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Introduction to the Special Issue on: Grey Literature and Multivocal Literature Reviews (MLRs) in Software Engineering

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Abstract: In parallel to academic (peer-reviewed) literature (e.g., journal and conference papers), an enormous extent of grey literature (GL) has accumulated since the inception of software engineering (SE). GL is often defined as “literature that is not formally published in sources such as books or journal articles”, e.g., in the form of trade magazines, online blog-posts, technical reports, and online videos such as tutorial and presentation videos. GL is typically produced by SE practitioners. We have observed that researchers are increasingly using and benefitting from the knowledge available within GL. Related to the notion of GL is the notion of Multivocal Literature Reviews (MLRs) in SE, i.e., a MLR is a form of a Systematic Literature Review (SLR) which includes knowledge and/or evidence from the GL in addition to the peer-reviewed literature. MLRs are useful for both researchers and practitioners because they provide summaries of both the state-of-the-art and -practice in a given area. MLRs are popular in other fields and have started to appear in SE community. It is timely then for a Special Issue (SI) focusing on GL and MLRs in SE. From the pool of 13 submitted papers, and after following a rigorous peer review process, seven papers were accepted for this SI. In this introduction we provide a brief overview of GL and MLRs in SE, and then a brief summary of the seven papers published in this SI.

Keywords: Grey literature; multivocal literature review; evidence-based software engineering; epistemology

1 GREY LITERATURE AND ITS STATE OF IN SOFTWARE ENGINEERING

While a hazy definition of "grey literature" had existed previously, the term is generally understood to have been coined by the researcher Charles P. Auger, who wrote *Use of Reports Literature* in 1975 [1]. Auger [1] referred to literature comprising intelligence reports and notes on defense research that had been produced, in vast quantities, by the Allied Forces during World War II. Auger first used the term "grey literature" during a conference held by the British Lending Library Division in 1978 [2].

The most widely used and accepted definition of “grey literature” (GL) is the so-called Luxembourg definition, which states that, “[grey literature] is produced on all levels of government, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers, i.e., where publishing is not the primary activity of the producing body” [3]. The Cochrane handbook for systematic reviews of interventions [4] defines GL as “literature that is not formally published in sources such as books or journal articles”.

Various models have been proposed to classify different types of sources of GL. For example, one model from the management sciences [5] organizes GL into three tiers:

- 1st tier GL (High outlet control/ High credibility): Such as books, magazines, government reports, white papers
- 2nd tier GL (Moderate outlet control/ Moderate credibility): Such as blog posts, online presentations, videos, Q/A sites (such as StackOverflow), Wiki articles
- 3rd tier GL (Low outlet control/ Low credibility): Such as emails, and tweets

An extensive amount of GL is already available in the field of software engineering (SE), and the volume of GL in SE is clearly expanding at a very rapid pace. For instance, there are a large number of SE technical blogs written by software

engineers, as well as a large number of free SE books and videos available online. The scale of GL in SE becomes even clearer by considering the fact that, according to some reports [6], as of 2018, there were about 23 million software engineers worldwide, and that number is estimated to reach 28 million by 2023. Even if a small fraction of those software engineers write blog posts or post SE-related videos online (e.g., in YouTube), there is still a considerable quantity of GL materials in SE.

To further understand the role and position of GL in SE practice and SE research, we present a high-level view of the community of SE practice versus SE research community in Figure 1 (adapted from Garousi et al. [7]). In this visualization, we also include the estimated population of the two communities. According to an IEEE Software paper [8], "4,000 individuals" are "actively publishing in major [SE] journals", which can be used as the estimated size (lower bound) of the SE research community.

As visualized in Figure 1, while there exist established ways to enable knowledge flow from software industry to academia, e.g., interviews, opinion surveys, ethnography, we believe that benefitting from GL knowledge in SE research is another prominent enabler for knowledge flow. However, we and many other researchers believe that insufficient effort has been made so far to utilize such knowledge in SE research. The encouraging news is that, recently, a number of SE researchers (e.g., the authros of the following studies [9-13]) have taken various steps in the direction of using GL in SE research. Also, we observe a recent and increasing trend of SE researchers benefitting from the knowledge available within GL.

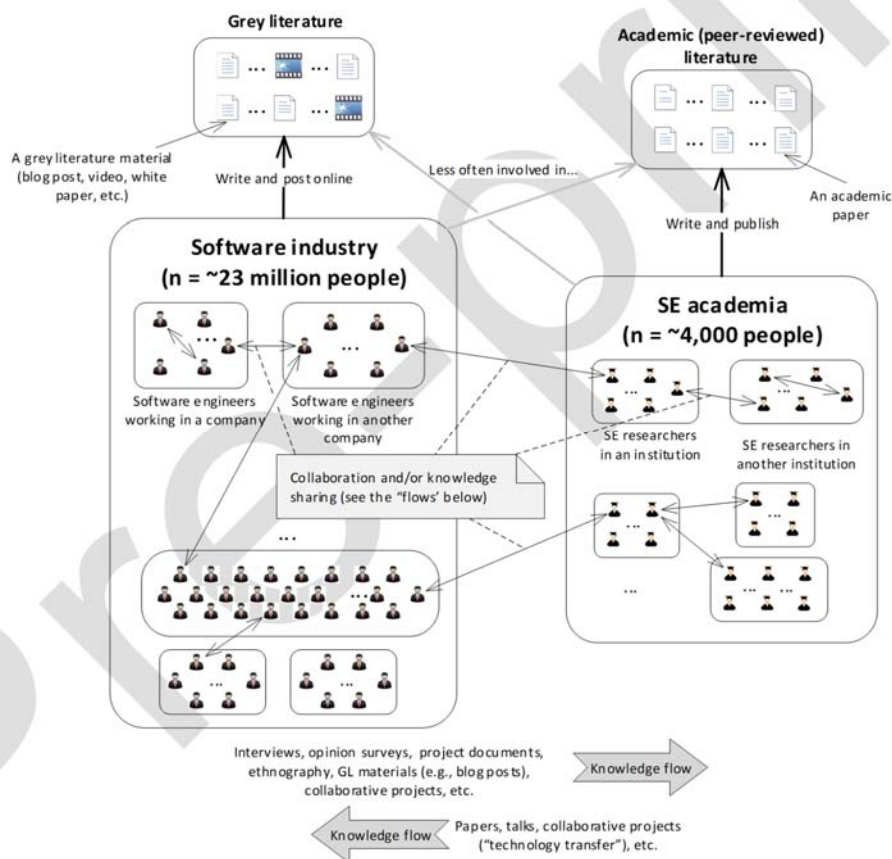


Figure 1- Visualizing the community of software practitioners and researchers, and the knowledge flow between them (including GL). Taken from [7].

2 MULTIVOCAL LITERATURE REVIEWS (MLRs) IN SOFTWARE ENGINEERING

The Multivocal Literature Review (MLRs) is a form of a Systematic Literature Review (SLR) which includes knowledge and/or evidence from the GL in addition to the peer-reviewed literature. MLRs are useful for both researchers and practitioners since they provide summaries of both the state of the art and the state of the practice in a given area. MLRs are popular in other fields and have recently started to appear in SE.

To get a sense of the publication trend of MLRs in SE, and to see whether there has been a growing trend, we performed a lightweight search for MLRs in SE in the Scopus database (scopus.com) using the search string "multivocal literature review" and *source* (venue, i.e., journal / conference name) including the term "software". This search approach for papers in common in bibliometric studies in SE [14, 15]. Results (as retrieved on June 14, 2021) are shown in Figure 2. Results for the year 2021 are partial. According to this search, a total of 21 MLRs have been published in SE. Also, a tertiary study of a set of 12 MLRs was published in 2019 [16]. According to our lightweight search, and to the best of our knowledge, the first MLR in SE was a MLR on technical debt, published in 2013 [17]. We can see in Figure 2 that, since 2018, there has been an increasing trend. Thus, we think it reasonable to predict an increasing number of MLRs in SE in the coming years.

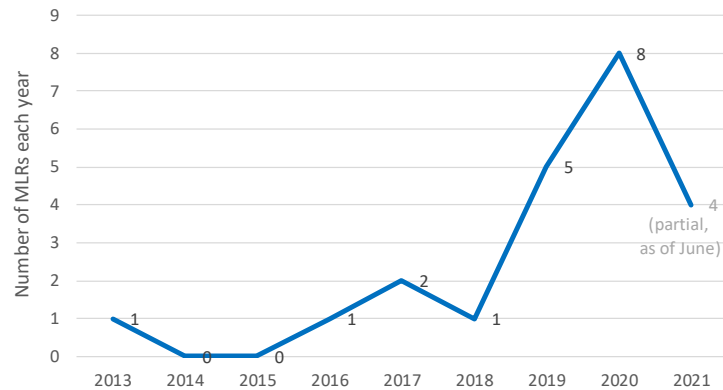


Figure 2-Trend of the number of published Multivocal Literature Reviews (MLRs) in software engineering (data from Scopus on June 14, 2021)

3 A REVIEW OF THE SEVEN PAPERS PUBLISHED IN THIS SPECIAL ISSUE

The idea for this Special Issue (SI) was conceived in 2020, and the aim was to focus on GL and MLRs in SE. In total, 13 papers were submitted to the SI by the submission deadline. A rigorous peer review process was executed on the pool of submitted papers, with several papers requiring revision. At the end of the process, seven papers were accepted for this SI. These are summarized and classified in Table 1. We also provide a simple classification of those seven papers in Table 1 (column "Type of paper"). Four papers [18-21] are Grey Literature Reviews (GLR), one is a MLR [22], one is a tertiary study [23] (a study of secondary studies such as SLRs, MLRs and GLRs), and one paper [24] is an experience report about performing a GLR. Thus, there is a good "diversity" in type of the paper. Let us note that all the GLR and MLR studies in this SI have followed the MLR / GLR guidelines [10], published in 2019. Next, we briefly summarize each of those papers.

Table 1-List of the seven papers accepted and included in this Special Issue (SI)

ID	Paper title	Authors	Type of paper	Reference	Number of sources reviewed		
					GL sources	Peer-reviewed sources	Other
P1	On the practitioners' understanding of coupling smells: A grounded-theory based grey literature study	Apitchaka Singjai, Georg Simhand, Uwe Zdun	GLR	[18]	48	0	
P2	Bridging the state-of-the-art and the state-of-the-practice of SaaS pricing: A multivocal literature review	Andrey Saltan, Kari Smolander	MLR	[22]	330	57	
P3	Understanding hypotheses engineering in software startups through a gray literature review	Jorge Melegati, Eduardo Guerra, and Xiaofeng Wang	GLR	[19]	95	0	
P4	The do's and don'ts of infrastructure code: A grey literature review	Indika Kumaraa, Martín Garrigaa, Angel Urbano Romeua, Dario Di Nuccia, Fabio Palombab, Damian Andrew Tamburria, Willem-Jan van den Heuvelaa	GLR	[20]	67	0	
P5	Grey literature in software engineering: A critical review	Fernando Kenji Kamei, Igor Wiese, Crescencio Lima, Ivanilton Polato, Vilmar Nepomuceno, Waldemar Ferreira, Márcio Ribeiro, Carolline Pena, Bruno Cartaxo, Gustavo Pinto, Sérgio Soares	Tertiary study	[23]			446 secondary studies
P6	Processes, challenges and recommendations of grey literature review: An experience report	He Zhang, Runfeng Mao, Huang Huang, Qiming Dai, Xin Zhou, Haifeng Shen, Guoping Rong	Experience report	[24]	-	-	-
P7	Game industry problems: An extensive analysis on the gray literature	Cristiano Politowski, Fabio Petrillo, Gabriel C. Ullmann, Yann-Gaël Guéhéneuc	GLR	[21]	200	0	-

Entitled “*On the practitioners' understanding of coupling smells: A grounded-theory based grey literature study*”, the papepr labeled as P1 in Table 1 is a GLR study of practitioners' understanding of how code smells relate to source-code "coupling". The

study performed several analyses, e.g., factors related to coupling smells, as well as smell impacts, trade-offs, relationships to other smells, relationships to practices and patterns, and fix options as perceived by practitioners. The paper further identifies gaps in the understanding of coupling smells between science and practice, and derived opportunities and challenges for future scientific work. This paper also presents five lessons as opportunities and challenges for future research.

The second paper in Table 1 (P2) is entitled: "*Bridging the state-of-the-art and the state-of-the-practice of SaaS pricing: A multivocal literature review*". It is a MLR study aiming at "bridging the state-of-the-art and the state-of-the-practice" in Software-as-a-service (SaaS) pricing. As the paper's objective, the authors argue that there is a lack of integration among different research areas focused on SaaS pricing and, more importantly, between academia and industry. The aim of this paper is to clarify this misconception by classifying, thematically analyzing the academic state-of-the-art and industrial state-of-the-practice of SaaS pricing. Based on the MLR, a taxonomy of pricing-related concepts was developed. The taxonomy classifies SaaS pricing aspects, affecting factors, and challenges facing SaaS providers. The findings and interpretations are summarized to emphasize the major research themes and practical challenges of SaaS pricing practices' transformation and provide further research guidelines in this area.

Paper P3 ("*Understanding hypotheses engineering in software startups through a gray literature review*") is a GLR on "hypotheses engineering" [25] in software startups. Hypotheses engineering is a recent trend in SE and is defined as "experiment-driven" software development [25]. The goal of the review was to understand what activities, as proposed in industry, are required for handling hypotheses, facilitating the comparison, creation, and evaluation of relevant techniques in this area. The authors analyzed the identified GL documents using thematic synthesis. The analysis revealed that techniques proposed for software startups in practice compress five different activities: (1) elicitation, (2) prioritization, (3) specification, (4) analysis, and (5) management. The results represent the first known description for hypotheses engineering, grounded in practice data. This mapping of the state-of-practice indicates how research could go forward in investigating hypotheses for experimentation in the context of software startups. For practitioners, the review represents a catalog of available practices to be used in this context.

Paper P4 ("*The do's and don'ts of infrastructure code: A grey literature review*") is a GLR on the do's (patterns) and don'ts (anti-patterns) of infrastructure-as-code (IaC). IaC is a DevOps tactic of managing and provisioning software infrastructures through machine-readable definition files, rather than manual hardware configuration or interactive configuration tools. The paper proposes a taxonomy of 10 primary categories for best practices (patterns) and 4 categories of bad practices (anti-patterns), for the three major IaC programming languages: Ansible, Puppet, and Chef. The review reveals insights and challenges concerning the top programming languages and the best practices adopted by practitioners to address (some of) those challenges. The review concludes that the field of development and maintenance of IaC is in its infancy and deserves further attention.

Paper P5 ("*Grey literature in software engineering: A critical review*") is a tertiary study that investigates how secondary studies in SE utilize GL. More specifically, the paper summarizes the last 10 years of secondary studies in SE research that have used GL, showing that GL has been essential for bringing practical new perspectives that are scarce in traditional literature. From the 446 selected secondary studies, only 95 used GL to answer a specific research question (RQ), representing almost 21% of all the 446 secondary studies. Moreover, by the time that this research was conducted (2020), 49% of the GL URLs were not working anymore. Based on its findings, the paper discusses some challenges in using GL and potential mitigation plans.

Paper P6 ("*Processes, challenges and recommendations of grey literature review: An experience report*") is an experience report on challenges when conducting GLRs that provides a number of recommendations. The authors presented a retrospective analysis on their review process of conducting a GLR on the topic of DevSecOps [26] with reference to Kitchenham and Charters's SLR guidelines [27] and Garousi et al.'s MLR guidelines [10]. The authors specifically reflect on the processes they had to adapt to tackle the challenges they faced when conducting that GLR. The authors also compare and contrast their GLR with existing MLRs or GLRs in SE to contextualize their reflections. The paper distills ten challenges in nine activities of a GLR process, provides reasons for those challenges, and further suggests ways to tackle them during a GLR process. The paper also discusses the decision process for selecting a suitable review methodology among SLR, MLR, and GLR and elaborates the impacts of GL on review results. Although the shared experience is derived from a one single case (a GLR on DevSecOps [26]), the authors believe that the experience is relevant and would be beneficial to other GLR or MLR studies.

Finally, paper P7 (“Game industry problems: An extensive analysis on the gray literature”) is a GLR on the problems / challenges faced by software engineers in the gaming industry. The paper argues that the SE research community and game developers would benefit from a compiled classification of the problems (challenges) faced by game developers in the video game industry, their evolution in time, and their root causes. This state of the practice would allow researchers and practitioners to work towards solving these problems. The paper derives a large number of challenges (927 problems) and divides them into 20 types, e.g., challenges in game design, technical challenges, and team problems. Through their 23-year analysis (1997-2019), the authors describe the overall landscape of problems in the game industry and how these problems evolved over the years.

4 SUMMARY AND CONCLUSIONS

As discussed above, GL is an integral and very extensive source of knowledge, experience, and evidence in SE. Since the year 2018, we have noticed an increase in the number of MLRs / GLRs in SE (Figure 2). Thus, it is logical to say that in the next few years, at least, we can expect to see a large number of MLRs in our field.

We are delighted to guest edit this Special Issue on GL and MLRs in Software Engineering. As with all methods of research, MLRs and GLRs bring opportunities and risks. The seven papers presented in this Special Issue demonstrate the potential value to software engineering research and practice of systematically using GL. The papers also demonstrate challenges, and report experiences and recommendations. We hope that this SI will encourage SE researchers to further conduct MLRs and use GL in their research.

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