

Survey Guidelines in Software Engineering: An Annotated Review

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ABSTRACT

Background: Survey is a method of research aiming to gather data from a large population of interest. Despite being extensively used in software engineering, survey-based research faces several challenges, such as selecting a representative population sample and designing the data collection instruments.

Objective: This article aims to summarize the existing guidelines, supporting instruments and recommendations on how to conduct and evaluate survey-based research.

Methods: A systematic search using manual search and snowballing techniques were used to identify primary studies supporting survey research in software engineering. We used an annotated review to present the findings, describing the references of interest in the research topic.

Results: The summary provides a description of 15 available articles addressing the survey methodology, based upon which we derived a set of recommendations on how to conduct survey research, and their impact in the community.

Conclusion: Survey-based research in software engineering has its particular challenges, as illustrated by several articles in this review. The annotated review can contribute by raising awareness of such challenges and present the proper recommendations to overcome them.

Categories and Subject Descriptors

[General and reference]: Empirical studies

General Terms

Theory

Keywords

Survey, guidelines, annotated review

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1. INTRODUCTION

Survey is a method to collect and summarize evidence from a large representative sample of the overall population of interest. Outcomes from survey research are then combined to identify patterns, which can be generalized to the overall population. Identified patterns can be even compared against different populations and evaluated over time.

Survey-based research has been used to capture opinions in different research disciplines. Social sciences often use surveys to analyze behavior (e.g. attitude, mood, feelings), while business disciplines also use it to evaluate professionals, organizations and strategies (e.g. election pools, advertising campaigns). In Software Engineering (SE), surveys are one of the most frequently used research methods for conducting empirical investigation studies [15].

Software Engineering research differs from other disciplines, in particular regarding its objectives and subjects. Objectives are often related to improving the development process or to explore novel techniques and methods. The subjects of such studies usually involve well-qualified professionals with strong opinions regarding their areas of interest. To address such peculiarities, a specific methodology adapted to the field is often required. The main objective of this study is to summarize and detail useful references supporting survey-based research in SE.

2. RELATED WORK

There are guidelines that provide information on how to conduct survey research regardless of the field, e.g. [22, 12, 13]. Such methodological books provide valuable support to academics conducting empirical research. The survey research process involves defining a research question, choosing the sample, designing an instrument to collect the data, as well as analyzing and reporting the findings. This process is extensively used in a wide range of disciplines, including medicine and the humanities, information systems and software engineering.

Moreover, some disciplines have developed their own guidelines to support the survey process. Such guidelines often focus on the merits and the particular challenges of survey research on the related fields. Examples of those are the guidelines for cross-sectional and longitudinal studies on marketing research [25], and the guidelines for reporting surveys of medical research [1].

Also the SE field recognized the value of survey research for gathering empirical evidence [20, 17]. Alongside with experiments and data mining research, surveys provide quantitative data that can be generalised to a broader population.

Main concerns on conducting surveys studies in SE include: *a)* how to obtain a representative sample of the population (also a common challenge in other fields); *b)* addressing the differences of the terminology between academia and industry; and *c)* data patterns resulting for surveys are often difficult to explore in depth .

Many SE researchers have made effective use of surveys, with relevant research topics addressed by surveys including: *a)* empirical research methods [27, 9]; *b)* software design models and patterns [23, 28]; *c)* software development process [26, 11].

Finally, with the advent of the Word Wide Web, distributing and managing data collection instruments became easier, including saving answers automatically and 24/7 data collection availability. Guidelines to support managing self-administrated and online surveys are provided [2].

3. METHOD

We conducted a systematic search to identify the guidelines, supporting instruments and recommendations describing how to conduct or evaluate survey-based research in SE. This process takes part in a broader study collecting similar guidance for different research methods (e.g. case study, experiment, action research).

3.1 Search and Selection Process

To retrieve relevant pieces of literature, we carried out an iterative search and selection process in three steps, as illustrated in Figure 1.

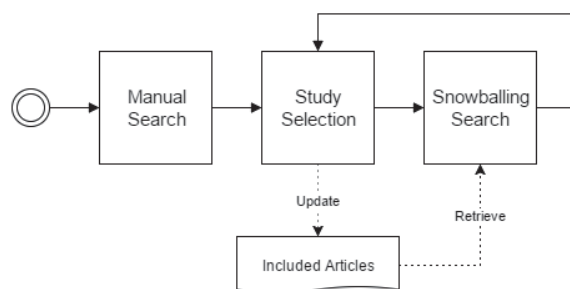


Figure 1: Search and Selection Process Overview

1. Manual Search: A manual search was done on the main fora publishing papers with a methodological focus, i.e. empirical software engineering focused conferences and journals, as follows:

- ESEM** International Symposium on Empirical Software Engineering and Measurement
- ISESE** International Symposium on Empirical Software Engineering
- EASE** International Conference on Evaluation and Assessment in Software Engineering
- METRICS** International Software Metrics Symposium
- IWSM-Mensura** International Workshop on Software Measurement
- ESE** Empirical Software Engineering Journal
- IST** Information and Software Technology Journal

2. Study Selection: Candidate articles, after collected into a single list, meeting the following criteria were included:

- I1** methodological articles for conducting surveys;
- I2** checklists and instruments to assess quality on survey-based research; and
- I3** articles reporting lessons learned and/or recommendations to improve the survey process.

3. Snowballing Search: Further, we complemented the manual search via backward snowball, sampling the included articles. A contextual reading of the papers provided references on related and similar studies. Articles collected during this stage were also aggregated into the candidates list, and selected according to the criteria described above. The process was performed twice, as a number of relevant references was still available after the first iteration.

3.2 Data Extraction and Analysis

A data extraction form was used to record the information from the relevant literature. All three researchers further piloted the form, checking for consistency. The retrieved data includes:

Reference Paper reference, i.e. authors, title, venue, publication year

Instrument Name of the guideline, supporting instrument or set of recommendations

Description Brief resume of the instrument/guideline and its objective

Research Method Context in which the instrument can be applied, i.e. for this research only surveys were selected

Activities Process activities covered by the instrument, i.e. planning, execution, analysis and/or reporting

Impact citation counting of the article until the end of 2015

Both **research methods** and **activities** could include more than one classification, as a particular guideline can support more than one method and a set activities, e.g. guidelines covering the whole process.

4. RESULTS

This section provides the description of the collected guidelines, supporting instruments and recommendations, alongside with the references to the papers detailing them.

4.1 Guidelines for Conducting Survey Research

We identified three main guidelines to support the whole survey process in SE [18, 15, 21]. Their processes slightly differ from each other, as illustrated in Table 1.

Principles of Survey Research in SE [18]. Over the years of 2001 to 2003, a series of articles discussed lessons learned on planning and conducting survey-based research. The most critical issues regarding the research method and several recommendations to overcome them were exposed and discussed.

The first article described the survey process as a set of ten activities: 1. setting specific, measurable objectives; 2. planning and scheduling the survey; 3. ensuring that appropriate resources are available; 4. designing the survey; 5. preparing the data collection instrument; 6. validating the instrument; 7. selecting participants; 8. administering and scoring the instrument; 9. analyzing the data; and 10. reporting the results. It also covers the first step, and summarizes three examples of survey research, detailing their research objectives and some notes regarding the process.

Principles of Survey Research [18]	Designing an Effect. Survey [15]	Guidelines for Cond. Surveys in SE [21]
1. setting specific, measurable objectives	1. identify the research objectives	1. defining research objectives
2. planning and scheduling the survey	2. identify & characterize target audience	2. identifying target audience and sampling frame
3. ensuring that appropriate resources are available	3. design sampling plan	3. designing sampling plan
4. designing the survey	4. design & write questionnaire	4. designing survey instrument
5. preparing the data collection instrument	5. pilot test questionnaire	5. survey instrument evaluation
6. validating the instrument	6. distribute questionnaire	
7. selecting participants		
8. administering and scoring the instrument	7. analyze results and write report	6. analyzing survey data
9. analyzing the data		7. drawing conclusions
10. reporting the results		

Table 1: Comparison among the activities described in the three main guidelines [18, 15, 21]

Further, this article’s part two discusses the survey design (activities 2 to 4 of the proposed process), starting from reviewing the objectives and deciding how to collect information to address them. Three descriptive design types are detailed, i.e. cross-sectional, longitudinal and case control surveys; and five experimental designs are also proposed in case of hypothesis testing. Later, sample size and response rate issues are also discussed. The three examples given in the previous publication are used to illustrate the issues discussed in this part.

The third part addresses the design and construction of the data collection instrument (activities 5 and 6). The particular activities of constructing and selecting questions, deciding on the type of responses and formatting the questionnaire are given. A questionnaire example is presented as an appendix at the end of the article. This part also refers to the other ones, as some issues were previously or should be later discussed.

The fourth part describes how to manage the survey (activities 7 and 8). The relevant issues in this phase are avoiding biased questions, motivating respondents, and evaluating the instruments through pre- and pilot tests. Finally, recommendations on documenting the survey process are presented, alongside rationales for the recommendations given.

The fifth part of the series address the population of interest and how to select a valid sample (mainly activity 7). The authors encourage researchers to apply a sampling approach, as invalid samples are the most commonly reported problems in SE surveys. Probabilistic and non-probabilistic sampling methods are discussed. The paper also presents statistical methods to determine an suitable sample size.

The last part focuses on data analysis methods (step 9), providing examples of analysis techniques appropriated to SE surveys. The data analysis activity is detailed in a series of actions, including data validation, partitioning the responses, data coding, and analysis both ordinal and nominal data. A final discussion unifies the issues and lessons covered in the whole series.

Designing an Effective Survey [15]. Kasunic proposes a seven-stage framework for conducting surveys in Software Engineering, as illustrated in Figure 2. This technical report details each stage, their particular sub-stages and the issues the researcher should be aware while designing a study. The content is sequentially well-organized, and the distinct actions of each stage are usually detailed in a ”questions and answers” format.

The forth stage ‘**design the sampling plan**’ is divided in four different sub-stages, as several iterations between them

could occur. Several steps require specific evaluations activities (e.g. testing the questions, piloting the questionnaire) to ensure the quality of the performed process. Finally, additional resources are listed as appendices, e.g. example of activities breakdown and cover letter. Though the guideline is comprehensive, it has not been updated since its publication, in 2005.

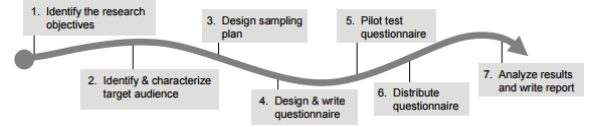


Figure 2: Survey process overview according to [15]

Guidelines for Conducting Surveys in SE v. 1.1 [21]. Recently, Linåker et al. developed a framework to conduct surveys as the result of a Ph.D. course on survey methodology. The method is divided into a number of sequential steps, as shown in Table 1. The article incorporates several lessons learned from conducting survey studies in SE (e.g. [5, 8, 9, 11]).

Unlike the previous framework, the guidelines do not present a step describing the distribution of the questionnaire and how to manage the responses. However, planning such actions is described mainly in step 3. ‘**designing sampling plan**’. At the end of the paper, the authors present a survey example reported according to the framework.

4.2 Common Survey Issues and Recommendations

Conducting on-line surveys in SE [24]. Based on experiences of conducting surveys through a Web-based environment, a series of lessons learned were proposed. Issues related to on-line self-administrated surveys are discussed, such as tracking responses in real-time, motivating respondents to return, and identifying drop-out questions, i.e. where people stop filling out the questionnaire. The implementation or acquisition of a data collection tool is also addressed.

Practical experiences in the design and conduct of surveys in empirical SE [4]. Describe a process to conduct questionnaire-based surveys based on a framework for quality improvement. The process is described in several steps detailing the preparation, conduction, and analysis of SE surveys. Although well-described, the article presents a few details on the stages of survey implementation and execution. Two large empirical studies about inspection technologies exemplify and validate the method.

Personal opinion surveys [19]. A book chapter of the “*Guide to Advanced Empirical Software Engineering*” describes survey-based research. It illustrates via three examples the use of surveys to address human-related aspects of SE, using both questionnaires and interviews as data collection methods. The process is summarized in six stages, lacking a specific activity for reporting the results.

A recently published book chapter discusses the characteristics of **Surveys** [17] as secondary studies (i.e. collecting evidence from primary sources). Some major challenges on conducting survey-based research are presented, such as the sampling frame, the kind of questions that could be answered, and how to report the survey. Examples of surveys in SE are also used to illustrate and discuss the challenges.

4.3 Recommendations for Conducting Surveys in a Particular Context

This section presents three sets of recommendations for conducting survey research with a particular objective, i.e. evaluating methods and tools; or within a particular context, i.e. international setting.

DESMET: a methodology for evaluating SE methods and tools [16]. A comprehensive approach aimed at technology evaluation through a combination of several research methods. In this context, quantitative and qualitative surveys are appropriate tools to collect information where the measurable impact is indirect, if the technology is in widespread use. The article discusses pros and cons of using surveys for such objective, and drawn recommendations to combine surveys with other research methods.

Reflections on conducting an international survey of SE [5]. Describe challenges and experiences on conducting a survey with industries in three European countries. Variations and biases in the study due to national peculiarities are discussed. Sampling suggestions based on lessons learned include: the importance to achieve a stratified random sample, and how to manage convenience samples of industry projects.

Some lessons learned in conducting SE surveys in China [14]. This experience report addresses issues related to sampling, contacting the respondents, data collection, and data validation in international setting. The main lessons are related to cooperation with a third-party organization with close relations on the target location.

4.4 Sampling Strategies in Surveys

A good sampling strategy is key to generalizing the findings from the sample to the population. Although the guidelines supporting the whole process [15, 21] describe how to manage representative samples, some issues arise when addressing large-scale surveys. Such issues are discussed in part five of principles of survey research series [18].

Supporting large scale sampling in SE surveys [6, 7, 8, 10]. A set of papers investigating the issues and proposing improvements for large scale sampling in surveys. Distinct actions on the ‘**Identifying Target Audience and Sampling Frame**’ phase are covered, as follows:

- defining the target population [8]
- characterizing units of observation, units of analysis and search unit [6, 10]
- establishing the sampling frame [8]
- recruitment strategies [7, 8]

First article [6] defines a conceptual framework and the requirements for establishing adequate sources of sampling subjects in SE surveys and to analyze its application to different sources of sampling. The **second article** [7] provides a set of lessons learned to improve the quality of samples (size, heterogeneity and level of confidence) based on a replication survey study.

A **third article** [10] identifies the most common sampling frames used in SE research and presents some recommendations on how to characterize the sampling frame. Finally, the **fourth article** [8] presents a set of experiences in applying large-scale surveys regarding the recruitment of subjects through a professional social network. The recruiting plan and automated support instruments are also provided. The information on this article partially overlaps the lessons given in [7].

4.5 Replication of Survey Studies

The main objective of a replication study is to compare the outcomes obtained in a different context setting. Through replication, data collected with similar samples over time can be used to assess the evolution of the investigated topic. Moreover, reproducing the same study could provide an evaluation of the process, its instruments and methods.

Addressing the challenges of replications of surveys in SE research [3]. An European survey on software process best practices was replicated in an Australian setting. During the replication process, several problems regarding the questionnaire content, response scale, sample selection, and statistical analysis were identified and analysed. A series of recommendations on how to address such problems are drawn based on such drawn experience.

5. DISCUSSION

In this section, we synthesize recommendations on how to better use the identified instruments and discuss the impact of the supporting instruments in an academic setting.

5.1 Recommendations on Conducting Surveys

In the previous section, we summarized several references of useful primary studies for researchers aiming to conduct survey-based research. However, it is important to consider the context and objectives of the survey when selecting the guidelines. The survey phases’ coverage by the different guidelines is summarized in Table 2.

Overall Process. Three main guidelines [18, 15, 21] reported in section 4.1 provide similar support for the whole process. The principles of survey research series [18] is a well-established starting point for novice researchers to understand the survey process and its main challenges. The six-part articles could be also used individually to support particular phases of the process.

Planning Phase. Several articles cover the survey design, and although formulated differently, most of the information is quite similar. In that sense, we recommend the researcher to follow a single reference.

The challenges related to the sampling are specifically investigated in the articles presented in section 4.4. A full coverage of the sampling sub-stage and its activities can be achieved by combining [6, 8], specially when a large scale sampling is required. To better understand the sample characterization and its implications, we recommend reading one of the following: [18, 17].

Phases	Principles of Survey Research [18]	Designing an Effective Survey [15]	Guidelines for Surveys v. 1.1 [21]	Conducting On-line Surveys [24]	Practical Experiences [4]	Personal Opinion Surveys [19]	Surveys as Secondary Studies [17]	Sampling Strategies [6, 7, 8, 10]	Replication of Surveys [3]
Planning									
Research objectives	1	✓	✓		✓	✓	✓		
Target audience	2	✓	✓	✓		✓	✓	✓	
Sampling plan	2,5	✓	✓	✓	✓		✓	✓	
Execution									
Design instrument	3	✓	✓	✓	✓	✓			
Evaluate instrument	4	✓	✓			✓			
Manage responses	4	✓		✓	✓	✓			
Analysing results	6	✓	✓		✓	✓			
Reporting results		✓	✓		✓		✓		
Replicating									✓

Table 2: Phases and activities covered by the supporting instruments, except for the recommendations for conducting surveys in a particular context [16, 5, 14]. Principles of survey research [18] comprises a series of papers, thus the specific part is identified when relevant.

Execution Phase. Most of the guidelines address the data collection instrument’s design. The evaluation of the instrument deserves special consideration as well. Such activity is usually addressed by piloting the instrument [15, 19, 21]. Reliability and validity issues are also discussed in the principles of survey research: part 4 [18] and more broadly in [22].

The effective survey framework [15] also includes a brief section to control and monitor the responses in on-line surveys. More in-depth recommendations on such actions are also provided in [24].

Analysing and Reporting Results. Similar information regarding the data analysis can be found in the main guidelines, however not all of them also detail the reporting process. In case of following one of those instruments, we further suggest as complementary reading [15, 21].

Replicating. Finally, replications of survey-based research are mainly discussed by only one paper [3], presenting lessons learned by an example. Also longitudinal studies involve repeated applications of the data collection instrument over different periods of time. Longitudinal surveys are discussed in [19].

5.2 Guidelines’s Impact

Since their reporting and/or evaluation, the identified articles have been used to support survey-based research. By counting the number of citations is possible to have an indication of their impact. We gathered the total number of citations until the end of 2015. It is important to note however, that several factors can influence in the number of citations, and the purpose of this discussion is not to evaluate, but instead illustrate the representativeness of such guidelines.

The principles of survey research [18] has had some impact in the SE community: part 1 has 182 citations; part 2 has

43; part 3: 122; part 4: 115; part 5: 216; and part 6: 63 citation. It is interesting to note that the less cited article is the one describing the survey design and objectives.

Personal opinion surveys [19] (114 citations), designing effective surveys [15] (88) and the recommendations to conduct on-line surveys [24] (69) also presented good on the community. On the other hand, the recent guidelines for conducting surveys [21] are not yet widespread in the community, presumably due to its too recent publication, i.e. June 2015.

The collection of studies on sampling strategies [6, 7, 8, 10] published between 2014–2015 follow a similar trend, having no more than 4 citations each. Although the book on Evidence-based Software Engineering (published in September 2015) received a couple of citations so far, none of them are directly related to its survey chapter [17]. Finally, both replications [3] and international surveys [5] seem to be weakly recognized by the community, i.e. circa of 10 citations were acquired each since their publication, in 2005.

This analysis of impact showed some newly published articles, covering the topics recently incorporated to the state of art (i.e. according to the discussed in section 5.1). One can conclude that the surveys conducted before this stage did not benefit from a particular guidance for that topic. Moreover, many published surveys did not cite the guidelines described in this study, which suggests: *a)* they follow guidelines from outside the SE field; *b)* they were conducted without literature support; or *c)* the supporting methodology was not reported. The causes and impact of such gap are interesting points for reflection that could be addressed as future work.

5.3 Validity Threats

This section discusses some of the potential threats to the validity of this study. **Search Strategy:** Our manual search strategy aimed at some of the most relevant venues for methodological articles in SE, however we cannot guarantee that all the guidelines and instruments were identified. Two snowballing iterations extended our search beyond these venues, but were still limited by the references in the selected papers.

Selection of Candidate Articles: Before the selection, we conducted a think-aloud pilot exercise with a sample of the candidate papers. The first author described the reasoning of selecting each one. The selection was further conducted by the three authors, and each candidate article was assessed by two of them. Any disagreements were mediated by the third researcher.

Snowballing Strategy: Papers retrieved by snowballing did not include all the references from the candidate articles, rather a contextual reading of the included papers was performed, and relevant citations were collected. Such citations included related work, background research, and comparisons between methods and tools. After the snowballing search, we noticed additional relevant references. Thus, the snowballing process was interactively performed a second time.

Data Extraction: A pilot of the data extraction phase was done to validate the extraction form. We found that, except form the open fields (i.e. guideline name and description), consistent information was retrieved. Further data collection was conducted mainly by one researcher. During this phase, judgmental errors may have happened while clas-

sifying the papers according to the research methods, and the covered phases.

6. CONCLUSIONS

In this paper, we presented a summary of the existing guidelines, instruments and recommendations to survey-based research in SE. Based on a systematic search strategy, 15 references from articles proposing such instruments were gathered and selected. The relevant literature was described in section 4 and later discussed in section 5.

Three main articles [18, 15, 21] provide a step-by-step overview of the survey process. However, to follow a single guideline sometimes is not enough, since they do not cover a particular activity or challenge a researcher may face. Relevant challenges addressed by complementary literature include monitoring the responses, designing and assessing the data collection instrument, and finding an appropriate sample frame.

Further, we briefly analysed the impact of the collected instruments in SE community. Some of them are well-established, and have been used to guide several survey studies during the last decade. However, some guidelines (e.g. [21, 8]) are recent and have yet not been evaluated by the community.

The need for a comprehensive review is motivated by the partial coverage of the existing guidelines and the lack of impact of articles covering the relevant challenges. We therefore hope this annotated review help researchers find and select the most appropriate guidelines. By using the proper guides, studies can achieve better quality thus providing the SE community with more meaningful evidence.

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