Bug! Falha! Bachi! Fallo! Défaut! 程序错误！ What about Internationalization Testing in the Software Industry?

Ronnie E. S. Santos
CESAR - Recife Center for Advanced Studies and Systems
Brazil
souzasantos.ronnie@gmail.com

J. Rafael Cordeiro
Philips do Brasil Ltda
Brazil
jrafaco@gmail.com

Yvan Labiche
Dept. of Systems and Computer Engineering - Carleton University
Canada
YvanLabiche@cunet.carleton.ca

Cleyton V. C. Magalhães
Liferay Inc.
Brazil
cleyton.vanut@gmail.com

Fabio Q. B. da Silva
Centro de Informática – UFPE
Brazil
fabio@cin.ufpe.br

ABSTRACT

Background. Testing is an essential activity in the software development life cycle. Nowadays, testing activities are widely spread along the software development process, since software products are continuously tested to meet the user's expectations and to compete in global markets. In this context, internationalization testing is defined as the practice focused on determining that a software works properly in a specific language and in a particular region. **Aims**. This study aims to explore the particularities of internationalization testing in the software industry and discuss the importance of this practice from the point of view of professionals working in this context. **Method**. We developed an exploratory qualitative study and conducted interviews with professionals from an international software company, in order to understand three aspects of internationalization testing: general characteristics and importance of this practice, particularities of the process, and the role of test automation in this context. **Results**. An amount of 13 professionals participated in this study. Results demonstrated that internationalization testing is mostly related to aspects of graphical user interfaces. In this context, truncation and mistranslations are the main faults observed, and test automation might be difficult to implement and maintain due to amount validations that are human-dependent. **Conclusion**. Internationalization testing is an important practice to guarantee the quality of software products developed for global markets. However, this aspect of software testing remains unpopular or unfamiliar among professionals. This study is a step forward in the process of informing and enlightening academic researchers and practitioners in industry about this theme.

ESEM '20, October 8–9, 2020, Bari, Italy

ACM ISBN 978-1-4503-7580-1/20/10…$15.00
https://doi.org/10.1145/3382494.3422167

CCS CONCEPTS

• CCS → Software and its engineering → Software creation and management → Software verification and validation

KEYWORDS

Software Testing, Internationalization, Localization

ACM Reference format:
Ronnie E. S. Santos, J. Raphael Cordeiro, Yvan Labiche, Cleyton V. C. Magalhães and Fabio Q. B. da Silva. 2020. Bug! Falha! Bachi! Fallo! Défaut! 程序错误! What about Internationalization Testing in the Software Industry? In ESEM' 20: ACM/IEEE International Symposium on Empirical Software Engineering and Measurement (ESEM) (ESEM' 20), October 8-9, 2020, Bari, Italy. ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3382494.3422167

1 Introduction

Testing is an essential activity in the software development life cycle, although it is commonly simplified as the process of observing the execution of a software in order to verify and validate if it behaves as intended. [1]. Nowadays, the importance of testing activities in software development is unquestionable. Historically, there are reports demonstrating that software testing is performed for over seventy years now, as testing activities existed even before the establishment of processes, practices and models for the software development life cycle [2] [3]. Gillenson et al. [2] discussed the value of software testing and demonstrated how this practice evolved from an activity simply focused on checking the results obtained from the source code execution to a leading and interactive activity essential for the development of software products.

Currently, especially considering agile software development, testing activities are widely spread among the development process and the system is continuously tested. Software testing is centered on delivering quality products, focused on users experience and expectations. In particular, as software testing is proven to be a vital

activity in the software development life cycle [1] [2] [3], practitioners experienced the need for defining and applying different strategies and techniques for testing, in order to ensure software quality. In other words, this means that the evolution of software products created new challenges for those involved in software testing in order to support the development of systems to be used in a variety of different contexts [4].

As a matter of fact, changing the context where a software will be used might involve the investigation of issues not only strictly related to the system's functionalities. In several cases, it might require that software testing professionals address cultural and regional aspects of the product, since the technology under development might be available worldwide [2]. This conveys that software testing shall encompass methods and approaches to verify and validate software products assuming that targeted users are scattered around the world and considering that the users' experience regarding regional aspects, such as culture, language, writing formats and other details must be observed, when quality is under discussion [5]. In this context, *internationalization testing* is the term commonly applied to define the facet of software testing that is specifically focused on determining that a software product works properly in a different language or in a specific region [6]. Broadly, *internationalization* can be defined as the process of developing a functional product that can operate anywhere in the world by being adaptable for cultural and regional individualities of a specified group of users [7].

Although the nature of the internationalization testing demonstrates its importance in the development of software nowadays [8] [9], e.g. software applications for global markets, this practice seems to be underrated by the software engineering community. A non-systematic search on the main Software Engineering repositories will retrieve only a few papers focused on studying this practice. This scenario suggests that the amount of knowledge regarding internationalization software testing is retained with professionals in the software industry, which justify the development of empirical studies focused on exploring and understanding aspects related to this practice. This is the main motivation behind the present research. Thus, considering the assumed impacts of internationalization testing on software quality nowadays, the present research is an exploratory study designed to collect and interpret the perspective and the opinions of practitioners regarding this practice. In this process, data was collected and analyzed in order to answer three research questions:

RQ1. How internationalization testing can be characterized in the software development process?

RQ2. What are the particularities of internationalization testing and how does it differ from other testing practices?

RQ3. What is the role of test automation in internationalization testing?

From this introduction and this brief background about internationalization testing, the paper is organized as follows. In Section 2, we detail the research method applied in this study. In section 3, we present and discuss the main findings. Finally, in Section 4, the general conclusions and directions for future research are presented.

2 Methodological Procedure

In this research, we conducted a qualitative study. This study was performed based on the methodology proposed in [10] [11]. Initially, this process involved the development of a broad literature review, which is compacted in Section 1, due to the limited number of pages in the template format. This review aimed to observe gaps in the literature that could be used in the study design. The main outcome of this step was the precise definition of internationalization testing as a construct and the identification of relevant topics to be explored while interviewing practitioners.

2.1 Data Collection

A well-established international mobile phone company was invited to participate in this study. Among other characteristics, this company was chosen because the internationalization testing is performed consistently across the software development process and the practice is well known to all current professionals in the testing teams. In addition, there is a well-established process of planning, executing and managing internationalization tests.

The selected company maintains operations worldwide and the team responsible for internationalization testing operates in Brazil, USA, and China. The internationalization team is composed of about 40 individuals responsible for activities related to software localization (4 professionals), internationalization quality assurance (14 professionals), development of tools to support automation and processes (8 professionals), language and translation services (4 professionals), testing management (6 professionals) and supporting activities (4 professionals). Since the present research is focused on testing activities, in this study the sample of participants was composed by 13 individuals, which represents about 30% of the amount of professionals in the team. The summarized profile of participants selected for this study is presented in Table 1.

Table 1. Profile of Participants

Background	Participants
Team Roles	11: Software tester 1: Software engineer 1: Project Manager
Genders	9: Males 4: Female
Education	3: Undergraduates 8: B.Sc. 2: M.Sc.
Experience with software testing	5: < 3 years 4: 3 – 5 years 4: > 6 years
Experience with internationalization testing	10: < 3 years 1: 3 – 5 years 2: > 6 years

As recommended in the literature [10] [11] semi-structured interviews were performed to collect multiple data from the selected participants in order to access different viewpoints about the theme. The interview script was composed of eleven questions involving general aspects of the internationalization testing, particularities of the practice regarding types of bugs, techniques and limitations faced in the process, and finally, aspects related to

test automation in this context. The validation of the interview scripts was accessed by conducting a preliminary interview with two software testers and one academic researcher. The script validation aimed to estimate the time required to perform the actual interviews and to adjust the questions when necessary, e.g., wording and sequence of questions. The final version of the interview script (English translation) is presented in Table 2. The data was collected by an interviewer and supported by a second researcher. All interviews were recorded producing about 5 hours of audio, which were posteriorly transcribed to support data analysis.

Table 2. Interview Script

Topic	Questions
Background	1. How long have you been working with software testing and with internationalization testing?
Internationalization Software Testing in General	2. How would you define internationalization testing in software development? 3. Please, summarize the process that you follow to perform internationalization testing.
Tests and Bugs in Internationalization Software Testing	4. What are the most frequent types of bugs in internationalization testing? 5. Describe tests that are exclusively executed in an internationalization testing process. 6. Describe types of failures that are not exclusively an internationalization issue, but that would affect the internationalization testing.
Automation in Internationalization Software Testing	7. How would you describe the automation process in the context of internationalization testing? 8. What are the efforts and costs associated with automation of tests in software projects?
Limitations in Internationalization Software Testing	9. What was the main difficulty that you had to face while working with internationalization testing? 10. What would you point out as the main limitation in internationalization testing?
Final Considerations	11. To conclude, please, comment about the importance of internationalization testing in software development.

2.2 Data Analysis

The objective of qualitative analysis is to consolidate, reduce, and interpret all data obtained from the field [14]. In this study, this process was performed by labeling and coding the transcripts obtained from the interviews in order to comprehend the perspective of participants regarding the topic under study. Following the guidelines, we performed data analysis in parallel with data collection, in incremental and iterative steps [12] [13] developed in three phases of coding [14] [15]:

a) Open Coding: The process of "breaking down" the transcriptions into discrete parts, which were closely examined and compared, looking for similarities and differences, in order to group concepts into representative categories.
b) Axial Coding: The process of developing an exhaustive and comprehensive analysis of the defined codes in order to find relationships and emphasize connections among different categories.
c) Selective Coding: The process of determining the interpretation of the case by constructing a comprehensive explanation to the phenomenon under investigation.

Figures 1 to 3 illustrate the data analysis process conducted in this research. Firstly, the interview's transcripts were divided into codes (Figure 1). Secondly, the codes arising from each individual interview were constantly compared to codes in the same interview and from other interviews and arising similarities allowed us to group them into categories (Figure 2). Third, relationships among codes and categories were identified through axial coding (Figure 3). Finally, a narrative was built (Selective Coding).

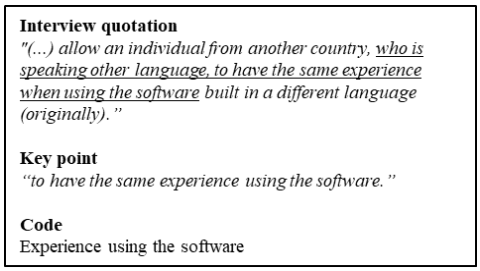

Figure 1: Open Coding

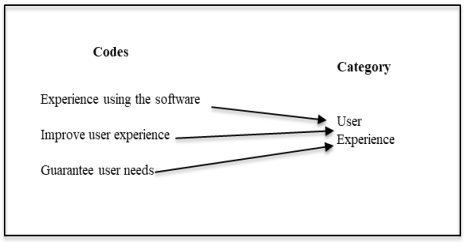

Figure 2: Building Code Categories

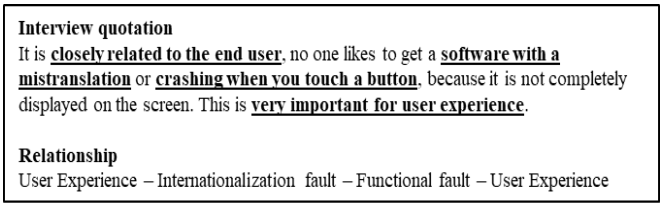

Figure 3: Axial Coding and Relationships

Following the guidelines [10] [11] [15], we concluded data analysis by comparing our findings with evidence available on the literature about the phenomenon under investigation. This comparison of results aimed to sharpen construct definitions and raise theoretical level, by contrasting the case with related studies.

2.3 Threats to Validity

First, validity and reliability aspects usually applied in positivist experimental research might not be suitable for qualitative studies, such this study. Instead, we accessed validity and reliability of results from the perspective of interpretative approaches [13] [14]. In this sense, the definition of constructs obtained in the interviews were contrasted to the definitions in the literature to assure adequacy. Second, internal validity is related to the degree of how closely the obtained results match the investigated reality. To achieve internal validity, we targeted maximum variation on the sources of data by interviewing participants in different roles, with different perspectives, and with different levels of experience. Third, reliability states that the

results can be replicated when necessary. In this study, for reliability purposes, we recorded the audio of all interviews in order to avoid losing any important information during data collection. In addition, we provided the interview script and reported the details of data collection and data analysis in order to support replications.

Finally, an important aspect of this research needs to be highlighted. As expected in qualitative approaches, such as case studies, the findings obtained in this study are dependent on the context where the data was collected. This type of methodological approach will rarely allow generalization of results to other contexts. Nevertheless, it is likely that practitioners can adapt the results to other realities, by analyzing the reported findings and contrasting them with their own environment.

3 Findings and Discussions

Our findings demonstrated that internationalization testing plays an important role in the software quality process. This is one of the main practices established to guarantee that the software meets the expectation of different users around the globe. In general, this practice aims to accommodate variations of idiom and cultural aspects into the software, providing to users a consistent scheme of appearance, feel, and functionalities across different language versions. Regarding this, participants were interviewed to describe internationalization testing based on their experience in order to answer: *RQ1. How internationalization testing can be characterized in the software development process?*

The analysis of the answers indicated that internationalization tests are usually performed in cycles of sanity, regression and exploratory testing. Nevertheless, these activities are not exclusively focused on testing activities, it might also include validations performed by professional linguists, since software testers are unlikely to hold deep knowledge about all idioms available in a product. Therefore, internationalization testing ought to be conducted as an interdisciplinary process. Most of the software aspects covered by internationalization testing refer to screen layout and to user interaction specifications, as presented in Table 3.

Table 3. Aspects of Internationalization Testing

Aspect	Description
Density	Refers to the fact that different languages would need larger text size to be readable.
Order and Sequence	In some languages, words are written in a sequence order different from the source language, e.g., adjectives are written in a different order in a phrase, when considering English and Portuguese languages. Therefore, this must be an important aspect of text adequacy.
Space and Display	After translation, some languages take more space to be presented. Therefore, interface elements, such as buttons, text fields or lists need to be adjusted to expand accordingly.
Wording	Focuses on avoiding mistranslations, e.g., the exact translation makes less sense in the target idiom than it does in the source idiom or the translation is a double entendre.
Direction and Alignment	Some languages, such as, Arabic or Hebrew are written in a right-to-left (RTL) pattern, that is, writing starts from the right of the page and continues to the left. Therefore, screen layout ought to follow the alignment accordingly.
Emphasis and Highlights	Culturally, there are different ways of emphasizing a word or a sentence, depending on the language, e.g., to use bold or a different color will depend on local standards.
Image View	Analysis of aspects related to images, graphics and videos, such as colors, sizes and arrangements considering different languages and cultures. Further, there is a particular need for analyzing such images and the context where they will be applied, in order to avoid cultural or regional misleading.

The findings summarized in Table 3 demonstrated that the key aspect of internationalization testing is to guarantee that users' experience will not be impaired while executing the software in their language. Participants described internationalization testing in software development as a quality practice that aims to verify the flexibility and versatility of a software in terms of locale and language. This practice is focused but not limited to user experience aspects, such as, grammar, time and date formats, display of non ASCII characters, among others, as illustrated in the quotations below, which were extracted from the interviews.

- "(…) these are tests that allow a user from another country, other language, to have the same experience (…)".
- "So the general definition would be like, you get your phone and you can use it in your own country, in your language, and it gets all the formats and it meets the expectations that you have".

Interviewees reported that the process of performing internationalization testing might extend the general testing activities in a complimentary way, as the software products are tested beyond system's functionalities. For instance, in many companies, testing activities are planned and performed aiming to attest whether a given requirement is correctly implemented or not. On the other hand, internationalization testing would extend this test to verify how the users experience this requirement while using the software in their idiom, as illustrated as follows.

- "(…). This is about worrying not just about the software functions but also about users' understanding and how clear the information is presented."
- "Most of the tests that we do extends the focus of functional issues, as we try to cover localization issues, which includes translation, but not limited to, plus we try to cover formats and patterns related to content exhibition."

When asked to describe the limitations in the process of internationalization testing, interviewees discussed that usually these tests require relatively high amounts of workload on manual (visual) validation. Therefore, time is a limitation in this context, even when automation scripts are available. Another limitation of this practice lies in the fact that internationalization tests are not as popular as other types of tests, which makes it difficult for professionals to obtain resources, tools and study material to rely. Training activities are usually affected by the lack of information available about this practice and even skilled testers who started to work in this particular context might face difficulties to understand the required validations. Participants reported that their tasks are usually unfamiliar even for co-workers from different teams in the same company. Quotations below illustrate the limitations of internationalization testing.

- "I came from a totally different context where we used to perform functional tests (…). This was my main difficulty, I had in mind the most

common test processes, the most popular, and I had to change this mindset to internationalization, which at the time was something somehow unknown for me."
- "One limitation that I can think right now is that there are many things that cannot be automatically identified and checked, without manual interaction. How to solve this?

Following, participants answered questions regarding the particularities of internationalization testing in order to answer: *RQ2. What are the particularities of internationalization testing and how does it differ from other testing practices?* Regarding this, participants pointed out that the most risky fault observed in internationalization tests is the problem of *truncation*. In general, presenting texts in the graphical user interface using a variety of languages might require that engineers reduce such texts, in order to adapt them to the size of the screen to be displayed. In many cases, the shortened version of a text is obtained by removing the end of a sentence, resulting in sentences finishing with suspension points, which most likely will result in writing ellipsis. The problem in this case, considering software quality, is that the resulting shortened text might confuse the user and damage the message's sense, and negatively affect users' experience. In the worst-case scenario, the truncated message can completely change the information displayed and confuse or offend the users, e.g., presenting inappropriate content, which might result in customers abandoning the software for a similar option available in the market. This discussion is demonstrated in the quotations extracted from the interviews.

- "There are truncation issues, when a text string is not completely displayed in the screen or it is being overlapped by images or some other text."
- "Truncation and mistranslations [about most frequent issues]. But with truncations you have to be careful, since you can have like, bad words or insults appearing on the screen."

Further, interviewees reported mistranslation, wrong formatting and pattern suitability as other types of common issues identified during internationalization testing. In general, these are problems that can negatively affect how users interact with the software. However, these faults tend to produce a relatively small negative effect in comparison to the truncation issues. Professionals reported that it is more likely for users to accept a time format fault, than a truncation that results in an explicit inappropriate content. Quotations below illustrate this finding.

- "Resources can present a poor translation, such as inconsistent formats in a specific country, like, date format, or like French, in which punctuation needs a space after the word".
- "It ends up being mistranslation issues, like, sometimes something is translated but for a different context".
- "Sometimes developers are not careful regarding which format fits better for a given locale that they are developing targeting (…) and usually, we have to point out this kind of problem."

Regardless of the fact that internationalization software testing focuses on a particular category of problems, this practice is not an isolated testing activity. The data collected in the interviews, and presented below, revealed dependencies of internationalization tests and other types of tests. This means that general software failures might interfere on internationalization issues and also affect the internationalization testing process. On the other hand, there is no evidence demonstrating the opposite scenario, that is, internationalization testing/issues affecting other types of tests, although due to the nature of these tests, we can hypothesize that internationalization tests would affect usability testing.

- "I would say that when we are performing internationalization testing, sometimes, we end up coming across problems that are not specifically our target, they would fit more like functional tests."
- "Of course, if there is a system problem that blocks me from accessing part of the content on the software, it will directly affect the process.

The next aspect investigated in this study was testing automation. Thus, data was collected from participants in order to answer: *RQ3. What is the role of test automation in internationalization testing?* Nowadays, test case automation is a crucial activity in software testing, since it supports the execution of a large amount of test cases in a short period of time. In internationalization testing, interviewed participants reported that automation is an essential portion of the process, since repetition of test cases is a common characteristic in this context. For instance, a product that will be launched covering 60 idioms, it is likely to have several test suites executed and repeated 60 times, one for each idiom. In this case, automation will allow better performance in the testing execution by reducing the time to complete it, as illustrated in the quotes below.

- "We have tests called locale dependent (…) and this kind of test will be executed in several different idioms, like 40, or 50, or 60 times, depending on the scope that was planned."
- "So automation is a great help, since we work to support several languages, there is a lot of repetitive work to be done".

Therefore, test automation will decrease the repetitiveness of work allowing professionals to focus on other activities that inevitably requires human validation. However, practitioners ought to determine a balance in this scenario, since internationalization testing is still highly dependent on human-centered activities, and many validations might not be suitable via automation scripts. In fact, interviewees revealed that, nowadays, there are many libraries available to facilitate programming for test case automation. However, most of them will only allow checking formats and patterns, which will cover only a fraction of internationalization tests. Thus, tests related to space, text format and alignment can be easily automated. On the other hand, tests related to density, emphasis, wording and images might require more human interaction, which could lead to partial automation. Finally, there are faults related to mistranslation and specially truncation that might not be simply checked using test scripts, since the meaning, the feeling and the presentation of the content will define whether a test fails or not. Quotations below illustrate this discussion.

- "There are things that need us to perform resource analysis, if it was translated, you have to visually check this."
- "Currently, we can't validate video (movie) contents, for instance, or anything that needs an interaction beyond touching it". [meaning visual validation]

In summary, our findings demonstrate the relevance of internationalization software testing and its importance to deliver

software products focused on improving users' experience independently of what language they speak. On some level, internationalization testing is also a unique strategy that might help to create or improve software value, helping companies to achieve and retain global markets. Quotations below reinforce these results.

- "I'd say that validating the user experience regarding internationalization is extremely important, because software products with poor translations end up appearing to be low cost products with low quality."
- "It's essential. (…) You have to provide users with the opportunity to use the software in their native language. In the end, they feel more comfortable. They see that the company cares about them."

4 Conclusions and Future Research

The present research is a qualitative study designed to explore and discuss aspects related to internationalization testing in the software industry. In this study, we investigated a global mobile phone company that operates worldwide and develops products used by millions of customers in a wide variety of regions. In this company, an internationalization team composed of about 40 professionals is responsible for planning and performing processes focused on the delivery of software products adaptable for over 70 languages. From the amount of professionals on this team, we collected qualitative data from a group of 13 individuals (30% of the team) in order to obtain perceptions, opinions and experiences about the practice of internationalization testing.

In summary, we concluded that there is an existing close relation between internationalization testing and several aspects of users' experience. Consequently, the internationalization test cases are planned and executed in order to validate the system from the perspective of how end users will experience the software in their own language. Due to this characteristic, many of the faults identified in this context are related to the system's GUI and how it is presented and perceived after idiom and locale adaptations. On a daily basis, professionals working with internationalization testing target several aspects of software appearance, since their main scope focuses on how comfortable users would feel using the system in their idiom. Thus, tests are designed and executed in order to identify and fix faults related to truncation, mistranslations and misunderstandings with patterns, format and values in specific regions. In addition, we observed that test case automation is an important practice in internationalization testing, since it reduces the effort of executing the same test for a large number of languages. It also reduces the repetitiveness in this process, which might positively affect professionals' by reducing monotony at work. However, practitioners ought to be aware of the existing balance among the tests that can be automatically executed and those that require human interaction in order to be successfully completed.

This study has implications for both academy and practice. For practitioners the present results are a reliable source of information about the basics of internationalization testing, covering general aspects, main characteristics and particularities of this practice, such as specific types of faults that are likely to be observed in this scenario. Thus, the present study can be used for training purposes and also for supporting managerial activities. Therefore, our findings are a step forward into enlightening practitioners, reducing the unfamiliarity of this practice, which has been reported on the interviews and also in the literature. Further, for academic researchers, this study revealed the need for the development of studies focusing on proposing methods, tools and guidelines that could support this practice. In particular, test automation is a topic that requires assistance in this context.

As for the next steps of this study, future research might include the development of a mapping study to collect evidence about internationalization testing from papers published over the years, in order to enlarge the body of knowledge about the theme and extend comparisons with the present findings. Further, more opinions and experiences from professionals are available on online communities where practitioners discuss aspects of software quality, such as *Stack Overflow*, and exploring these data might be a relevant way to improve the obtained results and raise generalization. Finally, since our research protocol demonstrated to be efficient in collecting information from the field, a replication of this study to collect data from other companies is planned to be conducted.

REFERENCES

[1] Bertolino, Antonia. "Software testing research: Achievements, challenges, dreams." 2007 Future of Software Engineering. IEEE Computer Society, 2007.

[2] Gillenson, Mark L., et al. "A Literature Review of Software Test Cases and Future Research." 2018 IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW). IEEE, 2018.

[3] Alaqail, Hesham, and Shakeel Ahmed. "Overview of Software Testing Standard ISO/IEC/IEEE 29119." International Journal of Computer Science and Network Security (IJCSNS) 18.2 (2018): 112-116.

[4] Bartram, Dave. "The internationalization of testing and new models of test delivery on the Internet." International Journal of Testing 6.2 (2006): 121-131.

[5] Abufardeh, Sameer, and Kenneth Magel. "QA/Testing Bi-directional Languages Software: Issues and Challenges." 2008 32nd Annual IEEE International Computer Software and Applications Conference. IEEE, 2008.

[6] Chang, David W., and William E. Malloy. "Method for automating internationalization software testing." U.S. Patent No. 7,895,576. 22 Feb. 2011.

[7] Archana, J., Senthil Raja Chermapandan, and Saravanan Palanivel. "Automation framework for localizability testing of internationalized software." 2013 International Conference on Human Computer Interactions (ICHCI). IEEE, 2013.

[8] Abufardeh, Sameer, and Kenneth Magel. "Software internationalization: testing methods for bidirectional software." 2009 Fifth International Joint Conference on INC, IMS and IDC. IEEE, 2009.

[9] Ramler, Rudolf, and Robert Hoschek. "Process and Tool Support for Internationalization and Localization Testing in Software Product Development." International Conference on Product-Focused Software Process Improvement. Springer, Cham, 2017.

[10] Yin, R.K. Case study Research: Design and Methods, third ed., Sage, London, 2003.

[11] Eisenhardt, K. M. Building Theories from Case Study Research. The Academy of Management Review, 1989.

[12] Merriam, B. S. 2009. Qualitative Research: A Guide to Design and Implementation. Jossey-Bass, San Francisco.

[13] MERRIAM, S. What Can You Tell From An N of l?: Issues of validity and reliability in qualitative research. PAACE Journal of lifelong learning, 1995, 4, 50-60.

[14] Seaman, C.B. 1999. Qualitative methods in empirical studies of Software Engineering. IEEE Transactions on Software Engineering, 25, 4, 557–572.

[15] Strauss, Anselm, and Juliet Corbin. Basics of qualitative research. Sage publications, 1990.