should organize activities and tasks considering not only the prescribed SRL process but also the appropriate allocation of resources such as methods and tools, among others, for achieving the proposed goal. There are additional activities (to those specified in Fig. 2) in which project planning should take into account such as documenting artifacts in all activities and control their changes and versions. The continuous documentation and versioning of artifacts are key factors to guarantee consistency, repeatability and auditability of SLR projects.

Currently, we are concluding the SLR study on software testing ontologies, in which a R&D group of the ORT University, Uruguay, is participating. Specifically, we are writing a journal article as part of the Conclusion Report in the Analyze and Document Review (A3) activity. This paper will document the followed SLR process, the produced artifacts, as well as the results and findings coming from the analysis of the Forms with the Extracted Data for twelve selected primary studies.

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