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Usability bugs in open-source software and online forums

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Abstract: The unlimited number of open-source software (OSS) users and the importance of end users' experience in determining software quality make usability an even more critical quality attribute for OSS than it is for proprietary software. The research model of this study establishes the relationship between usability errors in OSS and online public forums. The results of this empirical analysis provide evidence about active management of usability-related issues in OSS. To conduct this research, the authors used a dataset consisting of 1753 OSS projects, covering a broad range of categories. The results of the study show that online forums play a significant role in identifying and fixing usability bugs in OSS.

1 Introduction

The collaborative nature of the open-source software (OSS) culture utilises a volunteer community that conducts its development activities in a decentralised environment, effectively lowering production costs and improving software quality [1]. In recent years, the increasing use of OSS results from factors such as easy, and for the most part, free access to the internet. In OSS, the experience of end users has become an important issue. With the popularity of OSS among organisations as well as among common novice users, the OSS community is no longer limited to 'technically adept' individuals. Hence, the requirements and expectations of OSS are not the same as they were a decade ago, when software developers were considered to be the only OSS users.

In the ISO 9241-11 Standard [2], usability is defined as 'the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use'. Usability bug reporting refers to design-time or runtime errors in software that are specific to and reported by the user. Zhao *et al.* [3] relate improvement in software quality to usability of OSS products. By analysing a set of hypotheses they study the effects of different components on effectiveness and efficiency of OSS usability improvement. Nichols and Twidale [4] observe a partiality in treating usability bugs as compared with functionality bugs. Çetin *et al.* [5] consider effective feedback from end users as one of the ways to improve OSS usability. They suggest that effective feedback can be attained by providing users with a convenient way to report the software errors that they come across.

In OSS, the main route for users is via online forums. In this study we embark to empirically examine the role of online user forums, the main point of interaction for users, and the critical areas of bug reporting in general, and usability bug reporting and fixing, in particular. We have used a dataset of 1753 OSS projects covering a broad range of categories to study the research model of this investigation.

In the next section we are presenting the literature review that motivated this research work. Section 3 illustrates the research model and the hypotheses of this study. Section 4 explains the research methodology. In Section 5, we present data analysis procedure testing and the analysis of the results. It is followed by the discussion in Section 6 that also includes the limitations of the study. Finally, the paper concludes in Section 7.

2 Literature review: OSS quality and usability

According to Hansen *et al.* [6], OSS means that 'the source code is distributed along with the executable program. It is free to use. It includes a license allowing anyone to modify and redistribute the software'.

Koch and Neumann [7] explore the influence of different forms of OSS development processes on the resulting software and verify their effects on different quality aspects. These authors attempt to ascertain whether different variants of OSS development processes significantly influence the resulting products. Although OSS products are ultimately dependent on the skills of the developers, Hedberg *et al.* [8] believe that high-quality software can be produced by OSS. By developing an OSS success model from an existing information systems (IS) model, Lee *et al.* [9] identify the determinants for OSS success and realise the significance of software quality on user satisfaction. Furthermore, they recommend that 'usefulness, ease of use,

and reliability' are some of the major factors that OSS practitioners should heed in order to improve OSS quality.

Çetin *et al.* [5] identify users, customers and developers as the major groups involved in OSS bug reporting. In their empirical study for measuring the success of OSS projects, Lee *et al.* [9] also recognise the influence of software quality and user satisfaction over OSS use. Raza *et al.* [10] maintain that OSS developers should consider multiple key usability factors to improve usability of their projects.

Software usability is a subjective concept, and thus it cannot be directly measured. Additionally, many users experience difficulty in reporting usability errors. While analysing OSS usability aspects from industrial users' perspective, Raza *et al.* [11] realise that the popularity of user-centred designs in OSS is increasing, they however believe that usability is still not considered as one of the prime objectives in many OSS design scenarios. Nichols and Twidale [4] argue that it is challenging for a user to describe and hence report the difficulties s/he faces in the graphical user interface (GUI) of software. Viorres *et al.* [12] highlight a few potential areas of improvement for OSS usability, such as enhancing bug reporting facilities in software, improving the analysis of usability errors through the application of HCI principles, and supporting argumentation for resolving such issues. Ahmed *et al.*'s [13] study indicates the significance of public forums in managing software defects and implementing new in open-source projects.

However, there are several challenges associated with improving the usability of OSS. This is despite of the fact that OSS is gaining popularity among novice and non-technical users. In OSS environment, heavy reliance on voluntary mediums such as online forums raises many concerns on their effectiveness. In the light of different issues as highlighted in the above literature survey, we have set out to empirically examine the role of online forums in addressing usability-related issues.

3 Research model and hypotheses

The growth in the number of OSS projects and their users has increased tremendously in the recent years. In the OSS environment, online forums provide a platform for its diverse contributors to communicate and share their development issues. These forums play an active role towards managing new features and support requests. Our aim is to investigate the answer to the following research question (RQ):

RQ: Do online forums assist in managing usability bugs in OSS projects?

The purpose of the RQ in this study is to analyse the association between OSS usability bugs identification and fixing and public forums associated with these projects. In this study, we present a research model for analysing the relationship between usability-related errors and the online forums of OSS projects. The theoretical model that will undergo empirical testing is presented in Fig. 1. The research model deals with the association of online forums with software defects, in particular usability bugs. Messages and mailing lists are the two major forums where users can report their problems and errors related to different issues. Increase in messages and mails indicate the interest of people and helps in addressing the highlighted issues.

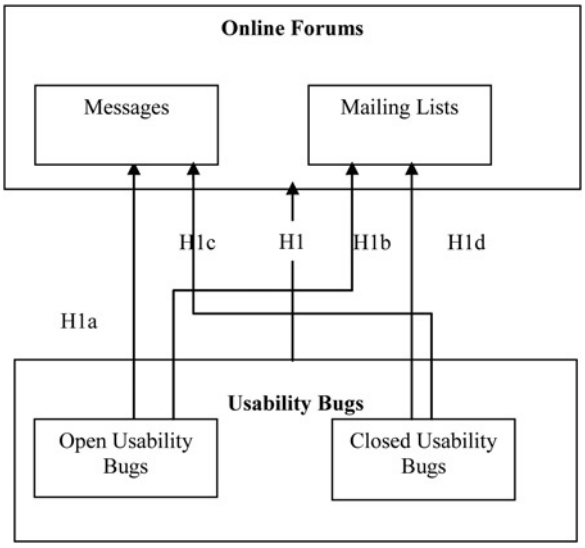

Fig. 1 *Research model*

As indicated in the model (Fig. 1), the dependent variables are online forums, messages and mailing lists, whereas the independent variables are usability bugs, open usability bugs and closed usability bugs. We would like to state here that the term 'open usability bug' is used as a usability error that has been reported but has not yet been fixed, whereas 'closed usability bug' refers to a usability error that has been reported and resolved. In order to empirically investigate the RQ, five hypotheses are presented in Table 1.

4 Research methodology

The data for this research study were collected from 1753 projects of a popular OSS projects repository, sourceforge.net. The dataset covers various categories of OSS projects such as communication, database, desktop, education, format and protocols, games and entertainment, scientific and engineering, security, software development, system and text editor. The first filtration activity removes the data of all those projects which has either total bugs of 0 or having no online forums. This reduces the dataset to 718 projects. In order to search for usability-related errors, we looked for words such as usability, user, display, run, menu, open, close, extract, zip, unzip, GUI, click, interface,

Table 1 Usability errors hypotheses

Hypothesis #	Statement
H1	Public online forums help in identifying and fixing usability errors in OSS projects
H1a	The open usability bugs are positively related with the number of messages in online forums
H1b	The open usability bugs are positively related with mailing lists in online forums
H1c	The closed usability bugs are positively related with the number of messages in online forums
H1d	The closed usability errors are positively related with mailing lists in online forums

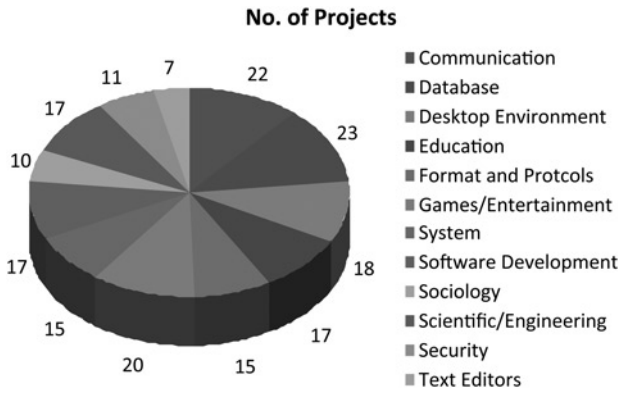

Fig. 2 *Pie chart of project categories*

input, output, help, guideline, install, uninstall and so on. These words/phrases can be found in Tracker–Bugs summary. We assumed that any summary of the bugs reported/fixed containing these words can be considered as usability-related bugs. Similarly for mailing lists, these phrases were searched in 'Topic' of mailing list archives. This filtration further reduced our dataset to 192 projects. In the dataset of this study we had communication (22), database (23), desktop (18), education (17), format and protocols (15), games and entertainment (20), system (15), software development (17), sociology (10), scientific and engineering (17), security (11) and text editor (7) projects. Fig. 2 illustrates the distribution of the dataset in various categories.

The maximum open bugs were found in the category of database (209). The maximum bugs that have been fixed were observed in a system software project (1156). The category of 'software development' has maximum number of mailing lists (07) in one project. The highest number of messages (5611) were found in a sociology project. Fig. 3 illustrates the relationship of open and close usability bugs with messages and mailing lists in online forums.

5 Data analysis procedure

To analyse the research model and check the significance of hypothesis H1, and its sub-hypotheses H1a, H1b, H1c and H1d, we used various statistical investigation techniques. We divided the data analysis activity into three phases. In Phase I, we conducted tests for the hypotheses using parametric statistics, such as the Pearson correlation coefficient. In Phase II, we utilized non-parametric statistical analysis, such as the Spearman correlation coefficient. In order to increase the external validity of the study, we used both statistical approaches of parametric and non-parametric methods.

Finally, Phase III entailed testing the hypotheses using the partial least square (PLS) technique. The PLS technique is especially useful in situations involving complexity, non-normal distribution, low theoretical information and small sample size [14, 15]. In the PLS testing of hypotheses, we kept one factor as independent and other as dependent variable. We used the PLS technique to increase the reliability of the results. All statistical calculations were performed using Minitab-16 Software.

The Pearson correlation coefficient and *t*-test were examined between variables involved in the hypotheses H1a, H1b, H1c and H1d. The Pearson correlation coefficient between open usability errors and number of

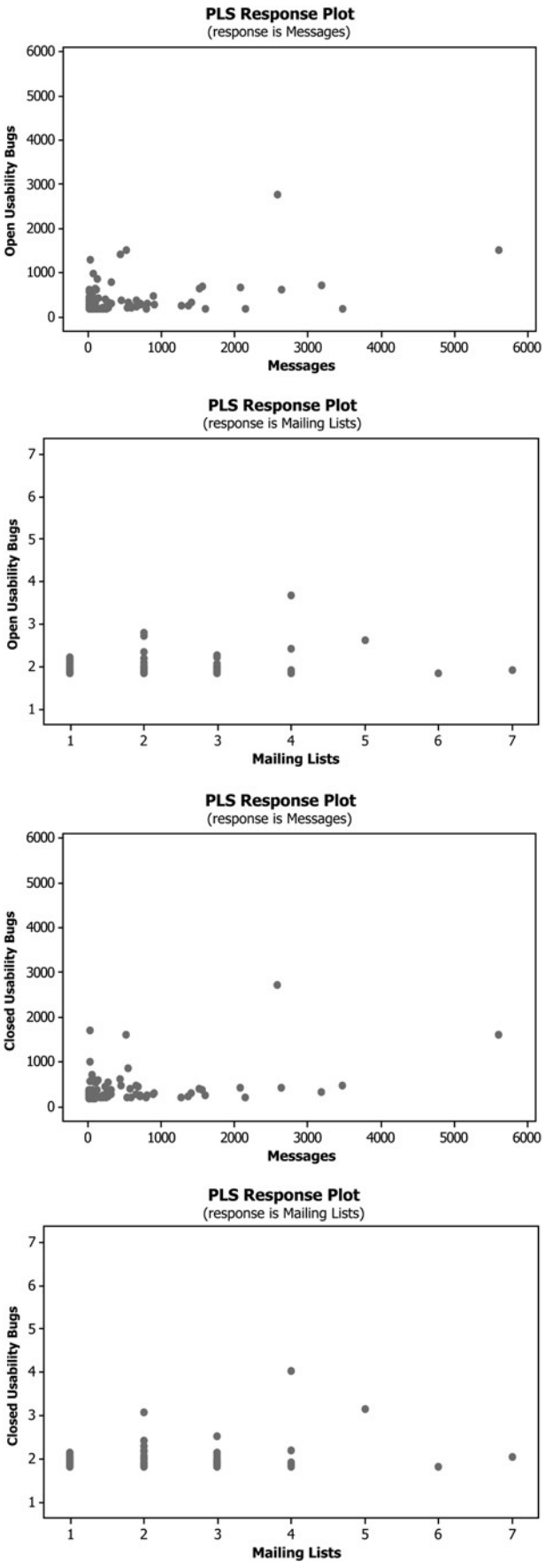

Fig. 3 *Open/closed usability bugs and online forums support*

messages in the public forums was positive (0.495) at $P = 0.0$, and thus provided a justification to accept the

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Table 2 Empirical analysis results

	Pearson correlation		Spearman correlation		Structural tests	
	Open usability bugs	Closed usability bugs	Open usability bugs	Closed usability bugs	Open usability bugs	Closed usability bugs
messages	0.495, $P = 0.0$	0.486, $P = 0.0$	0.388, $P = 0.0$	0.488, $P = 0.0$	coefficient: 0.27, R^2: 0.245, F-ratio: 61.37, $P = 0.0$	coefficient: 0.23, R^2: 0.235, F-ratio: 58.33, $P = 0.0$
mailing lists	0.240, $P = 0.001$	0.286, $P = 0.0$	0.218, $P = 0.001$	0.270, $P = 0.001$	coefficient: 0.23, R^2: 0.12, F-ratio: 97.15, $P = 0.001$	coefficient: 0.19, R^2: 0.18, F-ratio: 16.80, $P = 0.0$

*Significant at $P < 0.01$

hypothesis H1a. The hypothesis H1b was accepted based on the Pearson correlation coefficient (0.240) at $P = 0.001$, between open usability bugs and number of mailing lists in the online forums. The correlation coefficient of 0.486 at $P = 0.0$ was observed between the closed usability bugs and number of messages in the online forums, and hence H1c was accepted. The hypothesis H1d was accepted based on the Pearson correlation coefficient (0.286) at $P = 0.0$, between closed usability bugs and number of mailing lists in the online forums. Hence, it was observed and is reported here that hypotheses H1a, H1b, H1c and H1d, were found statistically significant and were accepted.

In order to increase the external validity of the study we conducted non-parametric statistical technique using Spearman correlation coefficient in Phase-II, to test our hypotheses. Hypothesis H1a was statistically significant at $P = 0.0$ with Spearman correlation coefficient of 0.388. A positive association was observed between open usability bugs and number of mailing lists (H1b) in the online forums (Spearman: 0.218 at $P = 0.001$). H1c, which deals with the closed usability-related errors and number of messages in the online forums, was also accepted (Spearman: 0.488 at $P = 0.0$). The Spearman correlation of 0.270 at $P = 0.001$ was observed for H1d. Hence, it was observed and is reported here that hypotheses H1a, H1b, H1c and H1d, were found statistically significant and were accepted.

In Phase-III of hypotheses testing, we used the PLS technique to cross validate the results of Phase-I and Phase-II. We tested the hypotheses H1a, H1b, H1c and H1d, by examining their direction and significance. The hypothesis involves two variables therefore in PLS we placed one variable as the response variable and other as the predicate. Table 2 reports the results of the structural tests of the hypotheses. It contains observed values of path coefficient, R^2 and F-ratio. The path coefficient of open usability bug (H1a) was found to be 0.27, R^2: 0.245 and F-ratio (61.37) was significant at $P = 0.0$. Open usability bugs (H1b) had positive path coefficient of 0.23 with R^2: 0.12 and F-ratio of 97.15 at $P = 0.001$ with number of mailing lists. Closed usability bugs with number of messages (H1c) (Path coefficient: 0.23, R^2: 0.235, F-ratio: 58.33 at $P = 0.0$) had the same direction as proposed. Close usability bugs and the mailing lists had path coefficient: 0.19, R^2: 0.18, F-ratio: 16.80 at $P = 0.0$, thus had the same direction as proposed in H1d. Overall, the hypotheses H1a, H1b, H1c and H1d, showed significance at $P < 0.01$ with a positive path coefficients and were in the same direction as proposed, therefore demonstrates that the hypothesis H1 is accepted. Hence, we concluded that online public forums help in identifying and fixing OSS usability errors, which provides an answer to the RQ.

6 Discussion on empirical findings

Owing to the involvement of and acceptance by big commercial IT vendors, OSS products have progressed from a fringe activity to enter into the mainstream [16]. OSS popularity is increasing everyday. OSS users come from all over the world, differ both in terms of technical experience and cultural background, and possess unique needs, expectations and demands. This diversity of users makes usability an increasingly challenging issue for OSS environment. Raza *et al.* [17] consider usability learning by OSS developers as an acknowledgement of the usability problem in open-source environment as well as a part of the solution.

It is evident from our analytical analysis that there is a positive correlation between the number of open usability bugs reported and the volume of messages posted on online forums in a particular OSS project. It illustrates the collaboration among OSS community to test and identify usability errors in a project. The research work indicates increase in the volume of interested contributors for projects with unsolved usability defects. The results of our study also demonstrate the positive correlation between the number of open usability bugs and number of mailing lists of a given project highlighting a significant support network of OSS community. This correlation advocates that the support network OSS community is significant and active. The voluntary nature of mailing list members in the collaborative environment of OSS generally leads to identification of possible solutions as well.

Furthermore, our empirical investigation supports the correlation between the volume of fixed usability bugs and the number of messages in the online forums. This may be considered another evidence of OSS community's collaborative support network which assists in the fixing of usability-related defects. Similar correlation has also been observed between the volume of users in the mailing list and the number of closed usability defects. This is because the number of active mailing lists is positively correlated to the number of usability bugs that have been resolved. Our analysis, thus, clearly highlights the involvement of OSS contributors, which may include users, developers, testers, architects and designers, in the identification and consequent fixing of usability errors in OSS projects.

6.1 Limitations of the study and threats to external validity

Empirical studies are always subject to certain limitations, and although we performed a number of measures to reduce the threats to external validity and increase the reliability, there are still some limitations to this study.

According to Easterbrooks *et al.* [18], construct validity, internal validity, external validity and reliability are four criteria of validity in an empirical study. Wohlin *et al.* [19] observe that in most cases, the researcher's ability to generalise the experimental results to industrial practice is limited by threats to external validity. We took specific measures to support external validity, including our use of a random sampling technique. Additionally, we retrieved data from the most active and well-known OSS reporting website, sourceforge.net, which includes a large number of projects.

The increased popularity of empirical methodology in software engineering has also raised concerns of an ethical nature [20, 21]. The data repository we used in this study is a non-profit organisation. Our study adhered to the recommended ethical principles to ensure that the empirical investigation would not violate any of the recommended experimental ethics.

Another aspect of validity is concerned with whether or not the study reports results that correspond to previous findings. This study strengthens the discernment that the OSS is getting popular and that its development life cycle relies heavily on online forums.

Another limitation of this study is its relatively small sample size. Although we started with a dataset of 1753 OSS projects, covering a broad range of categories, two filtration activities reduced our dataset to 192 projects (refer to Section 4).

Although the proposed approach has some potential to threaten external validity, we followed appropriate research procedures by conducting and reporting tests to improve the reliability and validity of the study, and certain measures were also taken to ensure the external validity.

It is worth mentioning here that other collaborative techniques such as blogs, wikis and t-wikis are also being used in the OSS world. Although they play a part in identifying and fixing usability bugs in OSS projects too, this study was primarily focused on the roles of messages and mailing lists. We are currently carrying out a comparative study of different collaborative techniques used to address perceptive and cognitive issues in OSS.

7 Conclusion

Addressing users' requirements is one of the major challenging options for improving usability in OSS. The objective of this study was to empirically analyse the association between usability defects in OSS and support through online public forums. The empirical results of this study strongly support the hypotheses that public online forums help in identifying and fixing usability errors in OSS projects. The study further helps in understanding the significant role of online forums in OSS development. However, as presented in our study, in only 10.95% (192 out of 1753) of the studied projects, usability-related issues have been highlighted. We would also like to mention that this research was first of its kind, in which we studied the role of online forums in relation to usability errors in OSS projects. Although it is very much possible to obtain different results with different source and number of OSS projects, it is nevertheless stressed that the level of usability and its related issues need to be addressed more thoroughly in OSS projects.

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