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Survey Research in Software Engineering: Problems and Mitigation Strategies

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ABSTRACT Background: The need for empirical investigations in software engineering is growing. Many researchers nowadays, conduct and validate their solutions using empirical research. The Survey is an empirical method which enables researchers to collect data from a large population. The main aim of the survey is to generalize the findings.

Aims: In this study, we aim to identify the problems researchers face during survey design and mitigation strategies.

Method: A literature review, as well as semi-structured interviews with nine software engineering researchers, were conducted to elicit their views on problems and mitigation strategies. The researchers are all focused on empirical software engineering.

Results: We identified 24 problems and 65 strategies, structured according to the survey research process. The most commonly discussed problem was sampling, in particular, the ability to obtain a sufficiently large sample. To improve survey instrument design, evaluation and execution recommendations for question formulation and survey pre-testing were given. The importance of involving multiple researchers in the analysis of survey results was stressed.

Conclusions: The elicited problems and strategies may serve researchers during the design of their studies. However, it was observed that some strategies were conflicting. This shows that it is important to conduct a trade-off analysis between strategies.

INDEX TERMS Empirical software engineering, surveys.

I. INTRODUCTION

Surveys are a frequently used research method in the software engineering context. Punter *et al.* [53] highlighted the increased usage of surveys over case-study and experiments.

A survey is one of the empirical investigation methods which is used to collect data from a large population [37]. Surveys have been characterized by different authors: Pfleeger highlights that a “survey is often an investigation performed in retrospection [51]”; Babbie adds that “surveys aim is to understand the whole population depending on the sample drawn” [2]. Fink [17] states that “surveys are useful for analyzing societal knowledge with individual knowledge.” Wohlin *et al.* highlight that “many quantifiable and processable variables can be collected using a survey, giving a possibility for constructing a variety of explanatory models” [65]; Fowler, Jr., [18] states that “statistical evidence can be obtained in a survey.” and Dawson adds that “surveys draw either qualitative or quantitative data from the population” [11].

Stavru [60] critically reviewed surveys and found limitations in relation to the definition of the sampling frame, description of the sampling method and the definition of the actual sample. Furthermore, the response rate was rarely identified. Sampling-related aspects were most highly prioritized as issues [60]. Given the limitations in the agile literature, there is a need to further explore the use of surveys and understanding how they were conducted in the software engineering context [60]. Stavru [60] also points to the need of frameworks to evaluate survey research as these were not available in the software engineering literature (cf. [60]). Researchers themselves recognize that they are facing problems when conducting surveys, highlighting problems such as limited generalizability, low response rate, survey reliability, etc. [13], [19], [23]–[25], [28], [50], [67], [68]. The reason for researchers facing problems could be either he/she is unaware of the problems or they lack strategies to overcome the problems in the survey process. In both the cases the outcome of surveys is unreliable (cf. [52]).

Thus, in this study the main focus is on identifying the problems researchers face and document in the surveys they are executing and the mitigation strategies they report. In particular, the following contributions are made:

- C1: Identify the problems researchers in software engineering face when conducting survey research.
- C2: Identify mitigation strategies.

The contributions are achieved through the review of literature combined with an interview-study has been conducted with nine subjects. In the literature review we focused on existing surveys and elicited problems observed as well as mitigation strategies reported in them. A traditional literature review has been used. The interview study was based on convenience sampling and face-to-face interviews. Thematic analysis has been used to analyze the results of the interviews.

The remainder of the article is structured as follows: Section II presents the background on survey research by explaining the general process of conducting survey research. Section III presents the related work where problems as well as strategies were elicited from existing guidelines as well as primary survey studies conducted in software engineering. Section IV explains the research design for the interview study conducted. The interview results are thereafter shown in Section V. Section VI discusses the findings from the literature study and the interviews. Section VII concludes the paper.

II. BACKGROUND ON THE SURVEY RESEARCH METHOD

Robson and McCartan [54] define the survey methodology as “a fixed design which is first planned and then executed”. Moller et al. reviewed the steps of survey research guidelines for software engineering [47]. Commonly defined steps are highlighted in Figure 1.

A. RESEARCH OBJECTIVES ARE DEFINED

The initial step is to identify the research objectives. They help to set the required research scope and context for framing the research questions. While identifying the research objectives it is essential to throw light on certain issues apart from just identifying the research questions. The following reflective questions should be checked when defining the research objectives [37]:

- What is the motivation behind Survey?
- What are the resources required to accomplish the survey's goals?
- What are the possible areas which are close to the research objectives that were left uninvestigated?
- What is the targeted respondent population of survey?
- How will the data obtained from survey be used? [6], [37], [41]

While defining the research objectives for a survey, the related work pertaining to that particular field must be considered. The knowledge about similar research helps researchers to narrow down the objectives.

Wohlin et al. [65] clearly defines the purpose (objective or motive) for conducting a survey. Based on the objective, any

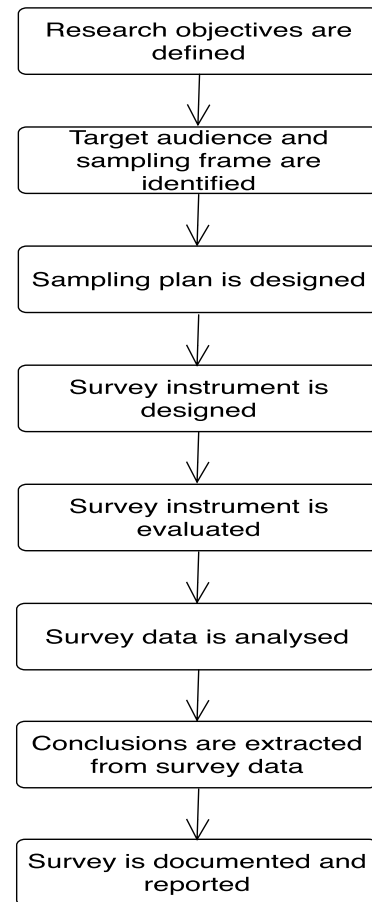


FIGURE 1. Eight steps of a survey.

survey falls into one of the below three categories:

- Descriptive Surveys are conducted with the intention of explaining traits of a given population. For example, they describe which development practices are used in practice.
- Explanatory Surveys investigate cause-effect relationships. For example, they try to explain why a specific software development practice is not adopted in practice.
- Exploratory Surveys helps the researcher's to look at a particular topic from a different perspective. These surveys are generally done as a pre-study. They help to identify unknown patterns. The knowledge obtained from this pre-study will serve as a foundation to conduct descriptive or explanatory surveys in the future [65].

B. TARGET AUDIENCE AND SAMPLING FRAME ARE IDENTIFIED

The identification of the target population implies the establishment of a targeted audience. The target audience selection must be driven by the research objectives. The survey instrument design must be designed from the respondent's perspective, which requires a clear definition of the population and target audience. Similarly, the rule must be applied while selecting the method of surveying (questionnaire or interviews) [37].

The target audience is generally selected from the overall population, if they are attributed with distinct values. The sample is selected from the sampling frame comprising of the possible respondents from the population. Populations can be categorized into sub-populations based on distinguishing attributes, which may be utilized for stratified or quota sampling [61]. Four basic problems of sampling frames are identified in [38] which are: “*missing elements, foreign elements, duplicate entries and group based clusters*”.

C. SAMPLE PLAN IS DESIGNED

Sampling is the process of selecting a sample for the purpose of studying the characteristics of the population. That is, sampling is needed to characterize a large population [35]. Sampling is mainly divided in two types [42], namely probabilistic and non-probabilistic sampling.

Probabilistic Sampling: Each member of the population has a non-zero probability of being selected. Below are the three types of probabilistic sampling techniques [62]:

- Random Sampling: Members of the sampling frame are selected at random.
- Systematic Sampling: A sampling interval is determined (k) and every k th element is chosen from the sampling frame.
- Stratified Sampling: The sampling frame is divided into different groups (e.g. based on experience level of developers in an experiment) and the subjects are chosen randomly from these groups.

Non-Probabilistic Sampling: Member selection in this case is done in some non-random order. Below are the types of non-random sampling techniques [18], [37]:

- Convenience Sampling: Subjects are selected based on accessibility. Examples are the utilization of existing contact networks or accessing interest groups (e.g. LinkedIn) where subjects are available that are clearly interested in the subject of the survey.
- Judgment Sampling: The sample is selected through the guidance of an expert. For example, a company representative for a company-wide survey may choose the subject best suited to answer the survey due to their expertise.
- Quota Sampling: Similar to stratified sampling the sample is divided into groups with shared traits and characteristics. However, the selection of the elements is not conducted in a random manner.
- Snowball Sampling: Existing subjects of the sampling frame are utilized to recruit further subjects.

D. SURVEY INSTRUMENT IS DESIGNED

Survey outcomes directly depend on how rigorous the survey has been designed. Questions (such as open and closed questions) are designed, and different question types are available (e.g. Likert-scale based questions). The factors which needs to be considered while designing surveys have been discussed by Kasunic [37].

E. SURVEY INSTRUMENT IS EVALUATED

After the Survey Instrument has been designed, it needs to be evaluated to find out if there are any flaws. To determine a questionnaire’s validity a preliminary evaluation is conducted. Examples of different evaluation methods are:

- Expert Reviews [59].
- Focus Groups [59].
- Cognitive Interviews [31], [44], [59].
- Experiment [48].

F. SURVEY DATA IS ANALYZED

The obtained survey data is analyzed in this step. The data analysis depends on the type of questions used in the survey.

- Common methods to analyze the results of open-ended questions are phenomenology, discourse analysis, grounded theory, content analysis and thematic analysis [3], [15], [22], [33], [56].
- For closed-ended questions, quantitative analysis can be employed. Methods such as statistical analysis, hypothesis testing, and data visualizations can be employed to analyze the closed-ended questions [65].

With regard to the analysis process Kitchenham and Pfleeger [40] suggest the following activities:

- 1) *Data Validation:* Before evaluating the survey results, researchers must first check the consistency and completeness of responses. Responses to ambiguous questions must be identified and handled.
- 2) *Partitioning of Responses:* Researchers need to partition their responses into subgroups before data analysis. Partitioning is generally done using the data obtained from the demographic questions.
- 3) *Data Coding:* When statistical packages cannot handle the character string categories of responses, researchers must convert the nominal and ordinal scale data.

Wohlin et al. [65] describes the first step of quantitative interpretation where data is represented using descriptive statistics visualizing the central tendency, dispersion, etc. The next step is data set reduction where invalid data points are identified and excluded. Hypothesis testing is the third step.

G. CONCLUSIONS EXTRACTED FROM SURVEY DATA

After the outcomes have been analyzed, conclusions need to be extracted from them. A critical review and an evaluation must be done on the obtained outcomes. Thus validity, reliability and risk management should be evaluated when presenting conclusions. Every research has threats, but the main motive is to identify them at the early stages and try to reduce them. Threats may be completely mitigated by research design decisions, while other threats remain open or may only be partially reduced. To handle such threats, it is advised that more than one method must be used to achieve a research objective for reducing the impact of a particular threat [6], [54].

H. SURVEY DOCUMENTED AND REPORTED

The documentation of the survey design is updated iteratively as the research process progresses. Different elements of documentation include research questions, objectives, activity planning, sample method design, data collection, data analysis methods, etc. This documentation is referred to as “questionnaire specification” by [41], while it is named a “survey plan” by Kasnunic [37].

The last step is the reporting of the analysis and conclusion. Even though the survey methodology is administered sequentially, results reporting might vary depending on the targeted readers (e.g. researchers or practitioners). Since the interests of audiences differ, Kasnunic [37] recommend conducting an audience analysis. Stavru [60] evaluated existing surveys in software engineering and identified the most critical elements to be reported in surveys. The most critical elements were:

- The sampling frame and the number of elements in the sampling frame.
- The strategy of sampling from the sampling frame
- The size of the sample
- The target population
- The response rate
- Assessment of the trustworthiness of the survey
- Execution of the survey (research steps)
- Concepts and theories used (e.g. variables studied)
- The design of the survey

III. RELATED WORK

A. GUIDELINES FOR SURVEY RESEARCH IN SOFTWARE ENGINEERING

Molléri *et al.* [47] surveyed the literature to identify guidelines for survey research. Three literature sources [37], [39], [43] presented the overall survey process, while several studies focused on individual parts of the process (e.g. only planning and execution). Overall, Molléri *et al.* [47] found that the different processes comprise of similar steps, while they have different granularities.

The article by Kasnunic [37] described guidelines for conducting a survey. The author describes each step in the survey process and formed the basis to structure the background reported in this paper (Section II).

In addition to overall processes prescribed for survey research several guidelines focused on specific aspects of survey research.

Punter *et al.* [53] presented guidelines focusing mainly on online-surveys. They have drafted a set of guidelines to perform online survey from their own experiences of conducting five on-line surveys. They highlighted that data obtained from online surveys is easy to analyze as it is obtained in the expected format while paper-based forms are error prone. Online surveys track the responses of invited respondents and log the details of those who actually answered the survey, which allows to more easily follow up and increase response rates. Punter *et al.* [53] argued that online surveys help to gather more responses and ease the disclosure of the results obtained.

Low response rates are a common problem for any survey, which was identified by Smith *et al.* [57]. Based on their expertise and the existing literature, they performed a post-hoc analysis on previously conducted surveys and came up with factors to improve participation rate. They even specified the limitations of the obtained results stating that “an increase in participation doesn’t mean the results become generalizable” [57].

Pertaining to the survey sampling, de Mello *et al.* [12] propose a framework consisting of target population, sampling frame, unit of observation, unit of attribute and an instrument for measurement. Ji *et al.* [34] have conducted surveys in China and addressed the issues relating to sampling, contacts with respondents and data collection, and validation issues. Conradi *et al.* [8] have highlighted the problem of method biases, expensive contact processes, problems with census type data, and national variations by performing an industrial survey in three countries - Norway, Italy and Germany. This is the first study in software engineering which used census type data. The problem of replications of surveys was highlighted by Cater-Steel *et al.* [4] who replicated a European survey, which was administered in Australian software development organizations.

B. PROBLEMS AND STRATEGIES

The problems and strategies in literature are structured according to the steps presented in Figure 1. We first present the problems (LP**) and the strategies (LS**) mentioned in the literature that were directly linked to the problems by the authors.

1) TARGET AUDIENCE AND SAMPLING FRAME DEFINITION AND SAMPLING PLAN

a: LP01: INSUFFICIENT SAMPLE SIZE

Insufficient sample size is the major threat for any software engineering survey. Meaningful statistical evidences cannot be obtained even when the parametric tests are applied on to a particular sample due to insufficient size [46], [49]. One of the main aims of Surveys is to generalize findings to a larger population. Generalizability increases survey’s confidence. Small sample size is attributed as the main cause for the lack of generalizability. If generalizability is not possible then the whole aim of the survey is not achieved [5], [13], [20], [28], [66], [68]. As Kitchenham and Fleegeer [40] describe, inadequate sample size negatively impacts the survey outcomes in two ways. Firstly, deficient sample size leads to results that do not show any statistical significance. Secondly poor sampling of clusters reduces the researcher’s ability to compare and contrast various subsets of the population.

Reasons are small sample sizes are busy schedules of the respondents [1], [19], poorly designed survey layout, lack of awareness about survey and long surveys [19]. Ji *et al.* [34] explained the impact of culture on response rates. They argued that socio-economic positions of the respondents

might hinder their willingness to answers. Authors showed that collectivism had direct influence on the information sharing, where people are not interested in sharing information outside their group (i.e. with researchers). Several solutions have been proposed in the literature:

- *LS01: Use personal contact network*: The personal contact network is used to recruit respondents [1], [13], [19], [50], [64].
- *LS02: Cultural awareness*: This issue can be handled by carefully designing questionnaire being aware of the cultures of the respondents [34].
- *LS03: Use probabilistic sampling*: If researchers aim is to generalize to a target population, then probabilistic sampling must be considered [40].
- *LS04: Use of convenience sampling*: Garousi et al. [21] describe the motivation for researchers selecting convenience sampling over other techniques, highlighting that convenience sampling is less expensive and troublesome.
- *LS05: Evaluate the trustworthiness of the sample* [60]: Different ways for calculating the sample size depending on the size of the population have been proposed [37].
- *LS06: Reciprocity*: Researchers can induce reciprocity (respondents answer more than once, e.g. for different projects) by giving rewards. Smith et al. [57] were not sure whether this practice was actually useful in software engineering domain as it may introduce a bias in the results.
- *LS07: Consistency*: It is the nature of humans to experience cognitive pressure when they are not performing the promised deeds. This characteristic can induce more responses for a survey [57].
- *LS08: Authority and Credibility*: The compliance for any kind of survey can be increased by the credibility of the person who is administering the survey. Researchers can utilize this benefit by providing the official designations like Professor or PhD in the signature of the survey request mail [57].
- *LS09: Liking*: Respondents tend to answer the surveys from known persons. The responsibility of gaining trust lies with the researchers [57].
- *LS10: Scarcity*: It is the human nature to react fast when something is scarce, research can increase the survey's response rate by convincing about the survey's uniqueness. [57].
- *LS11: Brevity*: Respondents tend to answer shorter surveys compared to lengthy ones. Researcher should address the number of questions at the start of survey, a progress bar must be placed to help respondents know the survey progress. Usage of close ended questions also helps to attract more respondents [57].
- *LS12: Social Benefit*: Authors describe that more respondents finish the survey if it benefits to a large group instead of a particular community. Researchers must convince the respondents that their survey benefits larger population [57].

- *LS13: Timing*: The time at which an email survey is sent also affects its response rate. A study shows that respondents tend to answer emails right after their lunch [57].
- *LS14: Define clear criteria for sample selection*: Selecting the respondents based on a set of criteria (that are defined at the survey instrumentation stage) can reduce the chances of improper selection [58].
- *LS15: Third party advertising*: Third party advertising can lead to more survey responses, Gousios et al. [29] obtained a 25% increase in responses rate by following this process. Gousios et al. [30] have used customized reports along with third party advertising to increase their response rate.
- *LS16: Use snowball sampling*: Respondents of the survey are asked to answer and forward it to their colleagues [20], [21].
- *LS17: Recruit respondents from GitHub*: Testers and coders can be recruited for a survey using GitHub [7], [30].
- *LS18: Provide rewards*: Researchers can attract the respondents by giving rewards like Amazon points or vouchers gifts. They have to be careful about the responses obtained, since respondents might just answer survey for sake of rewards or answer it twice [7], [10].

b: LP02: CONFIDENTIALITY ISSUES

In some case software engineering researchers would like to observe on-going trends in the industry or study about specific industrial issues. Though, the software companies do not allow the respondents to take the survey due to the issue of confidentiality. This is problem was faced by one of researchers in their survey “*their companies would not allow employees to take this survey due to concerns about confidentiality*” [34].

- *LS19: Personalized e-mails*: This threat could be mitigated by sending personal emails rather than system generated emails and by having a follow-up with all those respondents till the survey ends [34]. Even if this does not handle the issue then it is better to have personal meeting to discuss about the survey.

c: LP03: GATE KEEPER RELIABILITY

A gate keeper (person having all the details of employees) from a particular company is contacted by the researcher. The questionnaire is then sent to the gatekeeper, then he/she forwards it to respondents in that company. Sometimes respondents do not receive questionnaire resulting in the a lower participation rate for a survey.

- *LS20: Use IT responsables for reliable distribution of invitations*: This issue was reported by Conradi et al. in their research. Authors mitigated this problem by contacting IT-Responsible for that particular company for getting respondent details [34].

d: LP04: NO PRACTICAL USEFULNESS

Any surveys that does not prove to be useful to the respondents, chances are much likely to skip the survey. Torchiano and Ricca [63] clearly show this in the following lines “by far the study is interesting but to whom are the results useful for?”.

- *LS21: Explicitly motivate the practical benefit of the survey:* This issue can be handled by motivating the respondents by giving description about survey outcomes and need for answering survey.

2) SURVEY INSTRUMENT DESIGN, EVALUATION, AND EXECUTION

a: LP05: FLAWS IN THE WORDING OF QUESTIONS

Sometimes questions are ambiguous, confusing or leading [16], [29]. When survey questionnaire is not clearly understood the respondents arrive at wrong conclusions about questions, as a result they answer incorrectly [63]. Respondents may give two contrary answers for the same question, i.e. being inconsistent within the same survey [67]. This problem can be handled by posing same question in different ways [67].

- *LS22: Survey pre-test:* Researchers [16], [29] pretested the survey with subjects (internally as well as externally with real subjects).
- *LS23: Expert discussions:* Discussions with colleagues and domain experts were also the part of pre-test process. Gorschek et al. [28] have also done redundancy check in addition pre-tests and expert discussion to handle the Survey Instrumentation Problems. Spínola and Travassos [58] used external researchers that are not involved in the research and reformulated the questionnaire based on their reviews.
- *LS24: Ask the same question in different ways:* Lack of consistency and understanding can be handled by posing same question in different ways [67]

b: LP06: TRANSLATION ISSUES

Translation issue is one of the common problems faced in globally conducted surveys. Yang et al. [67] conducted a global survey in Europe and China. The authors posted a questionnaire after translation. As a result of a poor translation data loss occurred. It led to misinterpretation by the respondents leading to false answers.

- *LS25: Collaboration with international researchers:* This problem can be handled when researchers working same domain of the same origin are involved in translation process. Language issue like accent and sentence formulation can be handled in the same manner [29], [34]. Solutions are:

c: LP07: BIASES DUE TO QUESTION-ORDER EFFECT

Question-order effect [29] means that the order of the questions is a confounding factors influencing the answers by the subjects.

- *LS26: Order randomization:* This issue can be mitigated by the authors by randomizing the questions of the questionnaire [29].
- *LS27: Natural actions-sequence:* Designed the questionnaire based on a natural actions-sequence helping the respondents in recalling and understanding the questionnaire properly [30].

d: LP08: LIKERT SCALE PROBLEMS

A Likert scale is one dimensional in nature, researchers mostly use this in surveys with an assumption that respondent's opinions can be mapped well to a construct represented by the Likert scale (e.g. team motivation can be surveyed, but is a very complex construct). In a realistic scenario this is not true. Some respondents might get confused on what responses to pick, settling for the middle option. Analyzing the results obtained by higher order Likert scales for analysis posing a threat of misinterpretation or data losses [16].

- *LS28: Avoid two-point scales* Researchers should avoid two point Likert scales ‘yes/no’, instead they are advised to use other multi-point scales [4].

e: LP09: PEOPLE PERCEPTIONS

Perception of people answering the survey adversely impacts the survey outcome. In software engineering a survey is done to collect the attitudes, facts, and behaviors of the respondents. This issue cannot be mitigated or controlled completely [26], [63].

f: LP10: LACK OF DOMAIN KNOWLEDGE

A posted survey could be answered by the respondents without proper domain knowledge. This leads to misinterpretation of the questionnaire resulting in wrong answers [4], [34], [46], [67]. Ji et al. [34] commented that “busy executives likely ignore the questionnaires, sometimes their secretaries finish the survey. In some case the responses obtained are filled with out by the respondents without domain knowledge”. One solution proposed was:

- *LS29: Explicitly consider background knowledge in the survey:* Gorschek et al. [28] stressed the need for considering the impact of background influence of the subjects on survey results while surveying.

g: LP11: HIGH DROP-OUT RATES

Sometimes respondents start answering the surveys, but they lose interest after some time as the survey progresses; boredom leads to the low response rate. Lengthy surveys might a reason for the respondents to feel bored [19]. One obvious solution is:

- *LS11: Brevity:* Researcher should limit the number of questions.

h: LP12: TIME CONSTRAINTS OF RUNNING THE SURVEY

Time limitations put on surveys as a constraint limit the response rate. Nurdiani et al. [50] showed that time

limitation is the main factor for respondents not answering questionnaire or taking phone interviews. It can be clearly seen from these lines “*all the 13 respondents were asked to take part, due to time limitation we obtained only 9 responses.*” Sometimes researchers neglect the responses obtained from the actual subjects due to time limitation, following lines discuss about this issue “*due to rather low response rate and time limits, we have stopped on 33 responses, which covers 13.58% of the Turin ICT sector*” [14].

i: LP13: EVALUATION APPREHENSION

People are not always comfortable being evaluated, which affects the outcome of any conducted study [65]. It is the same case with survey studies, sometimes respondents might not be in a position to answer all the questions, instead they shelter themselves by just selecting safer options. This affects the survey outcomes. The following solution has been proposed:

- *LS30: Guarantee anonymity:* Anonymity of subjects reduced this problem of evaluation apprehension [28].

j: LP14: COMMON BIASES OF RESPONDENTS

Bias or one-sidedness is a common problem during the survey process. Common types of biases are:

Mono-Operation Bias: Sometimes the instrument in survey process might under present the theory involved, this is called mono-operation bias [65]. Solutions are:

- *LS24: Ask the same question in different ways:* Framing different questions to address the same topic [28], [46]
- *LS31: Source triangulation:* Collecting data from multiple sources [28], [46]

Over-Estimation Bias: Sometimes the respondents of the survey over-estimate themselves, introducing bias into survey results. Mello and Travassos [13] identified that “*LinkedIn members tend to overestimate their skills biasing the results*”.

Social Desirability Bias: There are situations where respondents tend to appear in the positive light. This might be due the fear of being assessed by the superior authorities. This has a lot of influence on survey outcomes. The following strategy is proposed:

- *LS30: Guarantee anonymity:* Maintaining the anonymity in responses and sharing the overall survey result after reporting [29].

k: LP15: HYPOTHESIS GUESSING

This is a construct validity threat where respondents guess the expected survey outcomes, they try to base that anticipation (hypothesis) towards answering questions either in a positive way or a negative way [65].

- *LS32: Stress importance of honesty:* Gorscheck et al. [28] tried to mitigate by stressing the importance of honesty in the introduction of the survey by means of a video and a web page.

l: LP16: RESPONDENT INTERACTION

This is a conclusion validity threat. During the survey process the respondents might interact and thus influence each other. In small surveys this threat has a large impact on the survey outcome, but in case of surveys done at large scale the impact gradually decreases [28].

3) DATA ANALYSIS AND CONCLUSIONS

a: LP17: ELIMINATING INVALID RESPONSES

In large scale surveys, during analysis this problem poses a lot of work to the researcher as they need to eliminate all the incorrect responses. A strategy is voluntary participation.

- *LS27: Voluntary participation:* This problem can be reduced by making the survey strictly voluntary and only collecting data from the respondents who are willing to contribute [67].

b: LP18: RESPONSE DUPLICATION

A major problem is faced in open-web surveys is response duplication, where the same respondent answers the questionnaire more than one time [16], [30], [45].

c: LP19: INACCURACY IN DATA EXTRACTION AND ANALYSIS

Inaccuracy in the data extraction and analysis might arise when data extraction from the questionnaire and result reporting are done by an individual person [16].

- *LS28: Multiple researchers conduct analysis:* Multiple researchers should be utilized when extracting and analyzing the data [16].
- *LS29: Check the consistency of coding between researchers:* Two researchers may check their inter-rater reliability through an analysis using the Kappa statistic [16].

4) REPORTING

a: LP20: LACK OF MOTIVATION FOR SAMPLE SELECTION

Many researchers fail to report their motivation for sample selection [60].

b: LP21: CREDIBILITY

For the survey methodology to be accepted as credible and trustworthy, the research method and results need to be clearly presented [60].

IV. RESEARCH METHOD

A. RESEARCH QUESTIONS

We formulated a corresponding research question for each contribution.

- *RQ1:* Which problems do researchers in software engineering report when conducting surveys?
- *RQ2:* Which strategies do they suggest to overcome the problems?

TABLE 1. Interviewee's details.

ID	Position	Research experience (years)	#Publications (DBLP)	Time taken (minutes)
1	Professor	32	170	80
2	Professor	16	73	90
3	Professor	12	70	60
4	Professor	15	37	40
5	Post Doctoral Researcher	8	11	60
6	Post Doctoral Researcher	9	18	60
7	PhD student	4	4	90
8	PhD student	5	10	50
9	PhD student	5	17	90

B. SELECTION OF SUBJECTS

Initially a list of 20 software engineering researchers were chosen to be interviewed. We focused on people conducting empirical software engineering research and included early career researchers as well as senior researchers (PostDocs and professors). Request mails were sent stating the research purpose and the need for their appointment. We received nine positive replies stating their willingness for an interview. The interviews were conducted face-to-face. All the interviews were conducted for a time-span of 50 to 90 minutes. The subjects included four professors, two PostDoc researchers and three PhD students, as shown in Table 1. Overall, the table shows that the researchers have substantial experience.

C. DATA COLLECTION

Generally, interviews are conducted either way individually or with group of people, focus groups [27], [55]. In this research we have conducted individual interviews where interviews are done one person at a time. The characteristics of the interview that we have conducted are as follows [36]:

- *Use of open-ended questions:* Through these questions we aimed for an extended discussion of the topic. In this way interviewees had the freedom of expressing their opinions based on their experiences.
- *Semi-Structured format:* We focused on getting an in-depth knowledge of topic thorough interviews. This can be achieved if the interviewer has a set of questions and issues that were to be covered in the interview and also ask additional questions whenever required. Due to this flexibility have chosen semi-structured interviews.
- *Recording of responses:* The interviews were audio recorded with interviewees consent. Field notes were maintained by the interviewer which were helpful in the deeper meaning and better understanding of the results.

The aim of this interview questionnaire is to investigate the problems faced by the researchers while conducting surveys in software engineering. This questionnaire is divided into two sets of questions The first set of questions mainly focuses on problems that are commonly faced by the researchers like cultural issues, instrument flaws, validity threats and generalizability issue. The interviewee is expected to answer these questions from a researcher's perspective. The second set of questions mainly focuses on problems that a respondent

faces while answering a survey. It also includes the questions asking for suggestions and recommendations regarding the questionnaire design. The interviewee (software engineering researcher) is expected to answer these questions from a respondent's Perspective.

Finally, the questionnaire ends by asking researchers for their strategies to address the problems raised earlier.

The complete questionnaire is can be found in Appendix A.

D. DATA ANALYSIS

We have chosen thematic analysis process to analyze the results obtained during the interviews. Although there are many other procedures that can be followed to analyze we have a strong reason for opting thematic analysis. The information which needs to be analyzed is the information obtained after conducting several interviews. Since, we were analyzing the results obtained from several interviews, we believed that thematic analysis will assist in analyzing the information very effectively. In the following part of this section, we are going to describe several steps performed during analysis [9].

1) EXTRACTION OF INFORMATION

In this stage, we collect all the data from the transcripts prepared from all interviews. As explained above, our transcripts were prepared immediately after the interviews. We have made field notes during each and every interview to make sure that all the interviewees exact view point and their suggestions about our research were penned down during the interview itself. We have collected all these information and documented as a part of this data extraction process. We have gone through all the interview transcripts several times in order familiarize ourselves about the information which we have extracted from our interviews both verbally and non-verbally. We made sure that we have a clear idea of all the information which we had extracted [9].

2) CODING OF DATA

As a process of coding our data, we have exclusive codes for all the interviews we conducted. We started with Interview1, Interview2 and so on. This will ensure that our information is segregated according to the interviews which will assist us during the later phases of analysis. We also provided

coding few concepts which are similar for all interviews like Interview 1.1 and Interview 2.1 and so on.

3) TRANSLATION OF CODES INTO THEMES

After all data was provided several codes we have generated. All the codes were translated into several themes according to the information. Our main in translating the coded information into themes was to obtain all similar information under one theme. This will also help us in analyzing the information which we collected.

4) MAPPING OF THEMES

Mapping of themes is the process which acted as a check point for the standard of information which we have collected. This assisted to assessing if the amount of information is sufficient for our research and also checks on if we have missed out on any aspect during our process. All the themed information is mapped with the relevant codes during this process.

5) ASSESS THE TRUSTWORTHINESS OF OUR SYNTHESIS

This process is to assess that if we had achieved our anticipated results and are the results obtained after the thematic analysis are in sync in what we actually desired. This also helped us in gaining confidence when we know that our analysis came out well and this analysis is going to contribute us a lot in advanced stages of our research.

E. THREATS TO VALIDITY

1) INTERNAL VALIDITY

Before designing the questionnaire, the objectives of conducting an interview have been clearly defined. The literature review was conducted prior to the interviews as input to the interview design. Interviews were recorded reducing the risk of misinterpretation or missing important information while taking notes. As the interview was semi-structured the risk of interviewees misunderstanding questions was reduced given the dialog that took place between interviewers and the interviewee.

2) EXTERNAL VALIDITY

A different set of researchers may have different experiences and views of how to conduct surveys. We reduced the threat by conducting an extensive review of the literature overall including more than 70 references. We assured that we included researchers of different experience levels included novice researchers (PhD students who had 3-4 years of experience); experienced researchers (8-10 years of experience) and very experienced researchers (who had 30 years of experience).

3) CONSTRUCT VALIDITY

While coding interviews data, chances are that we might have wrongly interpreted and coded the results. To mitigate this threat, the data after coding was crosschecked with the actual

descriptions from interviews. Furthermore, the coding and structuring into higher level categories were reviewed by multiple authors. This increased the trust in using and interpreting the constructs described in the interviews correctly.

4) CONCLUSION VALIDITY

Wrong conclusions may be drawn given the data. To reduce this threat multiple researchers were involved in the interpretation of the data. To also increase the reliability in the data we made sure that all the information obtained during interviews is documented immediately: *“As soon after the interview as possible, to ensure that reflections remain fresh, researchers should review their field notes and expand on their initial impressions of the interaction with more considered comments and perceptions [32].”*

V. INTERVIEW RESULTS

A. TARGET AUDIENCE AND SAMPLING FRAME DEFINITION AND SAMPLING PLAN

1) IP01. INSUFFICIENT SAMPLING

All the interviewers have one thing in common, they strongly believe that everyone who claims to use random and stratified sampling have actually done convenience sampling, the reason for this being in-feasibility to get a representative sample of the population. The main reason behind this is researchers cannot explicitly define the target population as all relevant variables characterizing the population are high in number and possibly not obtainable. There is no hard and fast rule for determining the desired sample size of a survey. It depends on various factors like the type of research, the researcher, population size, and sampling method. Also the respondents selected using random sample lack motivation as they might not know what for the survey is being done, or they might misinterpret the survey. Similarly, stratified sampling is believed to be challenging, expensive and time consuming, as the theoretical basis for defining a proper “strata” from the given population is missing. Also the timing factor of when the sample is obtained plays a role as the applicability of the findings. Thus, the value of the survey diminishes over time, as survey is just a snapshot of a particular situation at a specific point in time. Multiple strategies for sampling and obtaining the responses have been presented during the interviews.

- *IS01: Use random convenience sampling:* Random convenience sampling was described as obtaining a sampling frame from personal contacts and randomly sampling from the frame.
- *IS02: Use convenience snowball sampling:* Due to self-selection process which is followed by them all of them recommended the usage of convenience snowballing. In convenience snowballing the population characteristics are known before-hand, researchers select respondents based on their choice. Questionnaire is then filled and the respondents are asked to forward it to their peers. This way responses of high quality responses are obtained. Convenience snowballing can facilitate an

additional number of responses if extended to LinkedIn, most visited blogs and forums. Posting and re posting the survey link in such social networks will make it be on the top and helps to obtain diversified responses.

- *IS03: Strive for heterogeneous sample:* heterogeneous sample, based on existing literature and your requirements
- *IS04: Characterize sample through demographic questions:* Demographic question helps to easily categorize the obtain data. Proper analysis method and reporting helps researcher to generalize the results involving some constraints.
- *IS05: Brevity:* A questionnaire should be short and precise. It must have a balance between time and number of questions. Interruptions might occur while answering the questionnaire, researchers should expect this while designing a survey. Survey time and questionnaire length must be specified beforehand. Interviews longer than 20 minutes fail to get responses. The interviewee suggested a length of 10-15 or less. They encouraged the inclusion of a feature where respondents can pause and continue the survey, while count-down timers should not be used.
- *IS06: Attend conferences:* Attending the conferences related to the survey domain can also increase response rate.
- *IS07: Guarantee anonymity:* Anonymity must be guaranteed and preserved.
- *IS08: Outcome accessibility:* Motivate the respondents by promising them to present the outcome of your research.
- *IS09: Avoid rewards:* Respondents must not be baited, instead they have to motivated on why they should perform the survey and the benefits they derive from the participation. Thus, it was recommended to not give rewards. If using rewards they should be given at the end of the survey study to assure only receiving committed responses. If rewards were to be given then the handover to each respondent should take place in person, though this might reduce the members of participants due to rewards.

B. SURVEY INSTRUMENT DESIGN AND EVALUATION

1) IP02: FLAWS IN THE WORDING OF QUESTIONS

Respondents may misunderstand the context of questions, this is the common problem to every survey and cannot be neglected. Questions must be formulated with great care and must be understandable.

- *IS10: Consider question attributes:* Direct, consistent, non-contradictory, non-overlapping, and non-repeated questions must be asked to obtain vital information. A survey should have both open-ended and close-ended questions. Close ended save time and are easy for analysis, but open-ended give deeper insights about the study. Open ended answers also show the respondents commitment.

- *IS11: Survey pre-test:* At first an internal internal evaluation of the survey with research colleagues should take place followed by piloting with practitioners. Piloting the survey with 5 to 10 people helps to design the survey clearly.
- *IS13: Researcher accessibility:* Researcher must be approachable if there are any doubts about the questions that need to be clarified.

2) IP03: LIKERT SCALE PROBLEMS

Improper usage of Likert scale confuses the respondents.

- *IS14: Informed scale type decision:* Researchers need to investigate potential weaknesses of using different scales. Odd scales provide the respondent with the ability to be neutral by choosing the middle point of the scale, while even scales force the respondent to indicate a preference. The five-point Likert scale was suggested to be used due to its common usage in the information technology domain..

3) IP04: BIASES DUE TO QUESTION-ORDER EFFECT

This effect should be addressed in a survey.

- *IS15: Natural actions-sequence:* Randomizing the questions will not always work in software engineering because logical adherence might be lost. Only if the questions (or groups of questions in a branch) are self-contained then randomization can be done. Though, one should always consider that respondent might lose the context of the questions when randomizing.

4) IP05: EVALUATION APPREHENSION

Respondents expect to be anonymous when answering surveys with questions focusing on their assessment or questions that are personal in nature. Respondents also check for credibility of source while answering these questions.

- *IS16: Avoid sensitive questions:* Whenever possible these kind of questions must be generally avoided, if asked they should be placed at the end and be optional. Questions must be framed in such a way that the feeling of being assessed is masked for the respondents.
- *IS17: Include "I do not know"-option:* By putting options like "I don't know" or "I do not want to answer" will encourage respondents to be truthful, and also it helps to rule-out inconsistent responses.

5) IP06: LACK OF OF DOMAIN KNOWLEDGE

This problem cannot be eliminated completely, and is significant in the case of open web surveys where survey is being answered by many unknown individuals.

- *IS18: Define clear criteria for sample selection:* The target population should be clearly defined and communicated in the survey.
- *IS19: Stress the importance of honesty:* Explicitly motivate the respondents to be truthful about their experience when answering demographic questions.

6) IP07: HYPOTHESIS GUESSING

This is not a problem in case of explanatory surveys.

- *IS19: Stress the importance of honesty:* Respondents should not be influenced instead they should be motivated to be truthful on their part.
- *IS20: Avoid loaded questions:* Hypothesis guessing can be eliminated by not asking loaded questions.

7) IP08: TRANSLATION ISSUES

The correct translation is one of the major problems when conducting global surveys.

- *IS21: Collaboration with international researchers:* It is recommended to consult senior researchers who can translate the survey into their mother tongue and are from the same domain.
- *IS22: Avoid Google Translate:* Google translate must not be used for language translations of surveys.

8) P09: CULTURAL ISSUES

Cultural issues may appear when conducting surveys globally, in particular the context may not be understood.

- *IS16: Avoid sensitive questions:* In particular in an unknown context it may be unknown how sensitive questions may be perceived, thus they should be avoided.
- *IS11: Survey pre-test:* Surveys should be pre-tested, and it may be recommended to use face-to-face interviews to gain trust of the respondents and get better insights.
- *IS23: Use appropriate nomenclature:* Appropriate references and terms for things (e.g. concepts) should be used.

9) P10: RELIABILITY

It is important to rule out the people with no hidden agenda or else they result in invalid conclusions.

- *IS4: Determine commitment:* In order to ensure reliability, the researchers must check whether the respondents are really committed towards the survey or not. One way of doing that is to use demographic or redundant questions, or to include open questions (see IS10).

C. DATA ANALYSIS AND CONCLUSIONS

1) IP11: RESPONSE DUPLICATION

Response duplication needs to be detected, and will result in wrong conclusions if remaining undetected.

- *IS25: Track IP address:* It can be identified and handled by crosschecking IP addresses. One-time links can be sent directly to the mails, survey tools monitor the duplication.
- *IS26: Session cookies:* Tracking session cookies may help in detecting duplicates as well as information about how many times did the respondent paused and resumed while answering.

2) IP12: ELIMINATING INVALID RESPONSES

The respondents may contradict themselves, which puts the validity of the survey results into question.

- *IS27: Consistency checking:* During the analysis it is recommended to conduct a cross-analysis of questions using Cronbach's Alpha.

D. REPORTING

1) IP12: INCOMPLETE REPORTING

Incomplete reporting will result in the inability to assess and thus trust the outcomes of the survey. Two reporting items were emphasized:

- *IS28: Report inconsistencies:* Inconsistencies and invalid responses should not just be discarded, they have to be reported.
- *IS29: Report biases:* The researcher needs to identify relevant biases and report them correctly in the study.

VI. DISCUSSION

A. COMPARISON WITH RELATED WORK

Table 2 presents a comparison between the related work and the findings from the interviews. The problems and strategies are grouped by the phases of survey research (see Section II). Whether a problem or strategy has been identified in either the literature or interview is indicated by stating the identifiers (LP** for findings from the literature and IP** for findings from the interviews). Problems and strategies not identified by either literature or interviews are marked as "red"; those identified by both are marked as "green". The table shows that literature and interviews complement each other, as each has perspective (literature or interviews) clearly shows gaps. The table may be used as a consolidated view for strategies that researchers may employ to address the problems they face during the survey research process. However, it should be noted that (a) the strategies are not validated and their effect on the quality of surveys (e.g. insufficient sample sizes) is not quantifiable. Additionally, some strategies presented in the results (Section V) and Table 2 are conflicting, and thus designers of surveys need to make trade-off decisions when planning their research (see Section VI-B). Researchers conducting interviews as well as interviewees discussed incomplete reporting and the lack of motivating the sample selection. Complementary to these findings, the contents to be reported in a survey as presented by [60] should be highlighted, which we summarized in Section II-H.

B. CONFLICTING RECOMMENDATIONS AND TRADE-OFFS

Examples of conflicting strategies and the needs for trade-offs have to be highlighted considering the findings of the study.

To address the problem of small sample sizes it was recommended to have shorter surveys (Brevity, LS11), and as questionnaire attributes the interviewees recommended non-overlapping and non-repeated questions (IS10). However, using open questions helping to determine commitment and gathering qualitative information (IS4) will make the survey

TABLE 2. Comparison of findings between literature and interviews.

Problems and strategies	Literature	Interview
Phase: Target audience and sampling frame definition and sampling plan		
Insufficient Sample Size	LP01	IP01
Use personal contact network	LS01	
Cultural awareness	LS02	
Use probabilistic sampling	LS03	
Use random convenience sampling		IS01
Use of convenience sampling	LS04	
Use convenience snowball sampling		IS02
Strive for heterogeneous sample		IS03
Evaluate the trustworthiness of the sample	LS05	
Reciprocity	LS06	
Consistency	LS07	
Authority and Credibility	LS08	
Liking	LS09	
Scarcity	LS10	
Brevity	LS11	IS05
Social Benefit	LS12	
Guarantee anonymity		IS07
Timing	LS13	
Define clear criteria for sample selection	LS14	
Characterize sample through demographic questions		IS04
Third party advertising	LS15	
Use snowball sampling	LS16	
Recruit respondents from GitHub	LS17	
Attend conferences		IS05
Outcome accessibility		IS08
Provide rewards	LS18	
Avoid rewards		IS09
Confidentiality issues	LP02	
Personalized e-mails	LS19	
Gate Keeper Reliability	LP03	
Use IT responsibilities for reliable distribution of invitations	LS20	
No Practical Usefulness	LP04	
Explicitly motivate the practical benefit of the survey	LS21	
Phase: Survey instrument design, evaluation, and execution		
Flaws in the wording of questions	LP05	IP02
Survey pre-test	LS22	IS11
Expert discussions	LS23	
Ask the same question in different ways	LS24	
Consider question attributes		IS10
Researcher accessibility		IS13
Translation Issues	LP06	IP08
Collaboration with international researchers	LS25	IS21
Avoid Google Translate		IS22
Biases due to Question-Order Effect	LP07	IP04
Order randomization	LS26	
Natural actions-sequence	LS27	IS15
Likert Scale Problems	LP08	IP03
Avoid two-point scales	LS28	
Informed scale type decision		IS14
People Perceptions	LP09	
Lack of Domain Knowledge	LP10	IP06
Explicitly consider background knowledge in the survey	LS29	
Define clear criteria for sample selection		IS18
Stress the importance of honesty		IS19
High drop-out rates	LP11	
Brevity	LS11	
Time constraints of running the survey	LP12	
Evaluation Apprehension	LP13	IP05
Guarantee anonymity	LS30	
Avoid sensitive questions		IS16
Include "I do not know"-option		IS17
Common biases of respondents (mono-operation, over-estimation, social desirability)	LP14	
Ask the same question in different ways	LS24	
Source triangulation	LS31	
Guarantee anonymity	LS30	
Hypothesis Guessing	LP15	IP07
Stress importance of honesty	LS32	
Stress the importance of honesty		IS19
Avoid loaded questions		IS20
Respondent Interaction	LP16	
Cultural issues		IP09
Avoid sensitive questions		IS16
Survey pre-test		IS11
Use appropriate nomenclature		IS23
Reliability		IP10
Determine commitment		IS24
Phase: Data analysis and conclusions		
Eliminating invalid responses	LP17	IP12
Voluntary participation	LS27	
Consistency checking		IS27
Response Duplication	LP18	IP11
Track IP address		IS24
Session cookies		IS25
Inaccuracy in data extraction and analysis	LP19	
Multiple researchers conduct analysis	LS28	
Check the consistency of coding between researchers	LS29	
Phase: Reporting		
Lack of Motivation for sample selection	LP20	
Credibility	LP21	
Incomplete reporting		IP12
Report inconsistencies		IS24
Report biases		IS25

longer. In addition, asking questions to check the consistency of answers (IS27, LS24) leads to a longer survey. Hence, a trade-off between the survey length reducing the number of answers and the ability to check the consistency of the survey, and gathering qualitative information needs to be made. Also, the amount of demographic information to characterize the sample (IS04) is limited when aiming for a short survey.

Another decision concerns the type of sampling, namely probabilistic sampling (LS03) and the use of convenience sampling (LS04). As pointed out in the interviews, it is often challenging to sufficiently describe the characteristics of the population. The type of survey (exploratory versus explanatory) also influences the decision, and the degree of the ambition to generalize the survey to a population. Thus, the motivation of the sampling strategy and a clear definition of the sampling frame are essential [60]. During the interviews hybrid strategies were identified, namely using random convenience sampling, where the list of respondents comprises of the contact networks and accessible practitioners to the researchers. From this list a random sample is then selected to partially reduce biases.

Finally, rewards have been discussed as a strategy to increase the number of respondents. In the literature rewards were recommended as a strategy, while the risk of rewards has been pointed out (i.e. answering surveys multiple times for the sake of rewards). In the interviews it was recommended not to give rewards if mitigation strategies for addressing the risk are not addressed (e.g. receiving the rewards in person).

VII. CONCLUSIONS

In this study we identified problems and related strategies to overcome the problems with the aim of supporting researchers conducting software engineering surveys. The focus was on questionnaire-based research.

We collected data from multiple sources, namely existing guidelines for survey research, primary studies conducting surveys and reporting on the problems and strategies of how to address them, as well as expert researchers. Nine expert researchers were interviewed.

In total we identified 24 problems and 65 strategies. The problems and strategies are grouped based on the phases of the survey research process.

- *Target audience and sampling frame definition and sampling plan:* It was evident that the problem of insufficient sample sizes was the most discussed problem with the highest number of strategies associated with it (26 strategies). Example strategies are brevity (limiting the length of the survey), highlighting the social benefit, using third party advertising, and the use of the personal network to recruit responses. Different sampling strategies have been discussed (e.g. random and convenience sampling). In addition more specific problems leading to losses of in responses were highlighted, such as confidentiality issues, gate-keeper reliability, and the lack of explicit motivations of the practical usefulness of the survey results.

- *Survey instrument design, evaluation, and execution:* The main problem observed was poor wording of questions, as well as different issues related to biases (such as question-order effect, evaluation apprehension, and mono-operation, over-estimation, and social desirability biases). The strategies were mainly concerned with recommendations for the attributes of questions and what type of questions to avoid (e.g. loaded and sensitive questions), as well as the need for pre-testing the surveys. It was also highlighted that expert discussions are helpful in improving the survey instrument.
- *Data analysis and conclusions:* For data analysis the main problems were the elimination of invalid and duplicate responses as well as inaccuracy of data extraction and analysis. Technical solutions were suggested for detecting duplicates. Invalid responses are avoided through consistency checking and voluntary participation. Finally, the importance of involving multiple researchers in the data analysis has been highlighted.
- *Reporting:* Missing information was highlighted as problematic, including the lack of motivation for the selection of samples. It was also highlighted to report inconsistencies and biases that may have occurred in the survey.

A high number of problems as well as strategies has been elicited. In future work a consensus building activity is needed where the community discusses which strategies are most important and suitable for software engineering research. In addition, in combination with existing guidelines the information provided in this paper may serve for the design of checklists to support the planning, conduct, and assessment of surveys.

APPENDIX A INTERVIEW GUIDE

A. RESEARCHER PERSPECTIVE

- 1) You have been doing research, publishing articles since long time, by looking at your publications it is visible that you have conducted multiple surveys. Can you explain in which context you think choosing survey as a research method is more beneficial than action research, case studies and experiments?
- 2) Surveys are used in social sciences and other disciplines including software engineering, do you think there are some special instructions to be followed while conducting surveys. How is it different in software engineering? What factors one shall consider while designing surveys in software engineering research?
- 3) When designing a survey what type of questions do you prefer asking, (open-ended or close-ended) and why? (Is the evaluation method your primary motivating factor for choosing it? Are evaluation methods one of the reasons for choosing the type of questions? what are the other factors that enable you to include both type of questions in your Survey)

- 4) In a survey one question may have provided context to the next one which may drive respondents to specific answers, randomization of questions to some extent may reduce this question-order effect. Can you suggest some other techniques to deal with this question order effect?
- 5) How do you make sure that respondents understand the right context of your question, what measures do you adapt for making the questionnaire understandable?
- 6) Our literature analysis showed that 31.4% of primary studies used Stratified sampling technique, while only 15.7% of studies reported the usage of Snowball Sampling by researchers. (Literature describes that Snowball sampling leads to a better sample selection, where researcher has the freedom of choosing sample that suits to his/her requirements). Have you faced any situation where other sampling techniques were chosen over snowballing, what factors did you consider while making the selection?
- 7) Low response rates are common problem for any survey, how can the response rate be improved?
- 8) When a survey is posted, there are few respondents without a proper domain knowledge answering it. They might misinterpret data giving incorrect answers and this affects the overall analysis. In yours research how are such responses identified and ruled-out?
- 9) Our analysis showed that hypothesis guessing is an issue that can only be reduced to some extent rather than avoiding it completely. Explain how this problem is addressed in your work.
- 10) What measures do you take to avoid the duplication of responses in your surveys?
- 11) How do you overcome each of these common problems like bias, generalizability and reliability in the following cases? (a) Case A: Respondent's answering the survey just for the sake of rewards. (b) Case B: Respondents answering surveys posted on social networks like LinkedIn and Facebook.
- 12) How do you mitigate the issue of inconsistency in responses? (Case-When a respondent is asked about his familiarity with non-functional requirements he chooses a "Yes" option. When asked to elaborate his opinion he just writes "No idea", here comes the problem of inconsistency)
- 13) Assume you have conducted a global survey in Sweden, Norway, China and Italy collecting information from diverse respondents. How do you address the following issues in your research? (a) Issue: Questionnaire gets translated into Chinese making it understandable to respondents over there, due to poor translation there might be an issue of data losses. How do you handle this language issue? (b) Issue: There might be some cultural issues where people of one country are more comfortable in answering an online questionnaire, while people of another country are more responsive to face-to-face interviews.

In your opinion how can this kind cultural issue be mitigated?

- 14) In the review of the literature we found out that researchers used Likert scale as a question type. Even though it is commonly used, we could obtain few problems like central tendency bias when a 4-point or 7-point Likert scale is used, respondent fatigue and interpretation problems have been identified when 9 or 10 point scales have been used. How do you address these kind of issues in your research?
- 15) How do you decide upon a particular sample size for your survey?
- 16) What motivates you to select a specific analysis technique for your research?

B. RESPONDENT'S PERSPECTIVE

- 1) You must have answered many surveys till now, in your opinion how can a survey grab the attention of the respondent?
- 2) Does the questionnaire length affect your way of answering a survey?
- 3) What do you prefer mostly to answer, open-ended or close-ended questions?
- 4) Does time limitation affect your way of answering the Survey?
- 5) Would you be willing to disclose details about your research study when answering a survey? (Confidentiality issues, Intellectual theft)

C. CONCLUDING QUESTIONS ABOUT SURVEY GUIDELINES

- Do you think there is a need for the checklist of all the problems faced by the Software Engineering Researchers while conducting surveys?
- On the scale of 1 to 5, please rate the need for having such kind of checklist.

REFERENCES

- [1] R. Akbar, M. F. Hassan, and A. Abdullah, "A framework of software process tailoring for small and medium size IT companies," in *Proc. Int. Conf. Comput. Inf. Sci. (ICCIS)*, vol. 2, Jun. 2012, pp. 914–918.
- [2] E. R. Babbie, *Survey Research Methods*. Belmont, CA, USA: Wadsworth, 1973.
- [3] J. Boustedt, "A methodology for exploring students' experiences and interaction with large-scale software through role-play and phenomenography," in *Proc. 4th Int. Workshop Comput. Educ. Res.*, 2008, pp. 27–38.
- [4] A. Cater-Steel, M. Toleman, and T. Rout, "Addressing the challenges of replications of surveys in software engineering research," in *Proc. Int. Symp. Empirical Softw. Eng.*, Nov. 2005, p. 10.
- [5] Y. C. Cavalcanti, P. A. da Mota Silveira Neto, I. do Carmo Machado, E. S. de Almeida, and S. R. de Lemos Meira, "Towards understanding software change request assignment: A survey with practitioners," in *Proc. 17th Int. Conf. Eval. Assessment Softw. Eng.*, 2013, pp. 195–206.
- [6] M. Ciolkowski, O. Laitenberger, S. Vegas, and S. Biffl, "Practical experiences in the design and conduct of surveys in empirical software engineering," in *Empirical Methods and Studies in Software Engineering*. Berlin, Germany: Springer, 2003, pp. 104–128.
- [7] J. Cito, P. Leitner, T. Fritz, and H. C. Gall, "The making of cloud applications: An empirical study on software development for the cloud," in *Proc. 10th Joint Meeting Found. Softw. Eng.*, 2015, pp. 393–403.

- [8] R. Conradi *et al.*, "Reflections on conducting an international survey of software engineering," in *Proc. Int. Symp. Empirical Softw. Eng.*, Nov. 2005, p. 10.
- [9] D. S. Cruzes and T. Dybå, "Recommended steps for thematic synthesis in software engineering," in *Proc. Int. Symp. Empirical Softw. Eng. Meas.*, Sep. 2011, pp. 275–284.
- [10] E. Daka and G. Fraser, "A survey on unit testing practices and problems," in *Proc. IEEE 25th Int. Symp. Softw. Rel. Eng.*, Nov. 2014, pp. 201–211.
- [11] C. W. Dawson, *Projects in Computing and Information Systems: A Student's Guide*. London, U.K.: Pearson, 2005.
- [12] R. M. de Mello, P. C. Da Silva, and G. H. Travassos, "Investigating probabilistic sampling approaches for large-scale surveys in software engineering," *J. Softw. Eng. Res. Develop.*, vol. 3, no. 1, p. 8, 2015.
- [13] R. M. de Mello and G. H. Travassos, "Would sociable software engineers observe better?" in *Proc. ACM/IEEE Int. Symp. Empirical Softw. Eng. Meas.*, Oct. 2013, pp. 279–282.
- [14] E. Egorova, M. Torchiano, and M. Morisio, "Evaluating the perceived effect of software engineering practices in the Italian industry," in *Proc. Int. Conf. Softw. Process*. Berlin, Germany: Springer, 2009, pp. 100–111.
- [15] S. Elo and H. Kyngäs, "The qualitative content analysis process," *J. Adv. Nursing*, vol. 62, no. 1, pp. 107–115, 2008.
- [16] N. A. Ernst, S. Bellomo, I. Ozkaya, R. L. Nord, and I. Gorton, "Measure it? Manage it? Ignore it? Software practitioners and technical debt," in *Proc. 10th Joint Meeting Found. Softw. Eng.*, 2015, pp. 50–60.
- [17] A. Fink, *How to Conduct Surveys: A Step-by-Step Guide*. Thousand Oaks, CA, USA: SAGE Publications, 2012.
- [18] F. J. Fowler, Jr., *Survey Research Methods*. Thousand Oaks, CA, USA: SAGE Publications, 2013.
- [19] M. Galster and D. Tofan, "Exploring web advertising to attract industry professionals for software engineering surveys," in *Proc. 2nd Int. Workshop Conducting Empirical Stud. Ind.*, 2014, pp. 5–8.
- [20] V. Garousi, A. Coşkunçay, A. Betin-Can, and O. Demirörs, "A survey of software engineering practices in Turkey," *J. Syst. Softw.*, vol. 108, pp. 148–177, Oct. 2015.
- [21] V. Garousi, A. Coşkunçay, A. Betin-Can, and O. Demirörs, "Cross-factor analysis of software engineering practices versus practitioner demographics: An exploratory study in Turkey," *J. Syst. Softw.*, vol. 111, pp. 49–73, Jan. 2016.
- [22] Y. Ghanam, F. Maurer, and P. Abrahamsson, "Making the leap to a software platform strategy: Issues and challenges," *Inf. Softw. Technol.*, vol. 54, no. 9, pp. 968–984, 2012.
- [23] A. N. Ghazi, J. Andersson, R. Torkar, K. Petersen, and J. Börstler, "Information sources and their importance to prioritize test cases in the heterogeneous systems context," in *Proc. 21st Eur. Conf. Syst., Softw. Services Process Improvement (EuroSPI)*. Berlin, Germany: Springer, 2014, pp. 86–98.
- [24] A. N. Ghazi, "Testing of heterogeneous systems," Licentiate Dissertation Series No. 2014:03, Dept. Softw. Eng., Blekinge Inst. Technol., Karlskrona, Sweden, 2014.
- [25] A. N. Ghazi, K. Petersen, and J. Börstler, "Heterogeneous systems testing techniques: An exploratory survey," in *Proc. Int. Conf. Softw. Quality*. Vienna, Austria: Springer-Verlag, 2015, pp. 67–85.
- [26] A. N. Ghazi, R. P. Garigapati, and K. Petersen, "Checklists to support test charter design in exploratory testing," in *Proc. Int. Conf. Agile Softw. Develop. (XP)*. Cham, Switzerland: Springer, 2017, pp. 251–258.
- [27] A. N. Ghazi, K. Petersen, E. Bjarnason, and P. Runeson, "Levels of exploration in exploratory testing: From freestyle to fully scripted," *IEEE Access*, vol. 6, pp. 26416–26423, 2018.
- [28] T. Gorschek, E. Tempero, and L. Angelis, "A large-scale empirical study of practitioners' use of object-oriented concepts," in *Proc. ACM/IEEE 32nd Int. Conf. Softw. Eng.*, vol. 1, May 2010, pp. 115–124.
- [29] G. Gousios, M.-A. Storey, and A. Bacchelli, "Work practices and challenges in pull-based development: The contributor's perspective," in *Proc. IEEE/ACM 38th Int. Conf. Softw. Eng.*, May 2016, pp. 285–296.
- [30] G. Gousios, A. Zaidman, M.-A. Storey, and A. van Deursen, "Work practices and challenges in pull-based development: The integrator's perspective," in *Proc. 37th Int. Conf. Softw. Eng.*, vol. 1, May 2015, pp. 358–368.
- [31] H. Haeger, A. D. Lambert, J. Kinzie, and J. Gieser, "Using cognitive interviews to improve survey instruments," presented at the Annu. Forum Assoc. Inst. Res., New Orleans, Louisiana, Jun. 2012.
- [32] E. J. Halcomb and P. M. Davidson, "Is verbatim transcription of interview data always necessary?" *Appl. Nursing Res.*, vol. 19, no. 1, pp. 38–42, 2006.
- [33] H.-F. Hsieh and S. E. Shannon, "Three approaches to qualitative content analysis," *Qualitative Health Res.*, vol. 15, no. 9, pp. 1277–1288, 2005.
- [34] J. Ji, J. Li, R. Conradi, C. Liu, J. Ma, and W. Chen, "Some lessons learned in conducting software engineering surveys in china," in *Proc. 2nd ACM-IEEE Int. Symp. Empirical Softw. Eng. Meas.*, 2008, pp. 168–177.
- [35] J. F. Hair, Jr., W. C. Black, B. J. Babin, and R. E. Anderson, *Multivariate Data Analysis*. Upper Saddle River, NJ, USA: Prentice-Hall, 2009.
- [36] A. B. Kajornboon, "Using interviews as research instruments," *E-J. Res. Teachers*, vol. 2, no. 1, pp. 1–9, 2005.
- [37] M. Kasunic, "Designing an effective survey," *Softw. Eng. Inst.*, Carnegie-Mellon Univ. Pittsburgh, PA, USA, Tech. Rep., 2005.
- [38] L. Kish, *Survey Sampling*. New York, NY, USA: Wiley, 1965.
- [39] B. Kitchenham and S. L. Pfleeger, "Principles of survey research (parts 1–6)," *ACM SIGSOFT Softw. Eng. Notes*, vol. 28, no. 2, pp. 24–27, 2003.
- [40] B. Kitchenham and S. L. Pfleeger, "Principles of survey research: Part 5: Populations and samples," *ACM SIGSOFT Softw. Eng. Notes*, vol. 27, no. 5, pp. 17–20, 2002.
- [41] B. A. Kitchenham and S. L. Pfleeger, "Personal opinion surveys," in *Guide to Advanced Empirical Software Engineering*. London, U.K.: Springer, 2008, pp. 63–92.
- [42] B. A. Kitchenham *et al.*, "Preliminary guidelines for empirical research in software engineering," *IEEE Trans. Softw. Eng.*, vol. 28, no. 8, pp. 721–734, Aug. 2002.
- [43] J. Linäker, S. M. Sulaman, R. Maiani de Mello, and M. Höst, "Guidelines for conducting surveys in software engineering," Tech. Rep., 2015.
- [44] M. S. Litwin, *How to Measure Survey Reliability and Validity*, vol. 7. Thousand Oaks, CA, USA: SAGE Publications, 1995.
- [45] G. Lucassen, F. Dalpiaz, J. M. E. van der Werf, and S. Brinkkemper, "The use and effectiveness of user stories in practice," in *Proc. Int. Working Conf. Requirements Eng., Found. Softw. Qual.* Cham, Switzerland: Springer, pp. 205–222, 2016.
- [46] A. Martini, L. Pareto, and J. Bosch, "A multiple case study on the inter-group interaction speed in large, embedded software companies employing agile," *J. Softw., Evol. Process*, vol. 28, no. 1, pp. 4–26, 2016.
- [47] J. S. Molléri, K. Petersen, and E. Mendes, "Survey guidelines in software engineering: An annotated review," in *Proc. 10th ACM/IEEE Int. Symp. Empirical Softw. Eng. Meas. (ESEM)*, Ciudad Real, Spain, Sep. 2016, pp. 58:1–58:6.
- [48] J. Moore, J. Pascale, P. Doyle, A. Chan, and J. K. Griffiths, "Using field experiments to improve instrument design: The SIPP methods panel project," in *Methods for Testing and Evaluating Survey Questionnaires*. Hoboken, NJ, USA: Wiley, 2004, pp. 189–207.
- [49] P. A. da Mota Silveira Neto, J. S. Gomes, E. S. De Almeida, J. C. Leite, T. V. Batista, and L. Leite, "25 years of software engineering in Brazil: Beyond an insider's view," *J. Syst. Softw.*, vol. 86, no. 4, pp. 872–889, 2013.
- [50] I. Nurdiani, R. Jabangwe, D. Šmite, and D. Damian, "Risk identification and risk mitigation instruments for global software development: Systematic review and survey results," in *Proc. IEEE 6th Int. Conf. Global Softw. Eng. Workshop*, Aug. 2011, pp. 36–41.
- [51] S. L. Pfleeger, "Experimental design and analysis in software engineering," *Ann. Softw. Eng.*, vol. 1, no. 1, pp. 219–253, 1995.
- [52] S. L. Pfleeger and B. A. Kitchenham, "Principles of survey research: Part 1: Turning lemons into lemonade," *ACM SIGSOFT Softw. Eng. Notes*, vol. 26, no. 6, pp. 16–18, 2001.
- [53] T. Punter, M. Ciolkowski, B. Freimut, and I. John, "Conducting on-line surveys in software engineering," in *Proc. Int. Symp. Empirical Softw. Eng. (ISESE)*, Sep/Oct. 2003, pp. 80–88.
- [54] C. Robson and K. McCartan, *Real World Research*. Hoboken, NJ, USA: Wiley, 2016.
- [55] J. Rowley, "Conducting research interviews," *Manage. Res. Rev.*, vol. 35, nos. 3–4, pp. 260–271, 2012.
- [56] H. Sharp, M. Woodman, and F. Hovenden, "Tensions around the adoption and evolution of software quality management systems: A discourse analytic approach," *Int. J. Hum. Comput. Stud.*, vol. 61, no. 2, pp. 219–236, 2004.
- [57] E. Smith, R. Loftin, E. Murphy-Hill, C. Bird, and T. Zimmermann, "Improving developer participation rates in surveys," in *Proc. 6th Int. Workshop Cooperat. Hum. Aspects Softw. Eng. (CHASE)*, May 2013, pp. 89–92.
- [58] R. O. Spínola and G. H. Travassos, "Towards a framework to characterize ubiquitous software projects," *Inf. Softw. Technol.*, vol. 54, no. 7, pp. 759–785, 2012.
- [59] J. M. Stahura *et al.*, "Methods for testing and evaluating survey questionnaires," *Contemp. Sociol.*, vol. 34, no. 4, p. 427, 2005.

- [60] S. Stavru, "A critical examination of recent industrial surveys on agile method usage," *J. Syst. Softw.*, vol. 94, pp. 87–97, Aug. 2014.
- [61] S. K. Thompson, *Sampling*. New York, NY, USA: Wiley, 2002, p. 12.
- [62] S. K. Thompson, *Sampling*. New York, NY, USA: Wiley, 1992.
- [63] M. Torchiano and F. Ricca, "Six reasons for rejecting an industrial survey paper," in *Proc. 1st Int. Workshop Conducting Empirical Stud. Ind. (CESI)*, May 2013, pp. 21–26.
- [64] L. Vukelja, L. Müller, and K. Opwis, "Are engineers condemned to design? A survey on software engineering and UI design in Switzerland," in *Proc. IFIP Conf. Hum. Comput. Interact.* Berlin, Germany: Springer, 2007, pp. 555–568.
- [65] C. Wohlin, P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell, and A. Wesslén, *Experimentation in Software Engineering*. Springer, 2012.
- [66] A. Yamashita and L. Moonen, "Surveying developer knowledge and interest in code smells through online freelance marketplaces," in *Proc. 2nd Int. Workshop User Eval. Softw. Eng. Res. (USER)*, May 2013, pp. 5–8.
- [67] C. Yang, P. Liang, and P. Avgeriou, "A survey on software architectural assumptions," *J. Syst. Softw.*, vol. 113, pp. 362–380, Mar. 2016.
- [68] H. Zhang and M. A. Babar, "Systematic reviews in software engineering: An empirical investigation," *Inf. Softw. Technol.*, vol. 55, no. 7, pp. 1341–1354, 2013.



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