Chapter 2
Research Methodology

In this section, I will give an overview on the different types of research methodologies. This will be followed by the rationale behind selecting a particular method for this thesis.

2.1 Introduction: Research Approach

Research approaches are plans and the procedures for research that spans from broad assumptions to detailed methods of data collection, analysis, and interpretation. There are three approaches to research which are follows:

1. Qualitative
2. Quantitative, and
3. Mixed methods

Qualitative research is an approach for exploring and understanding a social or human problem as described by individuals. It is aimed at gaining in-depth understanding of a specific organization or event, rather than surface description of a large sample of a population. This type of research puts more focus on how people feel, think and make their choices.

This research is largely managed with discussion around the concepts with some open questions. Respondents are asked to explain the reasons for their responses. This can reveal underlying motivations, associations and behavioral triggers [8].

Common data collection methods that are used in this research are focus groups, in-depth interviews, uninterrupted observation, bulletin boards, and ethnographic participation/observation.
**Quantitative research** is an approach for testing objective theories by examining the relationship among variables. This type of research is a more logical approach that provides a measure of what people think from a statistical point of view. For example, if you wanted to know how many students use Android phone or services and how strongly they support it, you would do a quantitative research.

This research largely uses methods such as questionnaires and surveys with multiple choice questions where respondents are asked to select one or more of the given options. Answer options may include acceptance scale (strongly agree to strongly disagree), Likert scale, ranking in order of priority, etc.

This type of research can be conducted via telephone, web or with the help of paper questionnaires. The only constraint is that the number of respondents should be significant enough to be able to generate directional results.

“To help gain willing participants, companies often offer incentives such as free products or financial remuneration for their time” [8]

Following Table 2.1 illustrates key differences between qualitative and quantitative research

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Qualitative</th>
<th>Quantitative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Data</strong></td>
<td>Data is in the form of words, pictures or objects.</td>
<td>Data is in the form of numbers and statistics.</td>
</tr>
<tr>
<td><strong>Method used</strong></td>
<td>Methods include focus groups, in-depth interviews, and reviews of documents for non-numeric information.</td>
<td>Surveys, structured interviews &amp; observations, and reviews of records or documents for numeric information</td>
</tr>
<tr>
<td><strong>Process of Research</strong></td>
<td>Inductive approach used to formulate theory or hypotheses</td>
<td>Deductive approach used to test pre-specified concepts, constructs, and</td>
</tr>
<tr>
<td></td>
<td>hypotheses</td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Response options</strong></td>
<td>Unstructured or semi-structured response options</td>
<td></td>
</tr>
<tr>
<td><strong>Statistical test</strong></td>
<td>No statistical tests are performed</td>
<td></td>
</tr>
<tr>
<td><strong>Time required</strong></td>
<td>Time spend at the time of planning is lower than that spent during the analysis phase</td>
<td></td>
</tr>
<tr>
<td><strong>Objectivity/subjectivity</strong></td>
<td>Highly subjective</td>
<td></td>
</tr>
<tr>
<td><strong>Result</strong></td>
<td>Results depend on skill and accuracy of the researcher</td>
<td></td>
</tr>
<tr>
<td><strong>Final Report</strong></td>
<td>Report contains textual details &amp; verbatim from research participants</td>
<td></td>
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</tbody>
</table>

Table 2.1: Qualitative versus quantitative research

*Mixed methods research* is an approach that involves collecting both quantitative and qualitative data, integrating the two forms of data, and using distinct designs that may involve philosophical assumptions and theoretical frameworks. The core assumption of this form of inquiry is the combination of qualitative and quantitative approaches that provides better understanding of the research problem.

For example, before issuing a survey to gather quantitative results you will first want to find out more about what your customers consider to be important. With this in mind, you would first carry out qualitative research to put together questions that go deeper and can help the following questionnaire show real insight.
2.2 Qualitative and Quantitative Research in Software Engineering

The above discussed methods are applied in social sciences and natural sciences. Software engineering is a human oriented activity, so these methods are also used in the field of software engineering. In software engineering, the blend of technical and human aspects lends itself to combining qualitative and quantitative methods, in order to take advantage of the strengths of both [9].

After discussing the research methods in detail, now I will throw some light on how these methods are useful in terms of software engineering research.

2.3 Qualitative Research in Software Engineering

As mentioned earlier, software engineering involves people in all aspects of the software development process, whether it is software development, coding, testing or maintenance. In order to understand software engineering, one should study software engineers as they work – typically by doing field studies. Qualitative research can be used in the area of software engineering where different kinds of interaction take place i.e. Observation of meetings, the observation of cost estimation experts or interviews of software engineers on particular software engineering techniques.

2.4 Quantitative Research in Software Engineering

In quantitative research methods, decisions are made based on theoretical information provided by survey respondents. The decisions revolve around which variables to isolate and measure, and which ones to ignore or exclude [9]. This research method can also be used in software engineering and a big example of it is the development of COCOMO (Cost Constructive Model). COCOMO was developed by analyzing massive historical project data using mathematical regression.
Now next section will focus on the research method I have used in my research.

2.5 Methods used in this Thesis

Empirical Research Methods

**Interview:** There are three fundamental types of research interviews: structured, semi-structured and unstructured [10]. **Structured Interview** is a quantitative research method and commonly used in survey research. In Structured interviews, lists of predetermined questions are asked from the interviewees. The main objective of this type of interview is to ensure that the answers can be reliably aggregated and that comparisons can be made with confidence between sample subgroups or between different survey periods. The types of questions used in this style of interviews are often referred to as closed, close ended, precoded or fixed choice. The objective of this interview is more towards understanding the current state of the problem than generating/exploring new ideas. This may not be useful in areas where ‘in depth’ analysis is required.

On the contrary, **Unstructured Interview** is a qualitative research method. Unstructured interviews are more flexible as compared to the structured ones. They allow questions to be adapted and changed in accordance with the answers being received from interviewees. The interviews are unrehearsed and allow free flowing conversations. The questions are mostly open ended and can be shuffled depending on the topic in discussion.

**Semi-structured interview** lie between the above two methods. They contain a set of fixed questions and a set of open question. These interviews capture specific demographic information first (using fixed structured format) and then allow the respondents to express their thoughts with the help of open ended (unstructured) questions. The objective is to capture an individual’s free flow opinion in a specific area. They can provide reliable, comparable qualitative data. [11]
Personal, phone and email interview

Some other commonly used interview methods are personal conversation with the respondent, conversation on phone or through email. All these methods have their advantages and disadvantages which are as follows:

Personal Interview

Personal Interview is an interaction that happens face-to-face. This method helps in gathering data and opinion by asking respondents a series of questions. This provides interviewers/researchers an opportunity to probe into specific areas during the interview and not only capture verbatim but observe emotional reactions (which is not an option in cases of telephonic or web interviews). This method provides researchers with insights, new hypotheses, and understanding through the process of interaction. This method, however, is very time consuming as certain interactions and probing may last up to hours. Until sometime ago, this method also came with geographic limitations. This has now been overcome with the invention of applications like Skype. Another disadvantage is that these surveys do not favor anonymity and the respondents may provide manipulated answers in an attempt to please the interviewer.

Telephonic interview

In this method, interviews are taken over the phone. It could be via VoIP technology or there could be someone physically present on the other side of the call taking the interview. This is a very popular and preferred method as the questions here are quite direct and less time consuming. Additionally, there are no geographic limitations here unlike the personal interview method. The only disadvantage of this method is that the interviewer cannot see the body language and facial expressions of the interviewee while listening to the response.

Email interview

The third method is email interview. As the name suggests, interviews are conducted via email interactions, the set of questions is sent via emails and the respondent responds via
the same medium. Some of the advantages of this method are that it is less time consuming, emails can be sent to multiple participants at the same time, the respondents have the flexibility to respond as per their availability schedule, etc.

The only disadvantage of this method is the lack of the facial expression and body language of the interviewee while answering.

**Internet (Web-based) Surveys/Blogs**

Now days with the advent of advance technology, one can conduct online surveys in order to collect data. There are many websites available that allow you to design online surveys based on your research requirements. These websites not only support in designing surveys, but also help in data collection by identifying and rolling the survey out to appropriate audience. They have become a popular and attractive way to conduct survey research. When used appropriately, online surveys are an excellent survey method for a closed population in which every member of that population has a verified email address and internet access [13]. One of the biggest disadvantages of this method is its dependence on the internet which makes it challenging enough to reach remote audience. Additionally, there is high probability of fake / non-reliable data as some respondents would only provide answers for the sake of some incentives promised to them.

**Experiment**

The role of experiment in software engineering research is to compare different software engineering technologies, methods, etc. in terms of effectiveness, usefulness, or costs by letting software engineers conduct one or more software engineering tasks. This method helps in testing hypothesis and arriving at decisions as compared to the others that aim at observing and explaining. Hence, it plays an important role in answering key questions for practitioners in the IT industry, for example, what works best for a specific development task, method A or Method B?[15]

Experiments are a method of quantitative research [7]. “Experimentation is performed in order to help us better evaluate, predict, understand, control, and improve the software
development process and product” [14]. As mentioned above, these methods help in approving or rejecting hypothesis based on their results. They also establish and explain cause and effect relationships between variables.

**Literature review**

In research, a body of literature is a collection of published information like scholarly journals, scholarly books, databases and primary sources. Sometimes it also includes magazines, books, newspapers, films, and audio & video tapes, etc.

A literature review in any field is essential as it offers a broad overview and summary on the given scholarship from past to present, giving the reader a sense of direction for the new research [16]. Literature review helps in avoiding incidental plagiarism and also sharpens one’s research focus.

Literature review can be done in three ways:

1. A quantitative Study
2. A qualitative Study
3. A Meta-Analysis.

A quantitative study provides an understanding of the existing knowledge about the problem and provides a basis for the research questions. In qualitative study, researchers present literature discussions and integrate criticism of the literature into the text of a study. A Meta-analysis statistically summarizes the results of prior research.

**2.6 Research Methodologies Applied in this Thesis**

In this section, I explain the methodologies used in this research for the thesis. I started the research work with literature review wherein I tried to cover all relevant research papers, books and other readable material available on internet. The material is related to software cost estimation and software quality in order to get in-depth information and
knowledge of the subject. The sources of all referenced material are listed in the annexure section under bibliography for relevance and authenticity. This gives the reader an aggregated summary and classification of the relevant findings as well as the opinions of the respective authors of the discussed papers.

In addition to reading and analyzing the literature, system analyst, project leaders and software professionals along with cost estimation experts were interviewed in an unstructured personal discussion and on the phone. Email and online surveys were also conducted with the objective of gathering as much relevant information as possible. The reason for choosing unstructured interviews was to give an open discussion channel to the interviewee and not to limit the discussion. This allowed exploration of new ideas for the research and enabled me to collect as much information and knowledge one could be given on the topic. Email and online surveys were used to gather the information from experts who are geographically dispersed and could not be interviewed because of their busy schedule. These methods gave them the convenience to respond as per their availability schedule. After all, the discussions with the experts were directed to learning from the experts’ knowledge on the applicability of software cost estimation methods, as well as to learning how they integrate quality requirements into their cost estimates.