An Assessment of the Usability Quality Attribute in Open Source Software

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This thesis is submitted to the School of Engineering at Blekinge Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Software Engineering. The thesis is equivalent to 20 weeks of full time studies.

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ABSTRACT

Usability is one of the important quality attributes. Open source software products are well known for their efficiency and effectiveness. Lack of usability in OSS (Open Source Software) products will result in poor usage of the product. In OSS development it is hard to find a usability team, and one could therefore expect that the usability would be low for these products. In order to find out if this was really the case I made a usability evaluation using a questionnaire for four OSS products. The questionnaire was based on a review of existing literature. This questionnaire was presented to 17 people who are working with open source software products. This evaluation showed that the overall usability was above average for all the four products. It seems, however, that the lack of a usability team has made the OSS products less easy to use for inexperienced users. Based on the responses to questionnaire and a literature review, a set of guidelines and hints for increasing the usability of OSS products was defined.

Keywords: Usability, open source software (OSS), questionnaire, usability testing, usability evaluation, closed source software (CSS).
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ACKNOWLEDGEMENT

First, I would like to thank my parents for their support both personally and financially throughout my thesis work and the kind affection that they show on me. Then I would like to thank my University advisor Dr. Lars Lundberg, for his ideas and guidance that helped me a lot to start and conclude my thesis work. I would also like to thank him for his kind patience that he showed on me. The way he responded to my e-mails is really appreciable.

I would also like to thank Dr. Robert Feldt who guided me to Lars and Dr. Tony Gorschek who helped me academically. Thank you very much.

Mahesh Chandra Yelleswarapu
1 INTRODUCTION

Software Engineering practices have been changing since decades to produce good qualitative software products. According to ISO there have been different quality related attributes like efficiency, effectiveness, adoptability, usability etc [30]. Assessing these quality attributes will let us know areas where to improve the quality of the software. Many innovative software products were started as open source software products. There are several advantages of using open source software. In this Master Thesis the usability attribute in open source software is analyzed and assessed using a questionnaire.

1.1 Background and Motivation

Open Source Software (OSS) development began during the 1960’s in American computer science laboratories. If any developer changes or modifies the code, then he/she should submit it to the participating community. Richard Stallman has created the GNU project and has led to the creation of the Free Software Foundation to support the development of open source software [24]. Since then a lot of open source software products have evolved like Linux, developed by Linus Benedict Torvalds whose main intention is to provide an open source operating system to everyone [25]. A lot of programmers have been involved in the development of Linux. The notion of open source software was created by Eric Raymond who strongly believes that the software developers who are participating in the development of OSS should do so purely in their own interest, and the users are co-developers who will constantly monitor the code, provide feedback, suggest bug fixes etc [26].

Many people thought that open source software development is better than the closed software model [26]. According to Stallman’s view, open source software is a development methodology and free software is a social movement [27]. Participants use the internet to share code for the development of software. Examples of open source software products are Linux, UNIX, Mozilla, Bugzilla, Solaris, Java, Apache etc [28]. Among all open source software projects, the GNU project is the biggest one.

Software quality has several dimensions like customer satisfaction, absence of bugs and ease of use [29]. There are several quality attributes that are proposed in several software development models. Some of them are reliability, efficiency, effectivenes, usability, maintainability, interoperability etc [30] [31] [32] [33]. Capiluppi et al [1] states that, since there are number of programmers participating in the open source software project, it requires coding standards and guidelines. Following a standard will cover almost all quality related attributes and will also help the developers to provide proper documentation, which in turn helps the end users to understand more about the open source product. However, there is no standard for open source software development projects i.e., there is no strict development process to follow and moreover quality and usability assurance are often ignored [37]. Article [3] states a model for an open source software development environment which clearly shows that there is often a lack of management activities for the open source software projects. Article [4] proposes a quality model for open source software. As said earlier, since there is no particular standard or it is hard to follow a standard, there may be a chance of missing some of the quality related attributes and an assessment of these quality attributes will let us know the areas where the quality is lagging for a particular software product.

In traditional software development there is a quality assurance team that assesses and maintains the quality of the software throughout the development. This kind of a team is lacking in open source software projects and it can be seen from different open
source software development processes as the participants are often distributed all around the world and however, since there is no chance of face-to-face communication, it is hard to maintain such a team in an open source environment [54]. Article [2] says that in open source development environment quality is based on conformance to community requirements of the persons that participate in the development, rather than individual requirements. These requirements should also include the usability of the software.

Open source software is particularly meant for a large scale software market and for mass production. So in this case, the software has to attract a large number of users. This can be obtained if the software product is easy to use. A lot of research papers have already mentioned how to improve the return on investment by providing software products with more usability [34]. Increased usability also helps to increase the customer’s satisfaction and can decrease training budgets [35].

In a commercial software development process, companies will have a usability engineering team which will take care of usability throughout the software development [48] [49], but in OSS development there is no such a team or it is hard to maintain a team because of cultural barriers. So there may be a risk for lacking usability in OSS. Many researchers, research articles etc have proposed different ways of assessing the usability of OSS, but some are insufficient, expensive and not realistic [52].

Evaluating usability is a difficult task and article [5] proposes several methods of which “Questionnaire” is the most realistic. Different considerations have to be made in order to evaluate the usability criterion with the questionnaire method. The outline of these considerations is: the style of evaluation, information provided to the participants of the questionnaire, the resources required etc. These considerations have to be kept in mind in order to develop a questionnaire. The sub-characteristics like learnability, satisfaction, attractiveness etc can also be easily included in the questionnaire to assess [6].

1.2 Problem Definition

Usability is an important quality attribute that has to be taken care of. The kind of people participating in the development of OSS products varies from highly technical people to non-computer professionals. Moreover OSS products usually focus on reliability, effectiveness and maintainability etc. Usability is often ignored and there is a significant lack of research on usability in open source environment [55]. However, different OSS development projects follow different methods to develop the product [55], it is quite necessary to assess how the usability is in an OSS environment. An assessment is made in this thesis to investigate the usability of different OSS products.

1.3 Research Questions

In order to assess the usability quality factor of open source software, the following research questions have to be answered.

- What are the guidelines that the participating community in the development of OSS should follow?
- How to form a questionnaire to evaluate the usability quality factor? What should be included and what should be excluded from the questionnaire?
- How high is the usability of OSS?

Answering the first question will help development or participating community to improve the usability of open source software. In order to assess the usability quality factor of open source software, the second research question has to be answered first. This is done by having a systematic literature review. Then the questionnaire is
prepared. After that, the results of the questionnaire are analyzed and then some
guidelines are proposed based on these results and from a literature study. The answer
to the last research question is the whole study that is done in this thesis work which
includes the problems related to usability in open source software environment. The
systematic review helps to answer the 2nd and 3rd research questions. While 1st and 3rd
research questions are answered by the empirical data collected from different
participants who are supplied with the questionnaire and from literature review.

1.4 Thesis Outline

The next chapter (Chapter 2) presents the research methodology, how to find
relevant papers using the exact match up of keywords. It also includes a brief
comparison of open source versus closed source software, different assessment
methods of usability, the preparation of questionnaire based on the literature study.
Chapter 3 has a summary of the results that are obtained from different individuals,
companies, professionals etc. These results are then discussed in Chapter 4 and a
comparison between the literature study and questionnaire study regarding usability is
presented. Different validity threats have also been discussed in Chapter 4. The
conclusions are presented in Chapter 5.
2 RESEARCH METHODOLOGY

The purpose of this chapter is to present the methodology to answer the research questions. The research methodologies used for this thesis are a systematic review [51] and collection of empirical data through a questionnaire. The systematic review provides a good way to extract the data and information that is required to answer the research questions.

2.1 Systematic Review

A systematic review of different research papers has been done in order to address the research questions. This is done by first observing the keywords that are required for data extraction. It is like a systematic process to analyze, interpret and to identify the data that is required to answer a research question in an unbiased way [51]. The review starts with identifying the keywords.

2.2 Finding Keywords for data extraction

This is the first task and a very important one. Different keywords like “usability”, “open source software”, “OSS”, “Questionnaire”, “quality” etc. are used to extract the data. These keywords and search criteria are used in IEEE Xplore, Inspec, Compendex, and ACM Digital Library to get various papers related to the subject. The detailed list of the keywords and search strings that are used to extract the data are presented in Table 2.1.

<table>
<thead>
<tr>
<th>Keywords</th>
<th>Search Strings</th>
<th># Papers Found</th>
<th>Selection Criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usability</td>
<td>Assessing usability</td>
<td>201</td>
<td>Papers on usability related to software engineering are selected.</td>
</tr>
<tr>
<td></td>
<td>((usability) AND assessment)</td>
<td>185</td>
<td></td>
</tr>
<tr>
<td>Open source</td>
<td>What is open source software</td>
<td>2732</td>
<td>Papers related to introduction on open source software are selected.</td>
</tr>
<tr>
<td></td>
<td>(((quality) AND open source software) AND development)</td>
<td>130</td>
<td>Papers on issues related to quality of OSS are selected.</td>
</tr>
<tr>
<td>Usability AND Open Source Software</td>
<td>Usability and open source software</td>
<td>33</td>
<td>Papers on Usability in open source software.</td>
</tr>
<tr>
<td></td>
<td>(((attributes) AND usability) AND open source software)</td>
<td>2</td>
<td>Papers related to attributes of usability in open source software are selected.</td>
</tr>
<tr>
<td>Questionnaire</td>
<td>((preparing) AND questionnaire)</td>
<td>57</td>
<td>Papers on preparing a questionnaire are selected.</td>
</tr>
<tr>
<td></td>
<td>((assessment) AND questionnaire)</td>
<td>218</td>
<td>Papers on assessing using the questionnaire are selected.</td>
</tr>
<tr>
<td>Closed Source Software</td>
<td>(open source software) OR closed source software)</td>
<td>2897</td>
<td>Papers on open source software and closed software are selected.</td>
</tr>
</tbody>
</table>
The keyword Usability is used to find relevant papers on assessing the usability in different ways. The ‘Open Source Software’ keyword is taken to find the papers that have the information related to open source environment. The ‘Questionnaire’ keyword is used to find the papers that are helpful for forming a questionnaire, which helps us to from questions and to exclude unnecessary things from the questionnaire. A combination of the keywords that are presented in Table 2.1 also helps to find relevant information. After defining the search strategy a selection process has to be used to select relevant papers. The number of articles found from each resource is given in the following table.

<table>
<thead>
<tr>
<th>Resource</th>
<th># of articles found</th>
<th># of articles selected after final selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE</td>
<td>1257</td>
<td>12</td>
</tr>
<tr>
<td>ACM</td>
<td>452</td>
<td>4</td>
</tr>
<tr>
<td>Books</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td>Technical Papers</td>
<td>94</td>
<td>8</td>
</tr>
<tr>
<td>Conferences</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Journals</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>Others</td>
<td>49</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td>1964</td>
<td>55</td>
</tr>
</tbody>
</table>

So, overall 1964 papers have been selected from the records that are relevant to this thesis. Of these 1964 papers, 127 records have been considered after the primary selection and 55 were taken after final selection of the records. These papers have been studied thoroughly to perform the research work. The selection criterion for selecting the records is also mentioned in Table 2.1 and all other records are excluded. After selecting the records, a data analysis has been made which can be found in the next section.

2.3 Data Analysis

A detailed analysis of different research papers and articles is presented in this section. This analysis includes the concept of usability in both open and closed source software. Different ways of assessing the usability are also analyzed, and this mainly helps in preparing the questionnaire.

2.3.1 What is Usability?

Usability may be different for different software products; it changes from one perception to another perception. The degree of usability will depend on several factors such as [36]

- Ease of use
- Effectiveness of use
- Subjective satisfaction
- Experience of the user to use the software etc

Usability will ease the human computer interaction so that the user will communicate better with the software system [37]. According to [38] [36] usability can be defined as an extent to which a product can be used by a specific user to achieve specified goals with effectiveness, efficiency and satisfaction. The degree of satisfaction will vary from one user to another.

From the literature study I conclude that the Usability of a system must try to fulfill all the criteria that are expressed in the following definitions.
Shackel 1991 [7] defines usability as combination of three components which are effectiveness (speed), learnability (the time required to learn) and retention (ability to retain what is perceived).

Shneiderman [8] defines usability as combination of five components that are time to learn, efficiency, rate of errors of users, speed of performance and retention.

Nielsen [9] defines usability as a combination of five factors which are efficiency of use, learn ability, memorability (the extent of the system that is being remembered), absence of errors and user satisfaction.

Dix et al [10] defines usability as a concept that can be analyzed as a part of three levels that include learnability, flexibility and robustness.

Bevan and Macleod defines usability as follows [11]

“Usability is a use of computer tools in a particular context. Especially the authors assume that outcome of quality of use when working with computer software system includes the intended goals of system should be achieved (effectiveness) with optimal use of resource expenditure”.

Molish defines usability as a state that a user friendly system tends to fulfill the following goals that include Easy to learn, Easy to remember, Efficient to use, Satisfactory [12].

From the above definitions I came to the conclusion that the usability of open source software (in general for any kind of software) will be high if it has high efficiency and is easy to use. Other factors such as effectiveness, user satisfaction, error recovery, troubleshooting steps etc also play a vital role for the usability. Users may feel that software which does not require any prior experience to use the system will be more usable. These are the different things that I have included in the questionnaire for the assessment of usability (see Annex).

2.3.2 Usability in OSS when compared to closed software

Usability engineering is often used for traditionally developed software products. User satisfaction is important for closed or traditionally developed software. Since OSS is not intended for a particular user, it may be hard to obtain usability. The design phase of the software development process will help to improve the usability of closed software. In OSS, the design phase is very weak, and therefore it could be quite hard to obtain usability.

In order to make a comparison between open source software and closed source software I present the strengths and weaknesses of both.

2.3.2.1 Open Source Software

Benefits of OSS:

Cost: One of the major benefits of open source software is the price compared to the closed source. Users who cannot afford to buy closed source software due to its high price can use open source software products [13] [22].

Openness: Free access to the source code is one main advantage of open source. This makes it possible to control and mould the software to fit the user requirements [14] [23].

Reliability: One great advantage of open source software is that it is often very secure and reliable. This is mainly because of free access of code and easily customizable code so that everyone can change the code and there may be a chance of having rigorous testing methods imparted on a particular open source software, thereby increasing the reliability, and also the security imparted in open source software is very high [15].

The above mentioned attributes are either directly or indirectly affecting the usability of the software. If the software has more usability, more users will use the software and it draws more developers to work on the code of software, more testing
can be done and the application of open source software in different environment helps for the improvement of the reliability.

Weaknesses of OSS:
Maintenance: More and more software development projects are distributed across various sites. Many software companies in distributed projects mainly use open source software. In places where there is no face to face communication it is difficult to maintain the code [16].
Proper coordination between developers: One of the main challenges in open source practices is handling many potential volunteers. These volunteers have to coordinate themselves in order to achieve a good software product. This makes life hard for developers as there is usually no proper schedule and discipline among the volunteers.

2.3.2.2 Closed Source Software (CSS)
Benefits of CSS:
Commercial value: One of the main advantages of closed source software is that it provides profit to the developers. Once the code is written, it cannot be reproduced for free, due to the fact that free licensing is not used in such software. Closed source software is developed by a single person or single organization. One main advantage is that all the source code and main project initiatives are kept secret. Most closed source software products have copy rights and/or is patented. The software is thus legally protected as intellectual property.
CSS products are mainly created to satisfy only the present market requirements, and to get a competitive edge over other competitors. Customers can expect the documentation and application performance as per their needs [17].

Weaknesses of CSS:
They are relatively costly as discussed earlier, requires lot of financing to promote the product.
Frequent upgradations: So due to the fact that frequent upgradations are needed, there is an element of risk involved, also the stress factors do increase due to the frequent upgradations, new versions are developed, and it may involve risk. In OSS development also frequent upgradations are necessary but it is not forced by a single customer or users as seen in CSS, deadlines are made and forced by the customers in CSS.

This comparison of usability between OSS and CSS is important because, as discussed earlier there is a lack of usability team and usability engineering in OSS.

2.3.3 Why Usability is necessary in OSS

As said earlier, OSS development does not follow any model or standard. The main emphasis in OSS is on the development phase. A lot of the members participating in OSS development are developers. They may or may not the end users, so they develop according to requirements.
Open source software products must be evolved or must be developed within the right time frame, with in the right budget as per the necessities of the user i.e., with low or no cost, having more usability etc. In the modern era more and more software development projects have started to use open source software products, this is mainly due to easy accessibility and availability of code. Code should be available as per demand of customers and it must be easily tailored for use. One important aspect is that the code must be secure from all sides helping to make it more reliable and more
usable. The factors discussed above are important and have to be adopted in the process of development of quality for open source software.

Role of usability: From the discussions above, it is clear that usability is related to how the end user is going to perceive the product that is developed. More and more applications were developed using open source. Since many years, companies have started to use OSS products instead of CSS due to the substantial benefits provided in OSS products. Also most of the applications that are developed using OSS are said to be user centric applications, that means if the product does not meet quality criterion of users, it is a failure. So, it is important that the quality standards of such applications need to be assessed properly in order to satisfy user needs. In such a case usability is the attribute that also needs to be emphasized and looked upon in such OSS applications.

2.3.4 Different Measures of the Usability factor

Measuring usability quality attribute includes different sub attributes. These measures help to include different things in the questionnaire so that different other attributes or sub-characteristics of the usability attribute can also be assessed. Some of the measures from different models are presented here.

Usability measures are best approached, by quality models. Some quality models present ways to measure usability. They are listed below [18]

McCall presented that usability can be measured by following decomposable measures,

- Operability: How well system can be operable
- Trainable: How well user can get trained in the software
- Efficiency: How efficient the system going to be in different conditions

MUSIC framework by Bevan et al [19] provides a more advance form of measurement.

1. Effectiveness: How effectively the task is to be performed
2. Efficiency: Consists of many things like user efficiency, human efficiency, temporal efficiency and corporate efficiency
3. Satisfaction of user, task, environment and equipment
4. Control
5. Helpfulness
6. Learnability
7. Affect
8. Task Performance (subjective and objective)
9. User Effort

Semi automated interface designer evaluator model presents the following measures for the Usability of a software system. The 5 usability measures that are presented in this model are:

1. Efficiency
2. Alignment
3. Horizontal balance
4. Vertical balance
5. Element position

All these attributes define the position of an element on the screen. Element’s horizontal, vertical positions on the screen are measured and they are placed and/or evaluated according to these measures. This model mainly deals with evaluating the user interface design of the software.

Log processor presented in a frame work called DRUM (Diagnostic Recorder for Usability Measurement) contains all the metrics related to usability and these are
presented in DRUM database. It can help in measuring and automated calculation of the performance related attributes that are related to the usability. They are listed below.

1. Task time: It is the total time to perform tasks.
2. Snag time/Search time: It deals with amount of time, user wastes unproductively when performing hunting of the system and other related tasks.
3. Effectiveness: It relates to task performed successfully or not.
4. Efficiency: Whether user succeeded performing task in right time frame or not.
5. Productivity period: The percentage of time spent performing the right operations, not wasting time in snag operations [20] [21].

Different measures have been taken from different models which are discussed earlier. The measures for usability assessment which are recommended by ISO [36] [30] have also been taken for the assessment. According to [39] there are 3 phases to test the usability of a software product. These phases include preparing for the test, running the actual tests and analyzing the results that are gathered. In this thesis the first step of preparing the test includes analyzing and finding different ways of assessing the usability factor have to be observed. Based on this analysis a questionnaire is prepared. In second phase i.e., running of the actual test, the questionnaire is presented to different companies and individuals. The last step is analyzing the results which can found in Chapter 4.

2.3.5 Different ways of assessing the Usability quality factor

In this section different ways of assessing the usability factor are discussed. In the above section the different measures of usability quality factor are presented. There are different ways of measuring and assessing the usability quality factor. Different issues should be kept in mind while assessing the usability factor. It is quite different from the closed software, because in closed software, it is possible to check the software product against the requirements of the user. But OSS systems are not intended for any particular user, so it is hard to check the system against the requirements. Some factors include

- The domain in which the open source software is being installed and using.
- The typical users who are using the software.
- Experience of the end-user of the OSS product.
- The troubleshooting steps that the software should provide when it crashes.

Assessing as said earlier is a very difficult task. Some methods are expensive, some are not realistic, some aspects are missing in some methods etc. It is difficult because it can’t be measured in terms of numbers or it can’t be measured quantitatively. Different ways of assessing the usability factor includes [40]

- Interviews (common personal interviews)
- Questionnaire (preparing a questionnaire and presenting to users, developers, etc.,)
- Surveys (data collected from different case studies, past projects etc)
- Observation (by observing and comparing carefully the development process of CSS and OSS)
- Empirical methods (some other traditional ways as seen from CSS)

Different authors have proposed various other means of assessing or evaluating usability. Some of them are [41]

- Heuristic evaluation
- Usability testing
- Cognitive walkthroughs
- Focus groups
• Thinking aloud

Of these methods, the questionnaire is a practical approach. Each of the above mentioned techniques have their own advantages and disadvantages. Even [42] provides some more ways like direct questioning, observation and traditional evaluation methods. All these methods can be used individually or in groups and depends mostly on the situation on which the test has to be made. From [52] it is quite clear that using the questionnaire, the efficiency, effectiveness, satisfaction of the software can easily be assessed and evaluated. The taxonomy of different usability evaluation techniques is proposed and the questionnaire will fall under Real World usage [52].

2.3.6 Assessing using a Questionnaire

Questionnaire is an inexpensive way of assessing the usability factor. It is relatively easy to present the questionnaire to companies using open source software. The reasons for using questionnaire in my thesis project are:

- It is cheap compared to other ways
- Company people can feel better to answer indirectly unlike in interviews, since they may feel tensed during the interviews.
- In a questionnaire it is easy to include all the necessary questions.
- A large amount of information can be gathered from different people in a short time [41].

2.3.6.1 Preparing a Questionnaire

A questionnaire is prepared and is presented to different companies in India and to different individuals. This preparation includes a lot of literature study. By having this literature study it is possible to frame a better questionnaire and helps to include the questions that are helpful to assess the usability and its sub-attributes. The literature study also helps to prepare the questionnaire in a more precise way. It is prepared based on the people who are going to participate in the survey. These people include persons in companies, college/university students, a common/normal person etc.

The questionnaire that was prepared can be found in Annex [1]

2.3.6.2 Things that should be taken care while preparing the Questionnaire

Observing the advantages and disadvantages of taking a questionnaire survey is important. Selecting the right persons, preparing appropriate questions, managing timeliness are some of the issues that should be taken care of. As this survey using questionnaire includes people from different background, the questionnaire was prepared while keeping different people from different background in mind. So that everyone can understand the questions in a correct way.

Different usability related attributes are being kept in mind and they are presented indirectly in the questionnaire. The possible issues that have to be observed while preparing the questionnaire are

- The kind of people participating
- The kind of experience they have
- What kind of software they are working with
- Issues related to language (ease of understanding the questions)
- Time constraints
3 Results

The questionnaire was presented to 7 managers (project managers and general managers), 6 persons who are not software professionals, 4 software professionals (software designers and testers). So, overall 17 people were made part of this questionnaire survey. A scale is given in the questionnaire from 1.0 to 5.0.

Different attributes were taken for the questionnaire to assess the usability. These attributes represent usability aspects. A detailed description of these attributes is given below.

Ease of Use: It defines how easy it is to use the system is. For this attribute the rating 1.0 is taken as low (not easy to use) and 5.0 as high (very easy to use).

Efficiency: Efficiency of the software system is referred to as how well the software is using limited computer resources. 1.0 is means low efficiency and 5.0 is means high efficiency.

Effectiveness: Effectiveness is the attribute which refers to how well the software is performing the user’s task. The same scale as for efficiency is applied to this attribute also.

Subjective Satisfaction: It refers to the user satisfaction of using the software. 1.0 means that users feel less satisfied and 5.0 means that users are more satisfied with the software.

Prior Experience Needed: The experience needed to use software is often important, so it is taken into consideration for assessing the usability. A score 5.0 means that users need less experience and 1.0 means that users need more experience in order to use the software.

Learnability: The attribute is referred to as the how easy it is to understand the software. 1.0 means that the software is hard to understand and a score of 5.0 means that it is easy to understand.

Error Recovery: The attribute is defined as how fast and how well the software will recover after a crash. 1.0 represents worst recovery of the software and 5.0 is the best. It means that for the particular software with a score of 5.0 for this attribute the time taken to recover from error is rather low and for the score 1.0 it is vice versa.

Troubleshooting help from Vendor: How much support did the end users get of using the software, is taken by this attribute. The ‘vendor’ here for this attribute represents the community of software developers developing that particular software product e.g., Mozilla community for Mozilla Firefox. 1.0 means that having less support or help from the vendor and 5.0 means that having more support from the vendor of the software.

Overall Usability of OSS: The overall usability of the software is rated by this attribute. On a scale of 1.0 to 5.0, 1.0 is less usable and 5.0 is the best

Software products from different domains were taken, including operating system, web browser and development tools. The survey results of the questionnaire are summarized in the following tables.
Open Source Software #1 Linux: Linux is a well known open source operating system similar to UNIX. Linux was developed by Linus Benedict Torvalds and other developers the world. The source code for this open source product can be found at its home page [43].

Table 3.1 Summary of survey results of Linux.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1.0-1.9</th>
<th>2.0-2.9</th>
<th>3.0-3.9</th>
<th>4.0-5.0</th>
<th>Average Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Use</td>
<td>9</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Efficiency</td>
<td>1</td>
<td>6</td>
<td>8</td>
<td>2</td>
<td>3.1</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>3</td>
<td>3.1</td>
</tr>
<tr>
<td>Subjective Satisfaction</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>3.1</td>
</tr>
<tr>
<td>Prior Experience needed</td>
<td>15</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td>Learnability</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1.9</td>
</tr>
<tr>
<td>Error Recovery</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>5</td>
<td>3.9</td>
</tr>
<tr>
<td>Troubleshooting help from Vendor</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>4.1</td>
</tr>
<tr>
<td>Overall Usability of OSS</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3.1</td>
</tr>
</tbody>
</table>

From the above table it is quite evident that overall usability of OSS is falling around Medium range of score i.e., around the score of 3.0. The average score of the overall usability of the software is 3.1. This shows that the overall usability for this software product is not that high. This is due to the fact that, for Linux prior experience is needed to use the software and the results (from Table 3.1 average score of prior experience needed is 1.5) also show that Linux needs experienced professionals for its usage. Users without any experience will feel uncomfortable of using this software. The important attribute which helps to compensate the overall usability of this software is ‘Troubleshooting help from the vendor’, which is having a score of 4.1. Understanding this software is also very difficult as seen from the results of Learnability, which is having a score of 1.9.

Open Source Software #2 Mozilla Firefox: A saying by [44] “We believe that internet should be public, open and accessible”. These lines itself say that the software they are developing should help the general public to access the internet in an efficient way. Firefox is an open source internet browser application developed by the Mozilla community, which is distributed all over the world for free. It also accepts different add-ons which are developed by the participating community. This helps to attract more users to use the software. The table below shows the summary of the questionnaire for Mozilla Firefox.

Table 3.2 Summary of survey results of Mozilla Firefox

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1.0-1.9</th>
<th>2.0-2.9</th>
<th>3.0-3.9</th>
<th>4.0-5.0</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Use</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>4.4</td>
</tr>
<tr>
<td>Efficiency</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>9</td>
<td>4.0</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>10</td>
<td>4.5</td>
</tr>
<tr>
<td>Subjective Satisfaction</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>9</td>
<td>3.9</td>
</tr>
<tr>
<td>Prior Experience needed</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>15</td>
<td>4.5</td>
</tr>
<tr>
<td>Learnability</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>10</td>
<td>4.2</td>
</tr>
<tr>
<td>Error Recovery</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>3.6</td>
</tr>
<tr>
<td>Troubleshooting help from Vendor</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>8</td>
<td>3.5</td>
</tr>
<tr>
<td>Overall Usability of OSS</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>10</td>
<td>4.2</td>
</tr>
</tbody>
</table>
Mozilla Firefox is having more usability, this is because of its effectiveness (average score is 4.5) and no prior experience (average score is 4.5) is needed. The easiness with which the users feel to use this product is also high with an average score of 4.4. Different other issues such as efficiency, subjective satisfaction, learnability etc are also very high as seen from Table 3.2 which is convincing for a user to use this software. Its adoption of different add-ons will also make it more usable product, as users may feel more comfortable because of customization. Otherwise it would have been a less usable product.

Open Source Software #3 Netbeans: It is open source software used to create enterprise, desktop and web applications. It includes an open source IDE and an application platform and people can develop applications using J2EE, PHP, and AJAX etc. It also has the option to integrate 3rd party plug-ins, so that the job of the developer can be made easy [45]. The following table is the summary of the results from the questionnaire for Netbeans.

Table 3.3 Summary of survey results of Netbeans

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1.0-1.9</th>
<th>2.0-2.9</th>
<th>3.0-3.9</th>
<th>4.0-5.0</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Use</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Efficiency</td>
<td>1</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>2.7</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>3.2</td>
</tr>
<tr>
<td>Subjective Satisfaction</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>3.8</td>
</tr>
<tr>
<td>Prior Experience needed</td>
<td>15</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1.7</td>
</tr>
<tr>
<td>Learnability</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>1.9</td>
</tr>
<tr>
<td>Error Recovery</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>3.6</td>
</tr>
<tr>
<td>Troubleshooting help from Vendor</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>3.9</td>
</tr>
<tr>
<td>Overall Usability of OSS</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3.8</td>
</tr>
</tbody>
</table>

The overall usability of this software product lies above medium. Most of the aspects evaluated for this software are in the medium area of the above table. The Learnability and prior experience are the two areas that suffer for this product with scores 1.9 and 1.7 respectively. The effectiveness and troubleshooting help from the vendor are the parameters that help the software to have usability more than the average value.

Open Source Software #4 J2EE: It is an open source software development platform used to develop different web and enterprise applications. Using this software developers can improve productivity; can have less XML configuration for their applications etc. J2EE is an industry standard for enterprise Java computing.

Table 3.4 Summary of survey results of J2EE

<table>
<thead>
<tr>
<th>Parameters</th>
<th>1.0-1.9</th>
<th>2.0-2.9</th>
<th>3.0-3.9</th>
<th>4.0-5.0</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Use</td>
<td>9</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2.1</td>
</tr>
<tr>
<td>Efficiency</td>
<td>3</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>3.3</td>
</tr>
<tr>
<td>Subjective Satisfaction</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3.3</td>
</tr>
<tr>
<td>Prior Experience needed</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2.1</td>
</tr>
<tr>
<td>Learnability</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td>2.8</td>
</tr>
<tr>
<td>Error Recovery</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>2.7</td>
</tr>
<tr>
<td>Troubleshooting help from Vendor</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>3.6</td>
</tr>
<tr>
<td>Overall Usability of OSS</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>3.8</td>
</tr>
</tbody>
</table>
From the above table it is quite clear that the usability of the software product is rather high. But the average score of different important factors like efficiency, effectiveness etc is around medium. ‘Prior experience needed’ and ‘Ease of Use’ are having a score less than average with 2.1 each. This area should be concentrated by the software developers to improve. But the overall usability is 3.8; this is due to the fact that the above product is being adopted by many people around the world for development of different other products.

After analyzing the results, it is quite clear that the average overall usability for all the open source software products lies in the area of medium and above the medium score. Different aspects have to be considered while performing the analysis. For instance if ‘Effectiveness’ is taken, it is above average for all for OSS products. For Linux to have usability above average (a score of 3.1) effectiveness is probably the most important factor. This factor is also high for Mozilla Firefox. For Netbeans and J2EE the ‘Effectiveness’ score is 3.2 and 3.3 respectively.

The factor which is suffering in OSS environment is ‘Prior experience needed’. This attribute is quite low for Linux and the score is 1.5, and for Mozilla Firefox the score is 4.5, which is very high. This variation is seen because of the fact that the type of software and its application. This factor is also quite low for Netbeans and J2EE. So this is the factor on which the OSS community should take care of. If this factor is improved by providing better user interface to the users then there is a chance to improve the overall usability of the OSS products. Since Mozilla Firefox is having better user interface it does not need any experience. Similarly for complex software systems, if better UI is provided then the usability will get benefitted.

Another important factor is ‘Learnability’, which is low for different open source software products. It is quite low for Linux, Netbeans and J2EE with scores 1.9, 1.9 and 2.8 respectively. However ‘Learnability’ sub-measure is high for Mozilla Firefox with a score 4.2. This implies that it is quite hard to understand some of the open source software products. As said earlier, this is also due to weak UI design of the software product. Due to this attribute the overall usability of the OSS is at average for some of the products, otherwise the software products would have high usability.

To compensate the overall usability of OSS products, the factors like effectiveness, efficiency, troubleshooting help from vendor etc are high, so that the overall usability of the software is at average and above average. The results also show that some factors are having more score and while some are low to have the usability at above average score. But the factors like efficiency, effectiveness etc are high which is an encouraging sign to use open source software products.

These are the summary of the results that are taken from different people on 4 different open source software products. From all these results it is quite clear that, in order to use particular open source software prior experience is needed and some of the open source products are hard to understand. So it draws fewer amounts of users to use that software. A more generalized discussion of these results and a more generalized view of usability on open source software have been presented in the next section.
4 DISCUSSION AND VALIDITY THREATS

This section provides a detailed discussion of the results and from the literature review. This section also discusses different validity threats of the thesis work.

4.1 Discussion

A lot of research has been done on the software related quality metrics for general purpose software [46]. But there is a lack of research on these quality related attributes for open source software. The usability quality attribute taken in this thesis has been assessed for 4 different open source software products. The reason for taking the usability attribute is that, in OSS there is no requirements document and no usability team. So it is particularly important to assess the usability requirements [47]. The results from the questionnaire show that the usability is rather satisfying in OSS. The overall usability falls in the area of average and above average. As there is no dedicated usability team in open source environment, some of the important factors such as learnability, prior experience needed are missing to support usability but at the same time some other attributes such as effectiveness, efficiency, troubleshooting help are high in OSS. IBM has 25 user centric labs worldwide [48]. Microsoft is also investing a lot on the usability of their software products. Microsoft has more than 100 people which include usability engineers, usability specialists and other usability staff. These people are involved in the software product development from the design phase to the testing phase [49]. Like these companies many other companies are also investing a lot on testing the usability, to increase the usability of their software products. Unlike closed source software, if the open source software is having high usability it may generate more returns voluntarily, because of donations for different OSS products. This will help the OSS community to develop different innovative software products. Some open source software products are more easy to use while some are not. This is mainly because of the fact that differences in the participating community and complexity of the software systems. For example Firefox is easy to use (see Table 3.2). However, Linux is in the medium range (see Table 3.1). From this it is clear that some of OSS products are having more ease of use. Moreover Linux also requires prior experience. There are several other things that have to be taken care of, like when comparing the attribute ‘Prior experience needed’ between the four software products taken in this thesis; it is quite clear that, to use Linux more experience and proper training is needed and at the same time for Mozilla Firefox the results show that, very little experience is necessary to use that product. Learnability is another important attribute that is different for different software products.

The results also show that the usability differs from one software product to another and their application. For browser type applications more user centric software products are designed in OSS environment and for operating systems as more security and reliability is necessary, usability in somewhat been neglected. This indirectly draws less number of users to use that particular software product. The Table 3.1 from Chapter 3 also shows that for open source operating system, the usability is just above average (due to high score of efficiency and effectiveness) and for open source browser application it is high (due to ease of use, high learnability etc). Another important factor for variation of usability among different products is that the kind of people participating for the development of open source software differs from one product to another. The cultural barriers among different developers also play a vital role.

According to [40], the main aim of open source software development projects is not the User Centric Design. Lot of earlier open source software products developed
were compilers, libraries etc and usability has been ignored for a long time. The majority of the developers of open source software are having very little training and the users of OSS often need prior experience. The common public is getting used to commercial proprietary software products [50]. This is quite similar to the results that are obtained from the questionnaire as prior experience and learnability are the factors that are suffering in OSS environment.

Recommended Guidelines to be followed to improve the usability of OSS based on the responses from questionnaire and literature study.

- Involving the end-users to improve the design of the open source software product [53].
- Developing software products that can be used by less experienced people will draw more users to use OSS products, as some of OSS products need a lot of prior experience (see Table 3.1).
- Provide relevant troubleshooting support (see Table 3.1, 3.2, 3.3 and 3.4).
- Collect early feedback from the end-user [53].
- Providing better user interface, like in Mozilla Firefox, as ease of use seems to be high for this OSS product because of better user interface (see Table 3.2).
- Developing a standard for usability evaluation [39] will help us to produce more usable OSS products.
- Learnability is another important attribute of usability that is suffering (see Table 3.1, 3.2, 3.3 and 3.4), so providing a better “Help” and “Tutorial” sections for the software would be much satisfactory for the users.

These are some of the guidelines that the participating community should follow that may help to improve the usability quality factor for the open source software.

4.2 Validity Threats

Different validity threats may include internal validity, external validity and conclusion validity. The internal validity threats may include the information taken from the literature review and different conclusions drawn from the records. This threat was avoided by having a systematic literature review. External validity threats include the kind of people participated in this survey. This is avoided by selecting appropriate persons who include experienced and non-experienced persons as well as technical and non-technical people to generalize the survey. As conclusion is drawn from the questionnaire survey and literature review, this is also avoided. Unfortunately the number of people participating in the survey (17 people) is rather small. This limits the validity of the study somewhat.
5 CONCLUSION

Usability is one of the important quality attribute that has to be taken care of. Lack of usability does not attract users to use that particular software product. As open source software development does not have any usability team, it is up to the participating community to design the software product with high usability. In this thesis I have shown that some open source software products are having high usability while some are not. My study shows that some open source software products require a lot of experience in order to use and to maintain.

Regarding the research question “How high is the Usability of OSS?”, we could see that Mozilla Firefox had very high values for the different usability attributes as well as for the Overall Usability. For the other three OSS products the values of “Prior Experience needed” and “Learnability” were rather low, whereas the values for “Error Recovery” and “Troubleshooting help for the vendor” are high. The Overall Usability as above average for all four OSS products, thus indicating that the lack of a usability team in the development process did not result in unacceptable usability. The low values for the “Prior Experience needed” and “Learnability” attributes indicate that the lack of a usability team could, however, have made the OSS products less easy to use for inexperienced users.

For the other research question “How to form a questionnaire to evaluate the usability of OSS?” a questionnaire is prepared based on the literature study which helps to include the attributes that are related to usability and to exclude the other things. The resulting questionnaire is presented in Annex [1].

In order to answer the research question “What are the guidelines that participating community should follow?”, an analysis is made based on the literature study and the responses from different people to the questionnaire. With this analysis in hand some guidelines are proposed and are presented (see bullets at the end of Chapter 4). Following these guidelines will help the developers and end-users to find the areas that are lagging usability of open source software and also helps the developers to reduce re-design and re-work.

The future work of this thesis may include providing some guidelines to help the participating community to follow a standard (i.e., ISO) or a process model that could help to develop an innovative software product with high quality.
REFERENCES


ANNEX

[1] Hi, I'm going to take a survey and would like to have your opinion regarding the open source software that you are using. Here I have few questions for you and request you to answer.
R 1 What is the open source software you are using?
A.
R 2 How do you feel about the User Interface of the OSS you are using?
A.
R 3 How ease the UI is? How do you rate the easiness of the software on a scale of 5? (Rate from 5(Easy to use) to 1(Very hard to use))
A.
R 4 Is there any assistance being provided for the user to prevent errors?
A.
R 5 How frequently does the system get crashed?
A.
R 6 Does the OSS vendor take any feedback from the users?
A.
R 7 Are there any troubleshooting steps provided for the software?
A.
R 8 How many years of experience should a user have to use this software?
A.
R 9 According to you what is the usability of the software you are using?
A.
R 10 In what way is the documentation helpful to understand the open source software system?
A.
R 11 What is the average crash recovery time?
A.
R 12 Does the software require any re-designing to have better usability?
A.
R 13 How does the usability of the OSS you are using differs from legacy software systems?
A.
R 14 Can non-technical users use the OSS that you are using?
A.
R 15 How the usability of the OSS can help the project on which you are working?
A.
R 16 What is your know-how of the term usability in OSS?
A.
R 17 Can the crash reports and bug reports be easily understood by the user?
A.
R 18   How do you rate the efficiency of use on a scale of 5? (Rate from 5(More Efficient) to 1(Less Efficient))
A.
R 19   How do you rate the severity and subjective satisfaction of the OSS on which you are working on a scale of 5? (Rate from 5(More satisfaction) to 1(Less satisfaction))
A.
R 20   Overall how do you rate the usability of OSS that you are using on a scale of 5? (Rate from 5(Having more Usability) to 1(Having less Usability))
A.

Thank you for your responses. You are highly appreciated and I’m really very much thankful to you.