



Secondary studies in the academic context: A systematic mapping and survey

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ABSTRACT

Context: Several researchers have reported their experiences in applying secondary studies (Systematic Literature Reviews — SLRs and Systematic Mappings — SMs) in Software Engineering (SE). However, there is still a lack of studies discussing the value of performing secondary studies in an academic context.

Goal: The main goal of this study is to provide an overview on the use of secondary studies in an academic context.

Method: Two empirical research methods were used. Initially, we conducted a SM to identify the available and relevant studies on the use of secondary studies as a research methodology for conducting SE research projects. Secondly, a survey was performed with 64 SE researchers to identify their perception related to the value of performing secondary studies to support their research projects.

Results: Our results show benefits of using secondary studies in the academic context, such as providing an overview of the literature as well as identifying relevant research literature on a research area enabling to find reasons to explain why a research project should be approved for a grant and/or supporting decisions made in a research project. Difficulties faced by SE graduate students with secondary studies are that they tend to be conducted by a team and it demands more effort than a traditional review.

Conclusions: Secondary studies are valuable to graduate students. They should consider conducting a secondary study for their research project due to the benefits and contributions provided to develop the overall project. However, the advice of an experienced supervisor is essential to avoid bias. In addition, the acquisition of skills can increase student's motivation to pursue their research projects and prepare them for both academic or industrial careers.

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1. Introduction

Evidence-Based Software Engineering (EBSE) refers to the adoption of appropriate research methods to build a body of knowledge about when, how, and in what context methods or tools are more appropriate to be used for practicing Software Engineering (SE). EBSE was first introduced in 2004 as a means to advance and improve the discipline of SE (Kitchenham et al., 2015). In this context, secondary studies, such as Systematic

Review (SR) (a.k.a Systematic Literature Review (SLR)) and Systematic Mapping (SM) have provided mechanisms to identify and aggregate research evidence (Kitchenham et al., 2015). While SLR has been used to provide a complete and fair evaluation of the state of evidence related to a specific topic of interest, SM (also known as a scoping review) is a more open form of SLR, providing an overview of a research area to assess the quantity of existing evidence on a topic of interest.

Since their introduction in the SE field, SLRs and SMs have been gaining importance (Dybå et al., 2005). Their use is increasing as a method for conducting secondary studies in SE (da Silva et al., 2010b; Zhang and Babar, 2011). In other fields, secondary studies have also gained wide acceptance. For example, in social sciences, medicine and related professions, including biochemistry, many graduate students adopt secondary studies as a basis

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in their dissertations or theses (Daigneault et al., 2014; Puljak and Sapunar, 2017).

In SE, normally, students at both undergraduate and graduate levels are required to conduct traditional literature reviews, which, as they are frequently seen in the literature, do not use a systematic approach; hence one cannot rule out that the choice of studies and the conclusions drawn could be biased, thus providing readers with a distorted view about the state of knowledge regarding the area at the focus of the review. On the contrary, a secondary study uses a systematic process to identify, assess and interpret all available research evidence to provide reliable answers to a particular research question.

Over the past decade, most research in EBSE has emphasized potential advantages and disadvantages of the use of secondary studies (Riaz et al., 2010; Lavallée et al., 2014; Kuhmann, 2017) and presented challenges and lessons learned (Kitchenham and Brereton, 2013; Imtiaz et al., 2013). Several studies have attested that a secondary study is a valuable research mechanism for providing knowledge of a given topic and supporting the identification of gaps for future research (Dybå et al., 2005; Kitchenham et al., 2011b; Zhang and Babar, 2011). However, what is not clear yet is how this knowledge supports conducting M.Sc./Ph.D. research projects. There were no actual data that would indicate how SE graduate (M.Sc. or Ph.D.) students have used a secondary study as research methodology for their dissertations/theses and how the student and his/her supervisor (or any other researcher) perceives it. This article also addresses this gap by offering an overview on the use of secondary studies for developing M.Sc./Ph.D. research.

This article reflects upon the use of secondary studies in developing academic projects. Therefore, the purpose of this study is to explore SE researchers' perceptions, in particular M.Sc./Ph.D. students and their supervisors, about the value of secondary studies and how these perceptions impact decisions on conducting their research.

We believe that understanding the benefits and challenges of using secondary studies in an academic context is useful for both students who are starting their research projects, and those that will not continue their academic career (future practitioners), since they can all base their decisions on the best available evidence provided by secondary studies. Specifically, the main goals of this research are to:

1. evaluate the value of secondary studies in an academic context;
2. reinforce the importance of a secondary study in conducting a research project;
3. discuss how findings of a secondary study are used for conducting a research project;
4. report experiences of M.Sc./Ph.D. students conducting a secondary study as part of their research project; and
5. inspire graduate students to use EBSE, in particular, SLR/SM in their research projects.

Based on these goals, some of the questions we intend to clarify as well as the rationale for considering them are presented in Table 1.

This work combines two empirical research methods. Firstly, we conducted a SM on the use of secondary studies as a research instrument in SE. Secondly, for the identification of M.Sc./Ph.D. students' perceptions, we applied questionnaire based surveys. The use of two methods enabled us to minimize the potential limitations of applying single research method to achieve our goals.

It was concluded that using secondary studies can help researchers: improve the rigor and breadth of literature reviews;

Table 1
Research questions and their rationales.

| Nº | Research question | Rationale |
|------------|--|---|
| RQ1 | When and where the studies on the academic application of secondary studies in SE have been published? | This research question provides an understanding on whether there are specific publication sources for these studies, and when they have been published. |
| RQ2 | What is the academic purpose in applying secondary studies in SE? | This question looks for the purposes declared in the studies for applying secondary studies in an academic context. This is important to point out why such studies have been accomplished. |
| RQ3 | What are the benefits reported by SLR/SM authors related to the use of secondary studies in an academic context? | Provides an overview of the main benefits reported by authors related to the main advantages in applying secondary studies in an academic context. |
| RQ4 | What are the problems reported by authors related to the use of secondary studies in an academic context? | Provides an overview of the main limitations reported by authors with respect to the main difficulties in research applying secondary studies in an academic context. |

Table 2
Keywords of the Search String — Searching for related works.

| Search string | Keywords |
|---------------|---|
| | ("evidence-based software engineering" OR "evidence based software engineering" OR "empirical software engineering" OR "software engineering literature" OR "systematic review" OR "systematic literature review" OR "mapping study" OR "mapping studies") AND student OR novice OR university OR under-graduate OR undergraduate OR master |

demonstrate gaps in the literature; and turn into a publishable research paper. Conducting a secondary study involves a number of practical challenges, including: extended period of time to perform the study; data extraction; definition of the research questions; lacking of domain and secondary studies' process knowledge and the development of the study protocol.

The remainder of the paper is organized as follows. Section 2 presents the research method applied to perform the SM; results are also presented. Section 3 presents the survey and its results, focusing on students' perceptions on the use of EBSE in their research project. Section 3.2 discuss our main results and limitations of this work. Finally, Section 4 presents our concluding remarks.

2. The use of secondary studies as a research instrument in SE: an SM

We conducted a systematic two-stage search, as shown in Fig. 1, in order to identify the current literature on the use of secondary studies as a research instrument in SE.

First of all, in Stage 1, we created our search string, presented in Table 2. It was applied in Scopus, one of the most commonly used databases in Computer Science (Maplesden et al., 2015; Zhang et al., 2011) with more than 60 million records. Scopus database includes papers of many international publishers, including Cambridge University Press, Institute of Electrical and Electronics Engineers (IEEE), Nature Publishing Group, Springer, Wiley-Blackwell and Elsevier, just to name a few. We executed the search string in three metadata fields: title, abstract and keywords.

The selection criteria are organized in one Inclusion Criterion (IC) and seven Exclusion Criteria (EC):

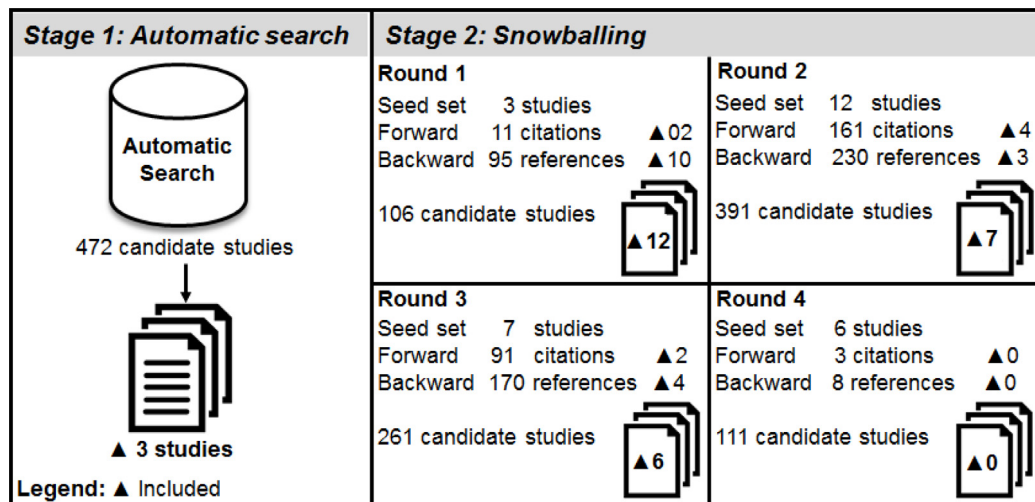


Fig. 1. Searching for studies on the use of secondary studies as a research instrument in SE.

(IC1) The study must be within the SE and discuss the use of secondary studies in an academic context.

(EC1) The study does not have an abstract;

(EC2) The study is just published as an abstract;

(EC3) The study is not written in English;

(EC4) The study is an older version of other study already considered;

(EC5) The study is not a primary study, such as editorials, summaries of keynotes, workshops, and tutorials;

(EC6) The study is not in the scope of SE, although it uses secondary studies in an academic context; and

(EC7) The study is in SE context, however, does not use secondary studies in an academic context.

As illustrated in Fig. 1 a total of 472 publications were returned. We considered the studies published until October 2018. The selection criteria (inclusion and exclusion criteria) were applied by the first author for title, abstract and keywords, leading to 154 studies. In the sequence, the selection criteria were applied jointly by two authors (first and second authors – 100% of agreement) considering the full text, resulting in a set of three studies from this stage.

During Stage 2, we used the three relevant studies selected for inclusion in Stage 1 as our seed set (starting set) for performing four iterations in snowballing where each iteration contained forward and backward snowballing. The citations (forward snowballing) were extracted with the help of search engines, such as *Google Scholar*, *ACM Digital Library* and *IEEE Xplore Digital Library*. The results from iterations 1–4 of the snowballing approach application are shown in Fig. 1 and detailed next.

Fig. 1 shows that during the first round the three studies that formed the seed set were cited by 11 studies – candidates for inclusion. Two of these 11 citations were included, when applying the same inclusion criteria used during Stage 1. The three articles totaled 95 references, out of these, ten were included. Round 2 started with 12 studies previously selected in round 1. They have been cited by a large number of studies (161). Out of these, four were included. 230 studies composed the references, however only three relevant ones were identified from these candidates. 91 studies have cited the seven studies previously included (round 2) and two were identified as relevant during round 3. Out of the 170 references, three were included. Thus, six (2: forward + 4: backward) studies were included. Finally, during round 4 no new studies were revealed. Therefore, the

Table 3

Summary of the extracting forms.

| Category | Rationale |
|--------------------------|--|
| Paper metadata | Used to manage and identify WHEN/WHERE the studies were published – RQ1 |
| EBSE application | Used to identify HOW EBSE has been used, for WHAT purpose and by WHOM – RQ2 |
| EBSE benefits | Used to identify the advantages in using EBSE in an academic context – RQ3 |
| EBSE problems | Used to identify the disadvantages in using EBSE in an academic context – RQ4 |
| Other information | Additional information could be recorded in this field |

four iterations of the forward/backward snowballing approach identified 25 relevant studies.

By combining the findings of the two stages (Stage 1: 3 + Stage 2: 25), we totaled 28 studies, presented in Table 4 and briefly described below.

In order to summarize the related literature presented above and answer our four RQs we extracted data in three stages. During Stage 1, we extracted the data and completed the associated forms, the content of which is summarized in Table 3. Then, in Stage 2, we grouped the data by topics. Finally, in Stage 3, we constructed summaries and visual representations of the data to help us analyze and classify the use of EBSE as a research instrument for students.

We considered different facets for classifying the studies. The facets were defined according to the RQs and taking the selected studies into account. So, depending on the focus of each scheme, the study was classified as either one or as any combination. In the following, the categories of these facets are presented.

The categories were established during data extraction, based on data provided by the analyzed studies. First of all, we read the full text of all included studies to identify concepts that reflected the contribution of each study. Secondly, we combined the set of concepts to obtain representative categories.

- **Purposes (RQ2):** in this facet, we wanted to learn the purposes for applying EBSE in SE. We have identified five main categories for such purposes:

→ **Assistance in Teaching and Learning:** this classification is related to the initiatives that use EBSE as an educational tool in SE;

→ **Benefits and Problems in conducting secondary studies:** this classification focuses on studies that explore

students' opinions about their experiences of conducting secondary studies, mainly the identification of benefits and problems encountered;

→ **Including EBSE into the curricula:** this classification covers studies discussing on how to include EBSE into the curriculum and its challenges;

→ **Assessing the use of secondary studies:** this classification represents studies investigating applicability, consistency and reliability of secondary studies processes and its application; and

→ **Application of secondary studies in actual projects:** this classification summarizes how the findings of a secondary study can guide research efforts in actual research projects.

- **Reported benefits (RQ3):** the categories for this facet are based on the main benefits related to the use of EBSE in an academic context reported in the included studies. We have identified 10 main categories of benefits, namely:

- Developing research skills;
- Encouraging students to reflect;
- Helping find out research opportunities;
- Providing a good overview of the literature;
- Perceiving the importance of searching for evidence;
- Acquiring experience of reading and understanding scientific studies;
- Learning from studies and assimilating knowledge;
- Publishing a paper;
- Providing baselines to assist new research efforts; and
- Collaborating with other researchers (teamwork).

- **Reported Problems (RQ4):** the categories for this facet are based on the main problems/difficulties highlighted by the authors of the included studies related to use of EBSE in an academic context in SE. We have identified 13 main categories of problems, namely:

- Lacking of domain knowledge;
- Lacking of SLR/SM process knowledge;
- Developing the protocol is longer than expected;
- Defining research questions;
- Finding synonyms and keywords;
- Searching the literature;
- Defining and applying the inclusion/exclusion criteria;
- Appraising the evidence for its validity;
- Extracting data;
- Classifying the literature;
- Extending the period of time to perform the study;
- Writing the report (SLR's results); and
- Limiting space while publishing.

2.1. Results

Here we present the results of our mapping as we used the facets of the classification schema aforementioned to answer the RQs.

2.1.1. Frequency of publication (RQ1)

In order to offer a general view of the efforts when using EBSE in an academic context in SE, a distribution of the 28 selected studies over the years is shown in Table 4. As it suggests, the research of EBSE in SE is recent, secondary studies were recognized as an EBSE method since Kitchenham et al. (2004) have published their pioneer work. The interest of its use as an educational tool

Table 4

Frequency of studies per year.

| Year | Total of studies — Studies ID |
|------|---|
| 2005 | 1 – S1 (Jørgensen et al., 2005) |
| 2006 | 1 – S2 (Rainer et al., 2006) |
| 2007 | 1 – S3 (Wohlin, 2007) |
| 2008 | 2 – S4 (Baldassarre et al., 2008); S5 (Rainer and Beecham, 2008) |
| 2009 | 4 – S6 (Brereton et al., 2009); S7 (Janzen and Ryoo, 2009); S8 (Oates and Capper, 2009); S9 (Babar and Zhang, 2009) |
| 2010 | 3 – S10 (Riaz et al., 2010); S11 (MacDonell et al., 2010); S12 (Kitchenham et al., 2010a) |
| 2011 | 3 – S13 (Kitchenham et al., 2011a); S14 (Brereton, 2011); S15 (Kitchenham et al., 2011b) |
| 2013 | 4 – S16 (Carver et al., 2013); S17 (Castelluccia and Visaggio, 2013); S18 (Catal, 2013); S19 (Wohlin et al., 2013) |
| 2014 | 2 – S20 (Dekhane and Price, 2014); S21 (Lavallée et al., 2014) |
| 2015 | 3 – S22 (Clear, 2015); S23 (Pejcinovic, 2015); S24 (Souza et al., 2015) |
| 2017 | 2 – S25 (Kaijanaho, 2017); S26 (Kuhrmann, 2017) |
| 2018 | 2 – S27 (Molléri et al., 2018); S28 (Ribeiro et al., 2018) |

Table 5

Publication vehicle.

| Publication Venue | Total of studies — Studies ID |
|-------------------|--|
| Conference | 15 (53.5%) – S2 (Rainer et al., 2006); S3 (Wohlin, 2007); S4 (Baldassarre et al., 2008); S5 (Rainer and Beecham, 2008); S6 (Brereton et al., 2009); S8 (Oates and Capper, 2009); S10 (Riaz et al., 2010); S12 (Kitchenham et al., 2010a); S13 (Kitchenham et al., 2011a); S22 (Clear, 2015); S23 (Pejcinovic, 2015); S24 (Souza et al., 2015); S25 (Kaijanaho, 2017); S26 (Kuhrmann, 2017); and S27 (Molléri et al., 2018) |
| Journal | 9 (32.1%) – S7 (Janzen and Ryoo, 2009); S11 (MacDonell et al., 2010); S14 (Brereton, 2011); S15 (Kitchenham et al., 2011b); S17 (Castelluccia and Visaggio, 2013); S18 (Catal, 2013); S19 (Wohlin et al., 2013); S21 (Lavallée et al., 2014); and S28 (Ribeiro et al., 2018) |
| Symposium | 4 (14.2%) – S1 (Jørgensen et al., 2005); S9 (Babar and Zhang, 2009); S16 (Carver et al., 2013); and S20 (Dekhane and Price, 2014) |

has been moderately increasing within 2009–2013, without a significant increase during other years.

Looking at the publication vehicle (see Table 5), conferences seem to be the main communication channel representing 53.5% (15 studies) of publications. Journals represent 32.1% (9 studies) and finally symposiums with 14.2% (4 studies).

2.1.2. Purposes of EBSE in an academic context (RQ2)

We can notice that studies involving undergraduate students (12 (42.8%) – S1 Jørgensen et al., 2005; S2 Rainer et al., 2006; S3 Wohlin, 2007; S5 Rainer and Beecham, 2008; S6 Brereton et al., 2009; S12 Kitchenham et al., 2010a; S13 Kitchenham et al., 2011a; S14 Brereton, 2011; S20 Dekhane and Price, 2014; S21 Lavallée et al., 2014; S22 Clear, 2015; S25 Kaijanaho, 2017) have the largest representativeness. The other two categories related to students were: • Master students (11 (39.2%) – S4 Baldassarre et al., 2008; S7 Janzen and Ryoo, 2009; S8 Oates and Capper, 2009; S16 Carver et al., 2013; S17 Castelluccia and Visaggio, 2013; S18 Catal, 2013; S23 Pejcinovic, 2015; S25 Kaijanaho, 2017; S26 Kuhrmann, 2017; S27 Molléri et al., 2018; S28 Ribeiro et al., 2018); and • Ph.D. students (8 (28.5%) – S9 Babar and Zhang, 2009; S10 Riaz et al., 2010; S12 Kitchenham et al., 2010a; S15 Kitchenham et al., 2011b; S16 Carver et al., 2013; S24 Souza et al., 2015; S27 Molléri et al., 2018; S28 Ribeiro et al., 2018). Only 4 studies (14.2%) assessed the use of EBSE by SLR experts (S10 Riaz et al., 2010; S11 MacDonell et al., 2010; S15 Kitchenham et al., 2011b; S19 Wohlin et al., 2013). Some categories that

were identified are strongly related, for instance, undergraduate and Masters (e.g. S16 Carver et al., 2013); Masters and Ph.Ds. (S25 Kaijanaho, 2017); or SLR experts and Ph.D. students (e.g., S15 Kitchenham et al., 2011b), thus, these studies were considered in more than one category.

In summary, while there have been several prior investigations on undergraduate (12 studies – 42.8%) and graduate levels – M.Sc./Ph.D. (19 studies – 67.7%), few focus on SE experts (4 studies – 14.2%). Table 6 shows different aspects of the adoption of secondary studies in SE. In the sequence, these aspects, which were grouped in 5 classifications, are discussed.

Assistance in Teaching and Learning: 11 studies (39.2%) used secondary studies as a means for teaching and learning undergraduate/graduate (M.Sc./Ph.D.) courses in SE; representing that secondary studies are effective educational tools.

- **S1** – Jørgensen et al. (2005), based on their previous experience and lessons learned in teaching EBSE to undergraduate students, wanted to inspire and support other universities to develop their own EBSE courses;
- **S4** – Baldassarre et al. (2008) described how SLRs were integrated as part of an EBSE course through a hands-on approach. According to the authors their approach was a useful means for making Masters students understand the importance of searching for evidence using SLR;
- **S7** – Janzen and Ryoo (2009) idealized and developed a community-driven Web database containing summaries of EBSE studies. This database was integrated into activities in a Master EBSE course;
- **S8** – Oates and Capper (2009) addressed the problem of teaching research skills to Masters students. They suggested to introduce SLRs and EBSE to improve, for example, students' literature-handling skills and well-defined research question formulation. They concluded that Masters students could be benefited by SLRs;
- **S16** – Kuhrmann (2012, 2017) described his experience in teaching EBSE using expert teams in a Master-level course enrolled with 70 students. In this course a seminar-like learning model where students form expert teams was used. These teams obtain extra expertise that they offer as service to other teams (cross-team collaboration);
- **S18** – Castelluccia and Visaggio (2013) shared their experiences about teaching EBSE to Masters students in Computer Science. The students conducted a collaborative SM on challenges in the adoption of open source software in a business context. The results were positive in terms of students' participation, teamwork attitude, professional interest in open source software, and exam passing;
- **S19** – Catal (2013) also described experiences on teaching EBSE to Master students. Each of the students delivered an SM on software architecture. The results showed that the teaching approach was quite useful for Masters students;
- **S22** – Lavallée et al. (2014) advocated using SLR as an educational tool for undergraduate students. They created a variation of the traditional SLR process called Interactive SR (iSR). In this adapted process the authors proposed to refine the protocol in iterations. Using iSR to teach SLR for undergraduate students could be beneficial because in each iteration, there is a progressive gain in expertise. Moreover, there is an amount of SLR's skills acquired in each iteration. Another advantage of an iterative approach is the refinement opportunity;
- **S23** – Clear (2015) adopted the SLR process to an undergraduate teaching setting aiming to produce an SLR on challenges and recommendations for the designing and conducting global software engineering courses. The author concluded that SLRs definitely have value as a method for research and teaching;

- **S24** – In Pejcinovic (2015), Pejcinovic mentioned that the practice in SLR could produce skills for undergraduate students, such as, improvement of critical thinking, better writing, increasing motivation, among others. He reinforced that the advantages of SLR in undergraduate education level are clear; and
- **S26** – Kaijanaho (2017) has attempted to teach the skill to read research literature critically to Masters students in a master's degree level course in programming languages over 15 years. He discussed his experience on the use of evidence-based practice and a flipped classroom for this purpose. Kaijanaho presented no firm conclusions, however he defends that university students, even at the bachelor's and master's degrees phases, should be given EBSE principles for their academic training.

Benefits and Problems in conducting secondary studies:

Looking at the studies that presented lessons learned, including benefits and problems in conducting secondary studies, 6 studies were identified (21.4%).

- **S5** – Rainer and Beecham (2008) evaluated the use of EBSE by undergraduate students. The students that were interviewed found EBSE very challenging, in particular the SLRs;
- **S9** – Babar and Zhang (2009) conducted a survey to explore opinions of research practitioners about their experiences in conducting SLRs. One of the analyzed perspectives was the value of SLRs for first-year Ph.D. students. Participants pointed out that some advantages of SLRs for Ph.D. students include: (i) systematic way of building a body of knowledge about a particular topic or research question (what has been done); (ii) clear statement and structure of state-of-the-art; (iii) learn from studies and getting knowledge; and (iv) find out gaps – research opportunities (ideas for further research);
- **S10** – Riaz et al. (2010) reported experiences of expert and non-expert researchers in conducting SLRs. The experiences and problems faced by expert researchers and non-experts (Ph.D. students) while conducting SLRs, and the approaches adopted to tackle the issues encountered vary. In summary, it is observed that Ph.D. students can be faced with big challenges, mainly due to their limited experience with SLR and, sometimes, with the research topic. The main problem faced by Ph.D. students is related to defining quality criteria;
- **S12** – The educational and scientific value of undergraduate and graduate (M.Sc./Ph.D.) students undertaking SM was assessed by Kitchenham et al. (2010a). Students had a valuable experience undertaking an SM. As positive aspects they mentioned that SM provides reusable research skills and a good overview of a research topic. However, undertaking the study in the required timescales, searching and classifying the literature, were the reported problems;
- **S14** – A case study was conducted by Brereton (2011) to explore the effectiveness of second-year undergraduate computing students in carrying out an SLR. The results suggest that the students found the conducting phase, including the selection activity, more problematic than the planning phase. Pearl concluded that undergraduates can perform SLRs (specially if undertaken by groups), but the task is clearly quite challenging and time-consuming; and
- **S15** – In order to assess the value of SMs (Kitchenham et al., 2011b) use a multi-case, participant-observer case study using five studies that were preceded by SM. The research question addressed by this case study was: "How do mapping studies contribute to further research?" As a result, Kitchenham et al. have identified some benefits that

Table 6

Summary of prior studies on the use/contribution of secondary studies in SE.

| ID | Purpose | Main topic | Ref. |
|-----|------------------------------------|---|----------------------------------|
| S1 | Undergraduate students | Experiences about teaching EBSE | Jørgensen et al. (2005) |
| S2 | Undergraduate students | Teaching Empirical Methods to Undergraduate Students | Rainer et al. (2006) |
| S3 | Undergraduate students | Introducing EBSE into a course/curricula | Wohlin (2007) |
| S4 | Masters students | Experiences about teaching EBSE | Baldassarre et al. (2008) |
| S5 | Undergraduate students | The use of EBSE by undergraduate students | Rainer and Beecham (2008) |
| S6 | Undergraduate students | The applicability of the SLR process | Brereton et al. (2009) |
| S7 | Masters students | EBSE web-database | Janzen and Ryoo (2009) |
| S8 | Masters students | Research skills | Oates and Capper (2009) |
| S9 | Ph.D. students | Value of SLRs for Ph.D. students | Babar and Zhang (2009) |
| S10 | SLR experts and Ph.D. students | Experiences conducting SLRs | Riaz et al. (2010) |
| S11 | SLR experts | Stability of SLR outcomes | MacDonell et al. (2010) |
| S12 | Undergraduate and Ph.D. students | Educational and scientific value of SM | Kitchenham et al. (2010a) |
| S13 | Undergraduate students | Repeatability of SLRs | Kitchenham et al. (2011a) |
| S14 | Undergraduate students | Effectiveness of SLRs | Brereton (2011) |
| S15 | SLR experts and Ph.D. students | Value of SMs | Kitchenham et al. (2011b) |
| S16 | Masters and Ph.D. students | Mentors for SLR conduction | Carver et al. (2013) |
| S17 | Masters students | Experiences about teaching EBSE | Castelluccia and Visaggio (2013) |
| S18 | Masters students | Experiences about teaching EBSE | Catal (2013) |
| S19 | SLR experts | Reliability of SM | Wohlin et al. (2013) |
| S20 | Undergraduate students | Experiences about teaching EBSE | Dekhane and Price (2014) |
| S21 | Undergraduate students | Variation of the traditional SLR process – Interactive SR | Lavallée et al. (2014) |
| S22 | Undergraduate students | Experience about teaching EBSE | Clear (2015) |
| S23 | Masters students | Experience about teaching EBSE | Pejcinovic (2015) |
| S24 | Ph.D. students | Use of SM findings | Souza et al. (2015) |
| S25 | Undergraduate and Masters students | Skill for reading research literature | Kaijanaho (2017) |
| S26 | Masters students | Experiences about teaching EBSE | Kuhrmann (2017) |
| S27 | Masters and Ph.D. students | Critically appraise scientific literature | Molléri et al. (2018) |
| S28 | Masters and Ph.D. students | Reliability of SLRs | Ribeiro et al. (2018) |

can accrue from basing research on a preceding SM, e.g., SM can save time and effort for researchers and also provides baselines to assist new research efforts.

Including EBSE into the curricula: Even with a smaller percentage of studies, 2 studies (7.1%) discussed how to include EBSE into the SE curricula.

- **S3** – Wohlin (2007) presented several aspects and challenges when introducing EBSE into the curricula. A positive aspect of this introduction into the curricula is the possibility to run empirical studies in student settings. A challenge is to balance educational and research objectives; and
- **S21** – Dekhane and Price (2014) described how to incorporate research, professional practice and methodologies into two undergraduate SE courses. The courses enabled introduction to undergraduate students on basic research skills.

Assessing the use of secondary studies: 8 studies (28.5%) have investigated EBSE more generally, emphasizing secondary studies' processes and the reliability of the results produced by their use.

- **S2** – Rainer et al. (2006) reported the use of EBSE by 15 final-year undergraduate students. The investigation produced inconsistent results. On one hand, their quantitative data suggested that students are making good use of some of the EBSE guidelines. On the other hand, their qualitative evidence suggested that the students are not using the guidelines properly;
- **S6** – Brereton et al. (2009) investigated the applicability of the SLR process by undergraduate students over a relatively short period of time. In common, they found that, with certain modifications to the process, it was possible to perform an SLR within a limited time period and to generate valid results;
- **S11** – MacDonell et al. (2010) investigated the consistency of SLR process and the stability of outcomes. The authors found out that two independent SLRs were very similar

when produced by domain experts with experience on the SLR process;

- **S13** – Kitchenham et al. (2011a) undertook a study to investigate the repeatability of SLRs (i.e., identification of the same studies when SLRs are performed independently by two novice researchers – undergraduate students). They concluded that in the case of novice researchers (undergraduate students) they will not necessarily select the same studies, in other words, they will not guarantee repeatability with respect to studies;
- **S17** – Carver et al. (2013) suggested how to help mentors guide Masters and Ph.D. students through the SLR process. Their findings highlight the importance of mentoring by an experienced researcher throughout the process;
- **S20** – Wohlin et al. (2013) also evaluated the reliability of SM. They investigated two SMs on software product line testing. They concluded that despite both studies are addressing the same topic, there are differences in terms of the number of included papers and their classification (categorization);
- **S27** – Molléri et al. (2018) investigated the application of checklists for supporting M.Sc./Ph.D. students to critically appraise scientific literature in a postgraduate EBSE course. 76 students (in pairs) participated in the experiment. They used two checklists to evaluate two papers (reporting a case study and an experiment) each. Students perceived checklist items as difficult to assess. The conclusion was that the clearer the reporting, the easier it was for students to judge the quality of studies; and
- **S28** – Ribeiro et al. (2018) mention that if similar SLR protocols are executed by similar teams of Masters and Ph.D. students, they should lead to equivalent answers for the same research question. The outcomes were different and six challenges contributing to the divergences, e.g., researchers' inexperience in the topic and researchers' inexperience in the method, among others. According to Ribeiro et al. it is not possible to rely on results of SLRs performed by Masters and Ph.D. students.

Application of secondary studies in real projects: Only 1 study (3.5%) discussed how the findings of a secondary study guided research efforts.

- **S25** – In summary, Souza and others (Souza et al., 2015) argue that SM had a great importance in conducting their Ph.D. projects. For example, from the findings of a mapping on Knowledge Management (KM) in Software Testing they noticed that the application of KM strategies in the field of software testing was a very promising research area. Moreover, the mapping also showed them that ontology-based KM solutions were even rarer in the software testing domain. This finding attracted their attention, since ontology is recognized as an important instrument for supporting KM in general. After the SM, they performed an SLR to investigate in details ontology-based KM in software testing. Finally, they undertook an on-line survey on the most important aspects of KM when applied to software testing. They used insights from the mapping to formulate some of the survey questions. Among the benefits of using SM, they can highlight that: (i) it establishes a solid baseline that serves as an important guide for research efforts, e.g. it shows gaps in a research topic; (ii) the identification of gaps is essential for definition of research questions to be investigated, and to define research strategies to follow; and (iii) it identifies several studies, which can be used as a baseline for comparison.

2.1.3. Reported benefits (RQ3) and problems using EBSE in an academic context (RQ4)

As we can see from this study (Table 7), there are 10 benefits of using EBSE in an academic context in SE. These benefits were named as B1–B10 in Table 7. Several studies (S5, S9, S10, S12, S14, S15) reported that secondary studies have been used to provide future SE researchers/practitioners with the knowledge and skills to enable them to make decisions based on evidence. Some of the scientific methods to become skillful are developed while conducting secondary studies, for example, identifying, selecting, interpreting, and evaluating evidence. These skills enable both future researchers and practitioners to make better decisions.

Despite the use of secondary studies bringing many benefits, some studies confirmed that adopting secondary studies in SE is challenging and a total of 13 problems (difficulties), named as P1–P13 in Table 8, were identified. We observed that while some of the challenges for those conducting secondary studies are common to both expert researchers and students, e.g., searching the literature (S5, S9, S11, S12, S13, S16, S18, S19, S23); and appraising the evidence for its validity and extracting data (S5, S16, S18, S27), there are others, e.g., developing the protocol (S6, S9, S10, S21, S23); finding synonyms and keywords (S10, S13, S16, S21, S18); and defining and applying inclusion/exclusion criteria (S6, S10, S12, S13, S14, S16, S19, S21, S27), that are only faced by students due to their limited experience with secondary studies in particular and with research in general.

The main contribution of this SM is to provide evidence on how secondary studies have been used in SE academic contexts. It is clear that secondary studies are not only being conducted by experienced researchers but also by students, including Masters and Ph.D. students.

A group of researchers have investigated the reliability of secondary studies as a research instrument (S2, S6, S11, S13, S17, S20, S27, S28). They concluded that the level of experience in secondary studies and research influences the repeatability of both process and outcomes. The results suggested that undergraduate/graduate (M.Sc./Ph.D.) students can perform secondary studies, especially if undertaken by groups, and under the supervision of an expert.

Table 7

Identified benefits using EBSE in an academic context.

| Benefit | Total of studies — Studies ID |
|---|--|
| (B1) Developing research skills | 5 – S1 (Jørgensen et al., 2005); S2 (Rainer et al., 2006); S8 (Oates and Capper, 2009); S20 (Dekhane and Price, 2014); S22 (Clear, 2015) |
| (B2) Encouraging students to reflect | 5 – S2 (Rainer et al., 2006); S8 (Oates and Capper, 2009); S14 (Brereton, 2011); S24 (Souza et al., 2015); S25 (Kaijanaho, 2017) |
| (B3) Helping find out research opportunities | 3 – S9 (Babar and Zhang, 2009); S15 (Kitchenham et al., 2011b); S24 (Souza et al., 2015) |
| (B4) Providing an overview of the literature | 5 – S12 (Kitchenham et al., 2010a); S15 (Kitchenham et al., 2011b); S20 (Dekhane and Price, 2014); S22 (Clear, 2015); S24 (Souza et al., 2015) |
| (B5) Perceiving the importance of searching for evidence | 6 – S4 (Baldassarre et al., 2008); S5 (Rainer and Beecham, 2008); S7 (Janzen and Ryoo, 2009); S8 (Oates and Capper, 2009); S9 (Babar and Zhang, 2009); S22 (Clear, 2015) |
| (B6) Acquiring experience of reading/understanding scientific studies | 5 – S1 (Jørgensen et al., 2005); S2 (Rainer et al., 2006); S8 (Oates and Capper, 2009); S15 (Kitchenham et al., 2011b); S25 (Kaijanaho, 2017) |
| (B7) Learning from studies and getting knowledge | 4 – S9 (Babar and Zhang, 2009); S15 (Kitchenham et al., 2011b); S20 (Dekhane and Price, 2014); S25 (Kaijanaho, 2017) |
| (B8) Publishing a paper | 1 – S9 (Babar and Zhang, 2009) |
| (B9) Providing baselines to assist new research efforts | 3 – S15 (Kitchenham et al., 2011b); S15 (Kitchenham et al., 2011b); S24 (Souza et al., 2015) |
| (B10) Collaborating with other researchers (teamwork) | 2 – S17 (Castelluccia and Visaggio, 2013); S26 (Kuhmann, 2017) |

It is clear from the above mentioned studies that, despite the difficulties, there are advantages in adopting secondary studies. However, it is not clear how a secondary study may contribute to M.Sc. or Ph.D. research project in the SE area. Our results revealed that there is only one research study (S25) (Souza et al., 2015) clarifying this topic. Moreover, we believe it would be very helpful to know the relationship between secondary studies and activities at M.Sc./Ph.D. level. Therefore, due to the lack of studies and the importance of this issue, we decided to conduct a survey to verify, in a more specific way, the use of secondary studies on behalf of graduate students (Master/PhD) and their perceptions on it.

3. Survey on the application of secondary studies in research projects

In the second part of this study, we conducted a survey on the application of secondary studies in research projects. We followed the six phases proposed by Kitchenham and Pfleeger (Kitchenham and Pfleeger, 2008) to conduct surveys:

– **Phase 1:** Setting the objectives – Our objective can be described by the following RQ: “What is the practical application of secondary studies in graduate (M.Sc./Ph.D.) research projects?”

– **Phase 2:** Designing the survey – As occurs with most of the surveys in SE (Kitchenham et al., 2008), our survey is also a cross-sectional study. Participants were asked about their past experiences on using secondary study results to support decisions on their research project.

– **Phase 3:** Designing the survey instrument (i.e., the questionnaire) – The survey comprises a questionnaire with 4 sections: (1) Profile (3 questions); (2) Practical view on the use of

Table 8
Identified problems using EBSE in an academic context.

| Problems (P) | Total of studies — Studies ID |
|---|--|
| (P1) Lacking of domain knowledge | 2 – S9 (Babar and Zhang, 2009); S28 (Ribeiro et al., 2018) |
| (P2) Lacking of SLR/SM process knowledge | 1 – S28 (Ribeiro et al., 2018) |
| (P3) Developing the protocol is longer than expected | 5 – S6 (Brereton et al., 2009); S9 (Babar and Zhang, 2009); S10 (Riaz et al., 2010); S21 (Lavallée et al., 2014); S23 (Pejcinovic, 2015) |
| (P4) Defining research questions | 4 – S9 (Babar and Zhang, 2009); S10 (Riaz et al., 2010); S16 (Carver et al., 2013); S21 (Lavallée et al., 2014) |
| (P5) Finding synonyms and keywords | 5 – S10 (Riaz et al., 2010); S13 (Kitchenham et al., 2011a); S16 (Carver et al., 2013); S21 (Lavallée et al., 2014); S28 (Ribeiro et al., 2018) |
| (P6) Searching the literature | 9 – S5 (Rainer and Beecham, 2008); S9 (Babar and Zhang, 2009); S11 (MacDonell et al., 2010); S12 (Kitchenham et al., 2010a); S13 (Kitchenham et al., 2011a); S16 (Carver et al., 2013); S18 (Catal, 2013); S19 (Wohlin et al., 2013); S23 (Pejcinovic, 2015) |
| (P7) Defining and applying the inclusion/exclusion criteria | 9 – S6 (Brereton et al., 2009); S10 (Riaz et al., 2010); S12 (Kitchenham et al., 2010a); S13 (Kitchenham et al., 2011a); S14 (Brereton, 2011); S16 (Carver et al., 2013); S19 (Wohlin et al., 2013); S21 (Lavallée et al., 2014); S27 (Molléri et al., 2018) |
| (P8) Appraising the evidence for its validity | 4 – S5 (Rainer and Beecham, 2008); S16 (Carver et al., 2013); S18 (Catal, 2013); S27 (Molléri et al., 2018) |
| (P9) Extracting data | 5 – S14 (Brereton, 2011); S15 (Kitchenham et al., 2011b); S16 (Carver et al., 2013); S21 (Lavallée et al., 2014); S23 (Pejcinovic, 2015) |
| (P10) Classifying the literature | 5 – S12 (Kitchenham et al., 2010a); S19 (Wohlin et al., 2013); S21 (Lavallée et al., 2014); S23 (Pejcinovic, 2015); S27 (Molléri et al., 2018) |
| (P11) Extended period of time to perform the study | 4 – S5 (Rainer and Beecham, 2008); S10 (Riaz et al., 2010); S12 (Kitchenham et al., 2010a); S23 (Pejcinovic, 2015) |
| (P12) Writing the report (SLR's results) | 2 – S23 (Pejcinovic, 2015); S27 (Molléri et al., 2018) |
| (P13) Limited space while publishing | 2 – S10 (Riaz et al., 2010); S14 (Brereton, 2011) |

secondary studies (3 questions); (3) Students/researchers' perception on the use of secondary studies (10 agree/disagree questions); and (4) Final comments (1 question). The questions of Section 2 refer to the same RQs answered in the SM (see Section 2), allowing a confrontation of the theoretical evidences with the practical perspective on the use of secondary studies in an academic context. For example, the answer options for the question: "What are the main benefits of conducting a secondary study during a research project?" are the benefits summarized in Table 7. An online version of the survey is available on: <https://zenodo.org/record/3948228>.

The possible choices to the agree/disagree questions vary from "Strongly agree" to "Strongly disagree", in a scale based on the Likert Scale method, which is a metric used in questionnaires such as attitude surveys. The final median score represents overall

Table 9
Keywords of the search string – searching for SE secondary studies' authors.

| Search string | ("tertiary study" OR "tertiary review" OR "tertiary systematic review" OR "systematic review of systematic review") AND "software engineering" |
|---------------|--|
|---------------|--|

level of accomplishment or attitude toward the subject matter. Moreover, the sequence includes a final comments section where respondents can provide any comments.

– **Phase 4:** Evaluating the survey instrument – We conducted a pre-test, i.e. we applied the survey to a smaller sample (3 SE researchers), intending to identify any problems with the questionnaire. The questionnaire was also evaluated by one experienced researcher in secondary studies. One of the modifications was to change the "Strongly agree" (option from the Likert Scale) to the right side of the screen and the "Strongly disagree" to the left side.

– **Phase 5:** Obtaining valid data – Definition of population: In order to identify our population (both experts and novice researchers – M.Sc. and Ph.D. students – performing secondary studies) we followed a two-stage systematic search process, as shown in Fig. 2.

During Stage 1, we reused the list of the 10 tertiary studies identified by Garousi and Mäntylä (2016). A tertiary study summarizes data from secondary studies, therefore identifying the secondary studies in SE area it was possible to identify researchers who are conducting those studies. Out of the 10 tertiary studies (see Table 10) we included 8, totaling 345 secondary studies.

With an objective to expand our set of studies (SE authors of secondary studies), i.e., increase both the number of authors and also the range of publication years, during the second stage, we created a search string (see Table 9), which was applied in Scopus in three metadata fields: title, abstract and keywords. The search string terms definition was based on the reading of titles and abstracts of tertiary studies included in Garousi and Mäntylä's study (Garousi and Mäntylä, 2016).

The selection criteria are organized in two Inclusion Criterion (IC) and seven Exclusion Criteria (EC). The following inclusion criteria were applied:

- (IC1) The study is a tertiary study and it must be within the SE context;
- (IC2) The list of secondary studies included in the tertiary study is available.
- (EC1) The study does not have an abstract;
- (EC2) The study is just published as an abstract;
- (EC3) The study is not written in English;
- (EC4) The study is an older version of other study already considered;
- (EC5) The study is not a tertiary study, such as editorials, summaries of keynotes, workshops, and tutorials; and
- (EC6) The study is not in the scope of SE, although it is a tertiary study; and
- (EC7) The list of secondary studies included is unavailable, although it is a tertiary study.

39 documents resulted from the automatic search and of this total, 12 tertiary studies were found (see Table 11). The range of secondary studies search was 2004–2017, a total of 10 tertiary studies were included, and 888 secondary studies were revealed. In summary, we added 18 tertiary studies (source 1: 8 + source 2: 10) and 1233 secondary studies (source 1: 345 + source 2: 888).

After identifying the secondary studies, we collected the main authors' names of this set of studies. Studies that did not provide

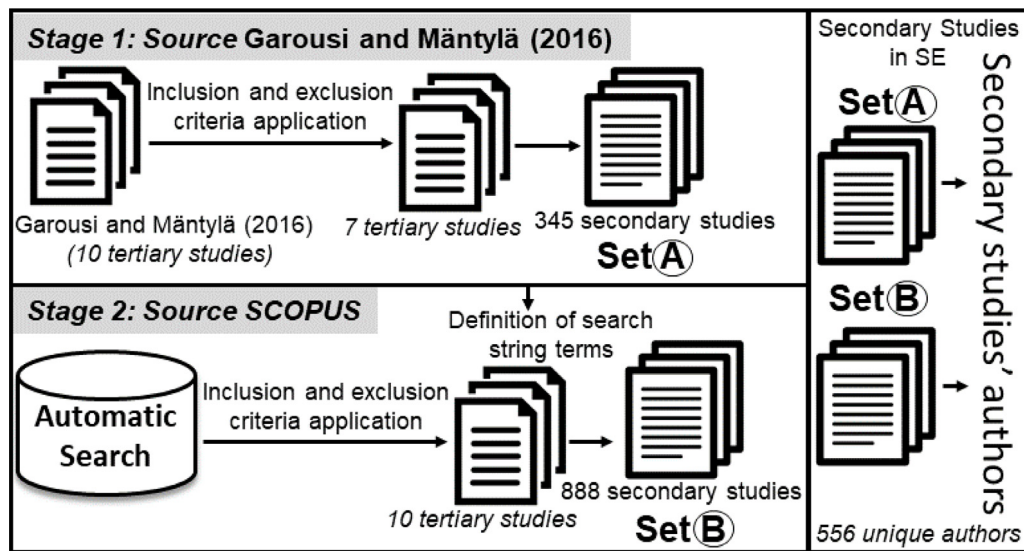


Fig. 2. Searching for SE secondary studies' authors.

Table 10
Secondary studies identified by Garousi and Mäntylä (2016).

| Study | Total | Year | Ref. | Status |
|---|-----------------------|------|---------------------------|-----------------------|
| SLRs in SE – An SLR | 20 secondary studies | 2009 | Kitchenham et al. (2009) | Included |
| SLRs in SE – A tertiary study | 33 secondary studies | 2010 | Kitchenham et al. (2010b) | Included |
| Critical appraisal of SLRs in SE from the perspective of the research questions | 53 secondary studies | 2010 | da Silva et al. (2010a) | Excluded ^a |
| Research synthesis in SE – A tertiary study | 49 secondary studies | 2011 | Cruzes and Dyba (2011) | Included |
| Six years of SLRs in SE – An updated tertiary study | 67 secondary studies | 2011 | da Silva et al. (2010b) | Included |
| Signs of Agile Trends in Global SE Research – A Tertiary Study | 12 secondary studies | 2011 | Hanssen et al. (2011) | Included |
| Systematic approach for identifying relevant studies in SE | 38 secondary studies | 2011 | Zhang et al. (2011) | Excluded ^b |
| SLRs in Distributed SE – A Tertiary Study | 14 secondary studies | 2012 | Marques et al. (2012) | Included |
| A tertiary study: experiences of conducting SLRs in SE | 116 secondary studies | 2013 | Imtiaz et al. (2013) | Included ^c |
| Risks and risk mitigation in global software development: A tertiary study | 34 secondary studies | 2014 | Verner et al. (2014) | Included |

Reasons for exclusions:

^aThe authors analyzed 53 literature reviews that had been collected in two published tertiary studies (Kitchenham et al., 2009, 2010a,b), both already included in our population.

^bThe authors conducted a search of SLRs published in SE, which extends the search reported in the tertiary study (Kitchenham et al., 2011b,a, 20 SLRs) with the updated records by the end of 2008. This up-to-date SLR search identified 38 SLRs. The list of the updated studies were not available. However, the (Kitchenham et al., 2011b,a)' study was extended by two other studies, already included in our population (Kitchenham et al., 2010a,b and da Silva et al. 2011).

^cThe list of studies were not available. However, due to the number of secondary studies included (116) and the general theme about SE, we decided to request the list to the authors, who kindly sent it to us.

the first author's email, we used the email of the corresponding author. A total of 555 authors were considered as not duplicated. These 555 authors formed our population and they were contacted by email.

– **Phase 6:** Analyzing the data – The answers were stored directly after they had been submitted by the respondents. A total of 11 respondents (17.19%) wrote free comments and all these comments were also analyzed.

3.1. Main results

The survey was carried out between November 17th and December 7th 2018. 555 emails were sent, but 164 returned with shipping errors. We believe that this happened because many of the authors changed place of work, research group, etc., and consequently changed their email account. We received in total 64 responses from 391 survey emails sent successfully (16.37%).

The majority of the respondents, with 25 (39.10%) are Faculty Members (Supervisors) followed by Graduate Students (Ph.D.)

Table 11

Secondary studies identified through an automatic search.

| Study | Total | Year | Ref. |
|--|-----------------------|------|---|
| SLRs in global software development: A tertiary study | 24 secondary studies | 2012 | Verner et al. (2012) |
| An SLR of SLR process research in SE | 68 secondary studies | 2013 | Kitchenham and Brereton (2013) |
| SLRs in requirements engineering: A tertiary Study | 53 secondary studies | 2014 | Bano et al. (2014) |
| Quality Assessment of SLRs in SE: A Tertiary Study | 127 secondary studies | 2015 | Zhou et al. (2015) |
| A map of threats to validity of SLRs in SE | 316 secondary studies | 2016 | Zhou et al. (2016) ^a |
| Practical similarities and differences between SLRs and SMs: a tertiary study | 170 secondary studies | 2017 | Napoleão et al. (2017) |
| Systematic Studies in Software Product Lines: A Tertiary Study | 60 secondary studies | 2017 | Marimuthu and Chandrasekaran (2017) |
| Reporting SLRs: Some lessons from a tertiary study | 37 secondary studies | 2017 | Budgen et al. (2018) |
| How do Secondary Studies in SE report Automated Searches? | 171 secondary studies | 2018 | Singh et al. (2018) |
| A tertiary study on technical debt | 13 secondary studies | 2018 | Rios et al. (2018) |
| Identifying, categorizing and mitigating threats to validity in SE secondary studies | 165 secondary studies | 2018 | Ampatzoglou et al. (2018) |
| A tertiary study on model-based testing areas, tools and challenges | 10 secondary studies | 2018 | Villalobos-Arias et al. (2018) ^b |

Reasons for exclusions:

^aThe list of secondary studies was not available.^bDownload of paper is not available.

with 21 (32.80%); Graduate Students (Masters) with 9 (14.10%) and Research Staff 6 (9.40%). We received 3 unique responses of respondents who classified themselves as Fresh Ph.D. Graduates (1.60%), Professors (1.60%) and General Managers (1.60%). None of the respondents are undergraduate students.

With the exception of only one respondent that mentioned “Startups”, all other respondents cited “Software Engineering” as their research area. 26 (40.62%) cited just “Software Engineering” as itself and the rest of 37 (57.81%) mentioned Software Engineering subareas such as “Empirical Software Engineering”, “Requirements Engineering”, “Software Architecture”, “Software Testing”, “Software Quality”, etc. In addition, more than half of the participants have more than 10 years of experience in the mentioned research area. Those with less time of experience mentioned 2–3 years. The average time of experience was 10.46 years.

With respect to conducting secondary studies, 10 (15.62%) participants have conducted 10 or more secondary studies, 7 (10.94%) have conducted between 5–9, 24 (37.50%) between 8–13 and the remainder of the 23 (35.94%) respondents mentioned having conducted only one or two secondary studies. The total number of secondary studies conducted by the respondents were 274. Out of the 274 secondary studies, 185 (67.52%) studies were published in conferences or journals. One respondent who

mentioned conducting three secondary studies did not report the number of published studies.

Participants were asked to indicate what was the academic purpose of the application of secondary studies in SE. The vast majority (see Fig. 3) (58–90.62%) agreed that the purpose was to analyze current SE research landscape or scope and identify new research areas. Other purposes appeared in the sequence: to guide research efforts in academic projects (33–51.56%), to replace the literature review section in dissertation/thesis (23–35.94%), to give assistance in teaching and learning – educational tool (16–25.00%). One respondent argued that he/she understands that “*nowadays the SLRs have been used for many different purposes, however he/she believes that the main purpose should be to analyze current SE research landscape or scope and identify new research areas as well as answering a research question (synthesizing knowledge)*”. Another respondent mentioned that in his/her university “*a secondary study is used to show that the work is unique due to an indirect requirement*”. Two others respondents emphasized “*the use of secondary studies is to identify the state-of-the-art or establish the borderline of a research area of interest*”.

Regarding the main benefits of conducting a secondary study during a research project (see Fig. 4), the biggest benefit highlighted is providing an overview of the literature (57–89.06%) followed by helping find out research opportunities (42–65.62%), learning from studies and getting (40–62.50%), developing research skills (38–59.37%) and providing baselines to assist new research efforts (38–59.37%). One interesting point is that 26 (40.62%) respondents agreed that publishing a paper as a main benefit of conducting a secondary study. The benefit of collaborating with other researchers (teamwork) appeared as the lowest rate with 11 (17.19%) responses.

The main problem of conducting a secondary study during a research project according to the respondents is the extended period of time to perform the study (38–59.37%) (see Fig. 5). Other problems include: data extraction (26–45.61%); defining research questions (28–43.75%); lacking of domain knowledge (27–42.19%); and developing the protocol is longer than expected (26–40.62%). Other less significant problems cited are related to the last phase of SLR: writing the report (SLR’s results) and the limitation of space while publishing the results, both with 13 responses (20.31%). Particularly in the comments, two respondents mentioned problems related to the search process in digital libraries due to the difficulty of performing automatic searches requiring different keywords combination and unavailability of some publications.

The third section of the questionnaire presents respondents’ perception about the use of secondary studies. The responses are based on Likert Scale method (1 to 5, where 1 means “Strongly disagree” and 5 “Strongly agree”). The responses of each question are illustrated in Fig. 6. In summary, most of the questions presented in this section of the questionnaire had positive responses (4 and 5 scales).

Reflecting on the questions: “The traditional/discursive literature reviews should be replaced with secondary studies”; “Secondary studies findings help in the choice of research methodologies to be used in a research project”; and “Secondary studies findings help in the choice of methods for data collection and interpretation” (the first three questions in Fig. 6), the biggest concentration of answers are in scale 3, which means a neutral opinion about them. The question with more positive answers is “Secondary studies (e.g. mapping study) identify relevant research literature on a research area” with 15 (23.44%) scale 4 (agree) answers and 38 (59.37%) answers scale 5 (strongly agree) out 64, totaling 53 (82.81%) answers.

Considering the free comments, 11 respondents wrote answers. Overall, all respondents in some way highlighted the importance of conducting secondary studies. One of them explained

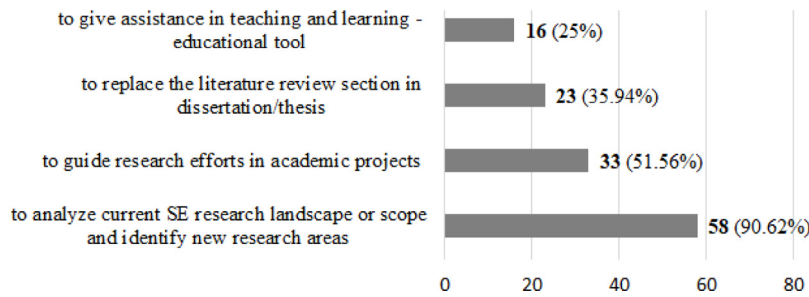


Fig. 3. Respondents' perception about the academic purpose of the application of secondary studies in SE.

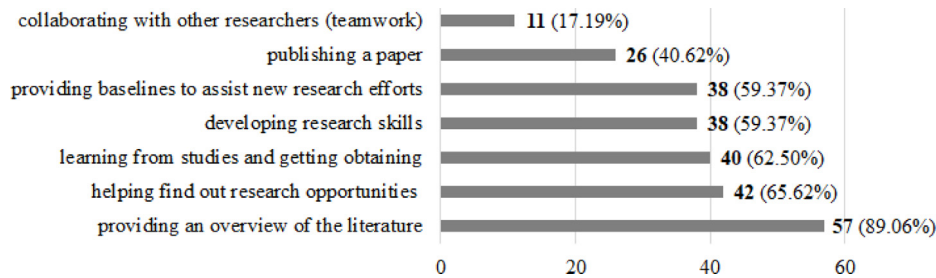


Fig. 4. Respondents' perception about main benefits of conducting a secondary study during a research project.

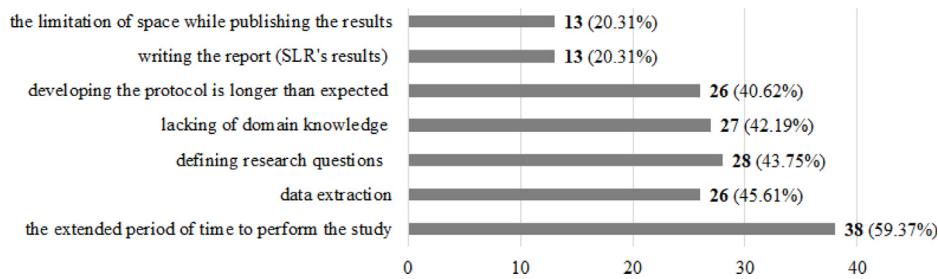


Fig. 5. Respondents' perception about main problems of conducting a secondary study during a research project.

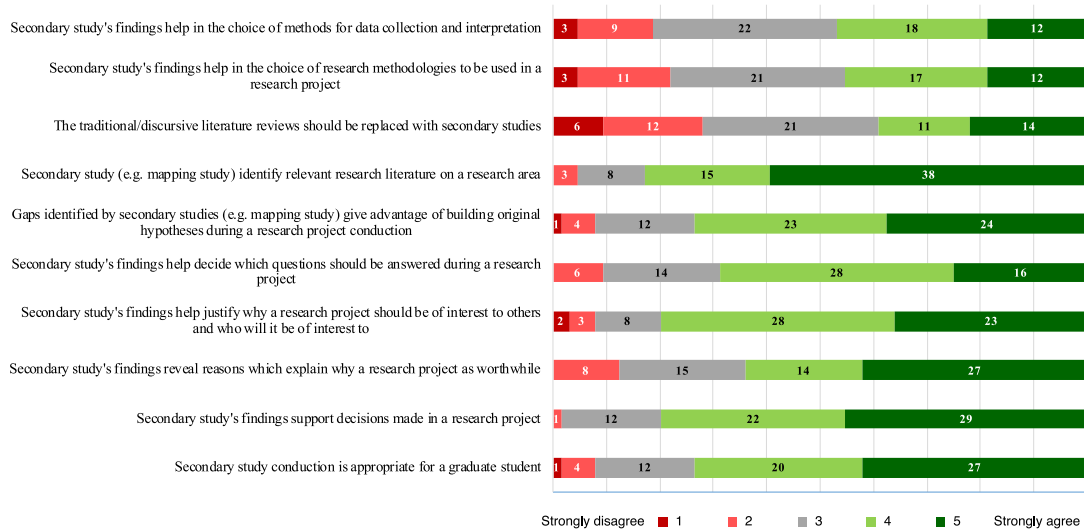


Fig. 6. Questions and responses regarding the respondents' perception about the use of secondary studies.

in details how he/she used secondary study in his/her Ph.D. thesis saying: "First I conducted a mapping study, second I detailed this mapping study. These were very important to define the theme and research questions to my thesis. Finally, I performed a systematic review to discuss the results (results from case studies and results from

third parties)". Other two researchers mentioned that secondary studies are a valuable tool for M.Sc. and Ph.D. students stating "I think every M.Sc./Ph.D. student must perform mapping study before proposing an idea".

They emphasize some points that have to be considered with attention by secondary studies practitioners: – Applicability of the study: *“I think that it is important to consider the applicability of the secondary studies. What if an area is new? Then there are no benefits of conducting a secondary study. What if it is very large? What if numerous literature reviews exist?”*; *“It is necessary to carefully evaluate when conducting a secondary study is actually appropriate”*; *“Secondary studies must be conducted properly and the purpose of performing a secondary study must be well-established. Otherwise, a lot of effort can be spent to produce results that are not meaningful to the research project”*; – Avoid bias: *“Nowadays, it is common to see one student performing a secondary study just with his/her advisor that ‘review’ only part of the findings. Therefore, for me, the biggest challenge is: How to avoid the researcher bias?”*; *“Depending on the research topic, other stakeholders such as practitioners’ input should be considered in addition to the research gaps found in the secondary studies”*.

The main contribution of this survey was the answers by SE researchers including faculty members (supervisors), Ph.D./M.Sc. graduates, among others and their opinions offered us an opportunity to better understand how secondary studies have been inserted and applied in the academic context. Based on the data provided by the respondents, the biggest contribution that secondary studies can bring is to provide an overview of the literature as well as to identify relevant research literature on a research area enabling to find reasons to explain why a research project should be provided and/or to support decisions made in a research project. One point worth highlighting is that the respondents agree or strongly agree that conducting secondary studies is appropriate for a graduate student, mainly Ph.D. students, due to the contribution that they can bring to the investigation, for example, the identification of gaps for building original hypotheses.

3.2. Discussions

The results provide interesting insights for conducting secondary studies including application for academic purpose, practical problems and benefits of and perceptions about their use.

The relationship between survey respondents’ appointments and the number of studies (SM) that mention a particular problem/benefit is illustrated in Figs. 7 and 8.

Comparing the results presented in Fig. 7, it is possible to observe that all problems listed in the studies resulted from the SM were pointed out by the survey respondents. The problems “P5 – Searching the literature” and “P6 – Defining and applying the inclusion/exclusion criteria” had the highest appearance in the studies (9 studies), however, the number of key points of both problems is low (P5 = 25.00% and P6 = 31.25%). The same behavior can be observed in “P4 – Defining the research questions” with 28 (42.19%) key points and 4 studies that mention it.

“P1 – Lacking of domain knowledge” was the third most problem pointed out by survey respondents, however it was mentioned by 2 studies only. The problem “P2 – Lacking of SLR/SM process knowledge” was mentioned by a unique study but 22 (34.37%) respondents considered it a problem. The problems “P12 – Writing the report (SLR’s results)” and “P13 – Limiting space while publishing” had a more balanced results with 2 mentions in both key points by the survey respondents and studies.

According to the survey respondents the biggest problem faced is “P11 – Extended period of time to perform the study” with 33 (59.37%) key points, and, this problem was mentioned by 4 studies. While a secondary study provides a methodical and reliable way of conducting the literature review, the process is rather intensive when compared to a traditional review. On one hand, secondary studies require, e.g., the definition of a

protocol in the planning phase, while a traditional review does not necessarily require a protocol definition. Moreover, activities, such as the definition of research questions, the creation of search strings, and the selection of study repositories, are non-trivial. Nevertheless, reviews based on a systematic approach result in a rigorous process, that controls, for example, the following activities: searching for studies on the Ph.D. research topic; reading and summarizing the main points from relevant studies; synthesizing the key ideas, theories and concepts; discussing and evaluating these ideas, theories and concepts. On the other hand, during a non-systematic review there is no control on how the tasks are run.

Despite the difficulties, one of the reasons why secondary studies should be conducted by Ph.D. students compared to informal reviews is their advantages, which include the identification of gaps in current research, which may suggest new research themes and provide a suitable way to position such themes in the context of existing research (state-of-the-art). Furthermore, conducting secondary studies develops important skills, such as, ability to search, identify, understand, critically appraise, and integrate data, for Ph.D. students.

We identified 21 experiences of Ph.D. students who have conducted a secondary study as part of their literature review for their Ph.D. thesis. The students argued that SLRs are not quick to conduct and, depending on the extent of the relevant literature, can take months to complete. As a main advantage, they emphasize that SLRs are useful in providing evidence on a research topic.

The same comparison regarding the number of studies from SM performed and survey respondents’ appointments was considered to the benefits, as shown in Fig. 8.

All benefits mentioned in the studies (SM) were pointed out by the survey respondents (see Fig. 8). The benefit “B4 – Providing an overview of the literature” was the most pointed out benefit by the survey respondents with 57 (89.06%) and also is one of the most mentioned benefit in the studies (5 studies). Indeed, secondary studies help to find out research opportunities as well as to provide baseline to assist new research efforts due to the overview of the state of art that secondary studies bring, even an SM that is more general.

Benefit “B5 – Perceiving the importance of searching for evidence” was the most mentioned benefit in the studies (6 studies), however it is one of the lowest pointed out by the surveys respondents (third less mentioned with 23 (35.94%) mentions). The benefit “B10 – Collaborating with other researchers (teamwork)” had the lowest number of key points by survey respondents and also a low number of mentions in studies (2 mentions only). The benefit “B8 – Publishing a paper” was mentioned by only one study in SM, however for the survey respondents it is an important point since this benefit was pointed out by 26 (40.62%) of the survey respondents.

In summary, we can say that the top three benefits (B3, B4 and B7) pointed out by the survey respondents agree with the benefits pointed out in the literature, since that all three benefits had appeared in 3 or more studies from the secondary studies we performed.

It is common knowledge that the incentive to train new researchers begins during undergraduate courses. Since research is an essential component of doctoral and master’s degree programs, having an undergraduate research experience is a valuable opportunity. One possible way to improve the research skills of undergraduate students would be to design disciplines covering SLR. Scientific activity enriches the student’s curriculum and improves their academic training. This practice also enables the integration of teaching and research activities in the university

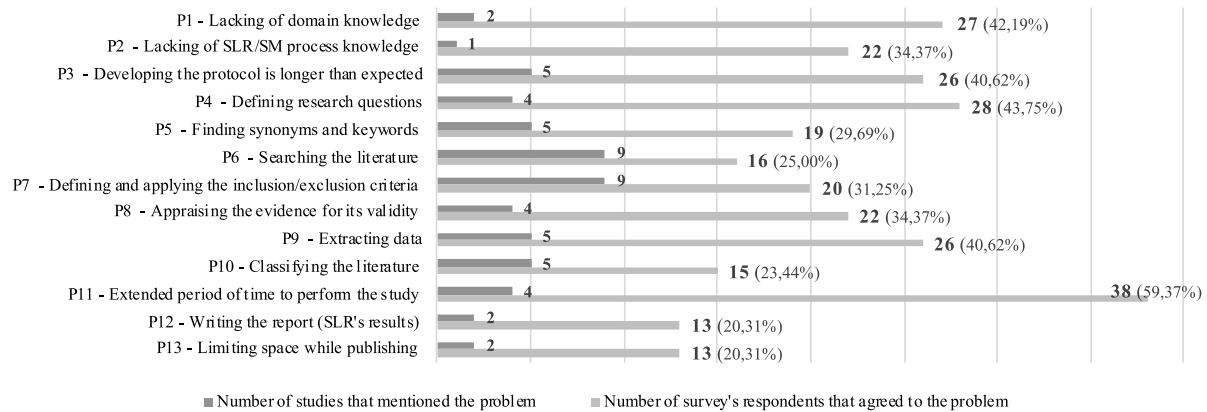


Fig. 7. Survey respondents' agreement x number of studies that mention the problem.



Fig. 8. Survey respondents' agreement x number of studies that mention the benefit.

and the training of more critical professionals. Encouraging undergraduate students to conduct an SLR can positively influence graduates (M.Sc./Ph.D.) learning.

We had positive experiences from undergraduate students who conducted secondary and tertiary studies to their completion of course work. Examples are Napoleão et al. (2017) and Mariano et al. (2015). In common these two students claimed that they gained educational benefits including, among others: • improving writing skill; • improving English skill; • contacting with specific research topics not covered at the undergraduate level (increased motivation), among others. Both undergraduate students started a postgraduate course. One contributing factor was that a secondary/tertiary study can identify current research gaps more precisely and, as a consequence, help define future research initiatives.

Some of threats to the validity are:

- Missed related works: Some of the relevant studies related to the topic of this research could be missed. To mitigate this issue we conducted a two-stage search strategy: automatic search and snowballing. The automatic search resulted in three studies and the snowballing application provided 25 relevant studies. We believe that most of the relevant studies were covered by our search strategy. Moreover, our seed set for snowballing was carefully created considering the studies identified as relevant in automatic search;
- Construct validity: Survey options do not cover all possibilities. However, both the direct and those Likert Scale questions emerged from the SM performed. We inserted some open questions and at the end of the survey a free space for final comments where the respondent could report any additional information without limitation;

- External validity: The survey was conducted between November 17th and December 7th 2018 including the first or the corresponding author of published secondary studies. Thus, we assumed that the respondents were researchers with some experience in conducting secondary studies in SE thus they were considered a suitable survey population. The response rate was 16.37% among authors successfully contacted via email. Therefore, we consider the result satisfactory. Another limitation is that not all recipients received the survey email successfully. In order to mitigate this threat of sending the email from a tool and these emails be blocked by anti-spam tools or firewalls, all emails were sent manually.

4. Conclusions

We administered a survey about the use of secondary studies in academic projects and the findings from this study are expected to contribute to the existing knowledge about the use and contribution of secondary studies in the academy. In summary, we concluded that secondary studies outcomes can be useful for M.Sc./Ph.D. students. Main reasons are:

1. Providing a structure for undertaking and writing broad literature reviews;
2. Demonstrating gaps in the literature, which can then help to improve the design and justify the research or find out further opportunities worth investigating;
3. Learning more about a certain subject of interest;
4. Identifying relevant research literature on a research area; and findings can support decisions made in a research project;

5. Gaining knowledge and practical research skills; and
6. Building connections with researchers, M.Sc./Ph.D. students, and other undergraduates who share similar research interests.

The acquisition of these skills and benefits increases students' motivation to pursue their research project and prepares them to both, academic or industrial careers. Although there are publications defining how to conduct secondary studies (Kitchenham and Charters, 2007; Petersen et al., 2008, 2015), there is still a need for studies addressing the main problems faced by secondary study practitioners mainly in order to provide better support to M.Sc./Ph.D. students. Among these problems we can emphasize the effort/time spent to conduct such studies, which is greater when compared to a traditional review.

In conclusion, secondary studies have a number of advantages in an academic context and therefore M.Sc./Ph.D. students should consider doing a secondary study for their research project, of course, under the supervision of more experienced researchers.

Other contributions of this paper can be highlighted as follows:

1. We found a more recent list of secondary studies in SE, including 1233 secondary studies; and
2. A common problem in conducting survey is sampling, in particular, the ability to obtain a sufficiently large sample (Amir and Ralph, 2018) (population lists – corpus). We believe that we have defined the actual sampling of researchers that perform secondary studies in SE.

One concern is how to adjust EBSE teaching in SE courses. One point that should be considered is to use evidence to solve a relevant SE problem or need. The focus of the course should not only be to teach EBSE, research skills, but also how to integrate evidence and practical experience. As a future work we intend to design a course for graduate students (M.Sc. and Ph.D.) covering SLR and SM. We believe that this course can improve their research skills and help them with their problems and challenges in conducting secondary studies. As a consequence, influencing positively learning, improving their academic training.

CRedit authorship contribution statement

Katia Romero Felizardo: Conceptualization, Methodology, Supervision, Formal analysis, Validation, Resources, Writing - original draft, Project administration, Funding acquisition. **Érica Ferreira de Souza:** Conceptualization, Methodology, Validation, Resources, Writing - original draft. **Bianca Minetto Napoleão:** Conceptualization, Methodology, Validation, Resources, Writing - original draft. **Nandamudi Lankalapalli Vijaykumar:** Writing - review & editing. **Maria Teresa Baldassarre:** Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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