A Decade of Best Practices of Software Engineering in Small Companies: A *Quasi*-Systematic Mapping

Alex Costa
Department of Exact Sciences
Federal University Federal of Paraiba
Rio Tinto – PB, Brazil
alex.costa@dcx.ufpb.br

Juliana Saraiva
Department of Exact Sciences
Federal University Federal of Paraiba
Rio Tinto – PB, Brazil
julianajags@dcx.ufpb.br

Yuska P. C. Aguiar
Department of Exact Sciences
Federal University Federal of Paraiba
Rio Tinto – PB, Brazil
yuska@dcx.ufpb.br

ABSTRACT
The following of best practices of Software Engineering (SE) is something that provides many advantages for software companies. In this scenario SWEBOK is a guideline that supports these companies with information about the core of knowledge of SE, including a list of Best Practices (BP) to adopt. For small companies, however, some restrictions such as limited budget, short schedule, reduced number of employees, can hinder the advantages of the adoption of these practices. In this scenario, it is necessary to have useful information about which BPs have been adopted in small companies. Therefore, this paper describes the planning and execution of a quasi-systematic mapping study in order to report the adopting scenario of SWEBOK BPs in small companies during the last decade. It was possible to observe that the most prominent BP adopted is "Test application", followed by the using of "Software Process Model" where the tests' execution is already contemplated by. On the other hand, "Budget Limitation" and "Staff Size" were cited as motivations for avoid the adoption of BPs in small companies.

CCS Concepts
Software and its engineering → Search-based software engineering

Keywords
Software engineering; SWEBOK; Best Practices; Small Company; Software Quality.

1. INTRODUCTION
A widely used guide on Software Engineering (SE) is the SWEBOK (*Software Engineering Body of Knowledge*). It is a project for supporting many organizations to build a consensus on the core body of knowledge of SE [6]. According to the SWEBOK, best practices can include the following activities: peer-to-peer review, testing, risk mitigation, knowledge management, reuse practices, among others [5, 6]. The adoption of these practices can improve business performance and productivity, and decrease project costs and budget. Consequently, the practices' adoption reflects on the product quality level, customer satisfaction, and financial returning - aspects that contribute for increasing company competitiveness [1].

Conference'10, Month 1–2, 2010, City, State, Country.

DOI: http://dx.doi.org/10.1145/12345.67890

Based on that, the best practices' adoption can be hindered in small companies by the informality during the software development process. Sometimes, it occurs because of the economic hardship faced by these companies [2]. In addition, the context of simple communication, unstable processes, deployment quickly demanded, and inexperience in applying software engineering concepts can be highlighted as difficulties during the best practices adoption [7]. Complementarily, new technologies and process approaches have been improving every day, making harder the professional training for this kind of companies that have to deal with small budget and short deadlines.

Therefore, it is notary the necessity of understanding how small companies of software development have been accessing information of best practices of software engineering and how they are applying day-by-day on the last decade. We believe that the spreading of the reporting of similar actions can motivate other companies that see the best practices adoption with skeptism. In addition, this information can make easier the decision-making process about which practices could be adopted, at least, in a particular software project/scenario of small companies.

In this context, the research problem addressed in this work is the lack of useful information about the best practices of software engineering adoption in small companies. The following Research Questions (RQs) guides the conducting of this study:

- **RQ01**: *What are the best practices of software engineering adopted in small companies?*
- **RQ02**: *What are the best practices of software engineering defined by SWEBOK Guide that have been (or not) followed by the small companies*?
- **RQ03**: *What are the reasons of the non-adoption of the best practices of software engineering in small companies?*

Thus, this study aims to map the best practices of software engineering adopted for small companies, compare the results with the SWEBOK Guide standardization, and report what have been done during the last decade in this industrial environment. The following specific goals were raised targeting the main goal: (i) to list the best practices of software engineering by the most recent publication of SWEBOK; (ii) to list the best practices of software engineering used by small companies; (iii) list the best practices of software engineering that are not used by small

Trabalho de Conclusão de Curso apresentado pelo aluno **Alex Juvêncio Costa** sob a orientação da professora Yuska P. C. Aguiar como parte dos requisitos para obtenção do grau de Licenciado em Ciência da Computação na UFPB Campus IV

companies; and (iv) to identify the reasons why the small companies do not use some kinds of best practices.

This paper is organized as follow: in Section 2, the methodology is presented. In Section 3, the results achieved by the research are discussed. The limitations and the threats to validity are depicted in Section 4, and finally, the conclusions and future work are shown in Section 5.

2. METHODOLOGY

The research conducted in this work is characterized as a theoretical exploration from the literature. The searching relied on a systematic mapping protocol, and the assessment of the resultant data was performed in quantitative and qualitative way. According to Petersen and contributors [4], a systematic mapping is a definite method for constructing a classification scheme and structure of a field in the interest area [3]. Its methodological procedure includes: the goal definition, the systematic mapping protocol building, primary studies selection, data extraction, and analysis of resultant data. Mapping studies try to gather all research related to a specific topic. Questions are broader and more general when compared to the ones in Systematic Literature Reviews (SLRs) [7,8].

In a *quasi*-systematic mapping studies, human resources and time are limited, reflecting on the amount of primary studies selected and the number of participants during its execution. In our case, a quasi-systematic mapping is justified by the conditions of the study, particularly regarding the participants available (1 student and 2 professors) and the time for its execution (4 months). The following subsections present the methodological steps of the research protocol that is completely available at the research website[1].

2.1 Methodological Steps

The research was composed by 6 steps depicted in Figure 01. It is important to highlight that the first step, in which deals with bibliographical study is not part of the mapping protocol, specifically:

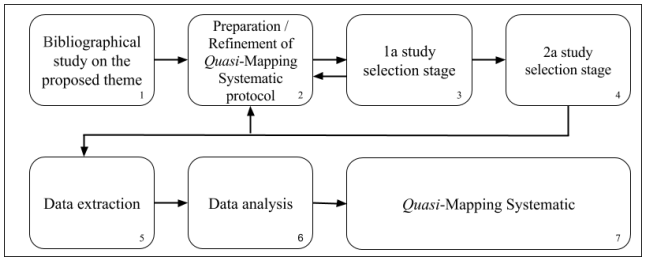


Figure 01: Research methodological steps.

2.2 Mapping Data Source and Search String

The search strategy encompasses well-known digital library search engines (data sources). They were chosen based on the relevance for the Computer Science Community and availability of papers for downloading:

- **IEEE**: http://ieeexplore.ieee.org
- **ACM**: http://dl.acm.org
- **SCIENCE DIRECT**: http://www.sciencedirect.com
- **SPRINGER LINK**: http://link.springer.com/
- **WILEY**: http://onlinelibrary.wiley.com/

The search string was set up to be used with similar semantic meaning in all search engines chosen. It is important to clarify that the string was refined and validated with experts. The list below shows the search strings after the refinement in each engine.

- **IEEE**: ((practice AND "software engineering") AND ("small bussines" OR "small company" OR "small companies" OR "small teams"));
- **ACM**: (+practice +AND +"Software engineering" +AND +"small company" +OR +"small companies" +OR +"small teams");
- **SCIENCE DIRECT**: practice AND "software engineering" AND ("small company" OR "small companies" OR "small teams");
- **SPRINGER LINK**: practice AND "software engineering" AND ("small company" OR "small companies" OR "small teams");
- **WILEY**: practice in All Fields AND "Software engineering" in All Fields AND "small company" OR "small companies" OR "small teams" in All Fields.

2.3 Primary Studies Search Strategies

This section describes the search strategy to select the primary studies. An ID was named for each paper, which is a unique identifier for each study (I.e.: P001 – First Paper). The selection of primary studies was conducted in three phases that are described below:

1. Selection of potentially relevant primary studies: reading title, keywords, and abstract.
2. Evaluation of the results from the first selection against the exclusion criteria;
3. Conflicts discussion, and final selection.

Initially (1), only the title, keywords and abstract were taken into account for paper inclusion. It is important to stress that only papers that were clearly out of scope were excluded in this selection. For this phase, the Inclusion Criteria (IC) were considered:

- **IC01** – Studies dealing with the practices of software development processes in small companies, projects or small teams;
- **IC02** – Papers published from 2006 to 2016 (for checking the decade of practice);
- **IC03** – Studies are complete papers (minimum 8 pages);
- **IC04** – Papers accessed by web (on digital libraries signed by Federal University of Paraiba).

On the second phase (2), the Exclusion Criteria (EC) were used to keep only the papers that contain information for answering at least one RQ previously raised. During this phase, the paper was read completely.

- **EC01** – Duplicate publications;
- **EC02** – Short papers (papers with less than four pages);
- **EC03** – Study that does not deal with small team, small companies;
- **EC04** – Study that do not contain best practices of SE;
- **EC05** – Secondary studies such as, literature review or systematic mapping was excluded.

[1] The study protocol is available on the link below: https://goo.gl/vX6dE2.

It is important to clarify that the first and second selections were performed only by the student, however under the advisors' supervision. Nevertheless, the three authors of this paper executed the conflicts discussion, the final phase of papers selection. A conflict resolution meeting was organized and the disagreements discussed. In this final phase (3) each researcher screened the full paper. The result of this meeting was the final set of primary studies.

2.4 Extraction and Data Analysis

After the final selection, the student read again the whole papers trying to extract the following information form them:

- *Authors*: Identify the names of the studies' authors;
- *Year*: Publication Year;
- *Publication Type*: Conference or journal;
- *Best Practices*: Good practices of software engineering for small companies.
- *Process Model*: Deployment models of software engineering adopted in small companies.

3. RESULTS DISCUSSION

This section discusses the results found. Section 3.1 presented an overview of the mapping study, and the answers of the RQ previously raised are depicted in Section 3.2.

3.1 Mapping Study Overview

The selection process occurred between 04/12/2016 and 14/04/2016. The results are shown in Table 1. The first column is the search engine identification; the second column shows the number of studies listed by each engine. The third and fourth columns indicate the number of studies that remained after the end of each selection phase.

Table 1. Number of studies selection

Search Engine	Studies Listed	1st Selection	2nd Selection
IEEE	232	5	3
ACM	435	1	1
SCIENCE DIRECT	195	4	0
SPRINGER LINK	194	3	3
WILEY	293	5	2
TOTAL	**1349**	**18**	**9**

Table 2 depicts the studies selected. The first column indicates the paper ID, the second column indicates the paper title, and the last column refers to year of study publication. As we are assessing the context of small companies, and the definition of the "company size" change from region to region, we are considering the company's size based on the description contained in the study selected.

Table 2. Selected Primary Studies

Id	Title	Year
P001	Selection of good practices for small software development teams: a knowledge-based approach	2013
P002	Practical Experience in Customization of a Software Development Process for Small Companies Based on RUP Processes and MSF	2007
P004	A reduced set of RUP roles to small software development teams	2012
P005	Software Process Practices in Small Software Companies in Botswana	2014
P011	Understanding the gap between software process practices and actual practice in very small companies	2015
P012	Software SMEs' unofficial readiness for CMMI®-based software process improvement	2015
P013	Challenges and industry practices for managing software variability in small and medium sized enterprises	2013
P015	Investigating the role of CMMI with expanding company size for small- to medium-sized enterprises	2010
P017	An exploratory study of software process improvement implementation risks	2012

3.2 Answering the RQs

After the selection process, information extraction was performed for answering the RQs aforementioned. The RQs are following discussed:

RQ01: What are the best practices of software engineering adopted in small companies?

Table 3 presents the list of Best Practices (BP) found in the SWEBOK Guide, and the relation between them with the studies selected. The first column indicates the BP identification, the second column indicates the name of the BP, and the last column shows the papers that mentioned the BP.

As it is possible to note the "Application of Tests" is the most prominent BP adopted in small companies. It can evidence the importance of test and the truth of the statement: it is impossible to deploy a software system without test, independently of the company size. On second place, the "adoption of any kind of process model", "project planning", and "requirement analysis" are important BP to be adopted by small companies. Consequently, it is notary that the small companies adopt a process model even that occur any adaption. This process guides them in the decision-making process about which BPs should be chosen. It seems that is also occurs with BP003 and BP004, minimally.

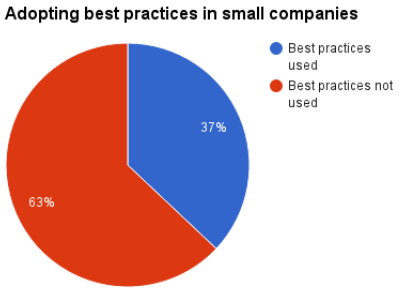
Table 3. Best Practices adopted in Small Companies

ID	SWEBOK BP	Study ID
BP001	Tests	P011, P013, P012, P015, P017
BP012	Adoption of Software Process	P002, P011, P012, P013
BP003	Project planning	P001, P004, P005, P015
BP004	Requirements Analysis	P001, P004, P005, P015
BP005	Software Configuration Management	P004, P005, P015
BP006	Project monitoring	P001, P004, P015
BP007	Resource Planning	P001, P004
BP008	Risk Monitoring	P015
BP009	Software Construction	P001
BP010	Budget control	P001
BP011	Designing the user interface design	-
BP012	Design activities Quality Analysis and Evaluation	-
BP013	Design Structure and Software Architecture	-
BP014	Design Notations, Strategies and Methods	-
BP015	Maintenance Planning	-
BP016	Software Configuration Management	-
BP017	Activities forms of project documentation generation	-
BP018	Design Reuse	-
BP019	Software Construction Project	-
BP020	Quality and Integration	-
BP021	Software Quality Requirements	-
BP022	Technical SCM - (Software Quality Management)	-
BP023	Measurement of Software Quality	-
BP024	Software Process Assessment	-
BP025	Software Process Improvement	-
BP026	Software Metering	-
BP027	Technical Software Process Measurement	-

RQ02: What are the best practices of software engineering defined by SWEBOK Guide that have been (or not) followed by the small companies?

A list of best practices that are not adopted by small companies and that are in accordance with the SWEBOK guide is shown in Table 3. The last column represented by the symbol "-" means that the BP was not adopted by any small company reported by the studies published by the literature (academia) during the last decade. On the other hand, the rows of the last column that contains any study ID, indicates that the BP was proposed by SWEBOK guide and followed by any small companies. After the data assessment it was possible to reveal that 10/27 (37%) of the identified practices are used by small companies, and 17/27 (63%) of them are not depicted in Graph 1.

Graph 1. Adoption of best practices of Software Engineering



RQ03: What are the reasons of the non-adoption of the best practices of software engineering in small companies?

Table 4. Reasons why do not adopt BPs

Reason why do not adopt BPs	Study ID
Budget Limitation	P002 / P005 / P011 / P013
Staff Size	P011 / P012 / P015
Exhaustive Project Documentation	P005 / P011 / P012
BPs Adoption Bureaucracy	P017 / P12
Staff Expertise	P002 / P001
Non-knowledge of BPs	P005
Short Deadline	P012

Throughout the Table 4 it is possible to note the reasons why small companies do not adopt some of SWEBOK BPs. The first column indicates the reason, and the second column represents the study ID that contains a discussion about the reason mentioned. As expected, "Budget Limitation", "Staff Size", and "Exhaustive Project Documentation" are shown as the most issues took into account by the small companies for do not adopt the BPs. It can be explained because limitation of time and money is one of the most intrinsic characteristics of small company.

4. LIMITATIONS AND THREATS TO VALIDITY

Limitations and threats to validity can influence on the result of any research. Thus, during this study, we tried to deal with these threats. A threat to construct validity was identified when we considered the SWEBOK BPs as reference of the state-of-practice. Maybe other books, papers, articles, guides, and documents related to SE can address BPs for small companies that were not considered for this work. However, we adopted the SWEBOK guide because it is widely followed by software companies around the world.

The fact of only one researcher carry out the 1st and 2nd studies' selection can be considered as a threat to internal validity. Nevertheless, it is important to clarify that 2 professors supervised the selection process for minimizing the threat. Another threat to internal validity is the using of academia's literature to build an overview of BPs adopted in industrial environment. However, the papers published in the engines used in this work are widely accepted and followed by SE researchers and practitioners. The number of papers selected in the mapping (18) can be seen as a threat to external validity. However, we followed Kitchenhamn guideline [7, 8] trying to gather all possible information about the interested topic during the last decade: BPs adopted in small companies.

5. CONCLUDING REMARKS

This article presented the processes carried out in a *quasi*-systematic mapping aimed to map the best software engineering practices already adopted for small organizations to help other companies in decision-making with the adoption of software engineering practices. All the process was described, so, other researchers can replicate this study.

Thus, during the last decade small companies have been adopted 10 BPs suggested by the SWEBOK guide. The majority of BPs adopted are related to testing, using of software process model, project planning, and analysis requirements. Another information to point out is that "Budget Limitation" and "Staff Size" were reported as causes of the non-adoption of SWEBOK BPs.

Therefore, considering that they are characteristics inherent to small companies, it is necessary the building of an instrument that allows companies estimate the approximate cost for adopting each BP. Since the cost can change in each company according by the application scope, available time, team expertise, budget, and so on, a way to make easier the calculation of these cost is demanded. We believe that through the existence of this instrument, it is possible to infer more accurately the fact of adopt or not each BP.

For future work, we will propose a catalog of best practices suitable to small companies. In addition, we would like to perform some case studies for checking in loco the companies' reality.

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